Study Committee B2

Overhead Lines

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Resilience Assessment 400 kV Overhead Line Stevin – Horta in Belgium

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Motivation

- Background-The HVDC Nemo is connected to the grid via the 380kV Stevin - Horta antenna. In case of unavailability offshore wind farms will be curtailed.
- Aim of study - Define supplementary measures to reduce probability of failure and deliver a specific resilience/emergency plan to restore the operation ASAP in the case the unavailability of the 380 kV Stevin – Horta axis.

Method/Approach

- A qualitative risk assessment was executed. Inputs for this risk assessment were project related documents about installation, maintenance, and operations, and the design information of the overhead line assets.
- The assessment also includes some feasibility studies regarding the installation of the available Emergency Restoration System (ERS) at specific sites. Information about Elia's ERS the was used as input.
- The outcome of the qualitative risk assessment was input for a detailed assessment of the installation risks with respect to the available emergency restoration system for 6 critical locations.

Objects of investigation

- In Q1 2019, the HVDC Nemo link between UK and Belgium came into commercial operation. The Nemo link is connected to the Elia grid via the 380kV Stevin - Horta antenna.
- In addition, in case of unavailability of the 380 kV Stevin-Horta axis, the connected offshore wind farms will not be able to inject into the grid and hence have to be curtailed.

Risk inventory

- The results of risk inventory is a list of 12 risks divided into two categories:
- Primary risks; risks related to failure of the line or to a damaged line which could lead to failure caused by another event.
- Secondary risks; risks directly related to the (temporary) restoration of the line after failure which take too much time. The maximum restoration time is defined as one week for temporary restoration and 6 months for final restoration.

Discussion

- The design of the overhead line to resist environmental loads is adequate including failure containment measures which are qualified as good as reasonably possible.
- Some supplementary measures have to be taken for temporary and final ASAP restoration of operation in case of unavailability
- The ERS is the key mitigation measure available in case of tower failures . How ever for the effective use the system owned by Elia, additional components are required. Also maintenance and contractor crews should become additional trainings.
- In addition, detailed scenarios have to be prepared for the installation of the ERS for specific critical situations/locations.

Conclusion

- The resilience or risk assessment confirmed the structural design
- Is provided input for a plan with specific supplementary prevention and mitigating measures in case of an exceptional failure that will further enhance the availability of Stevin-Horta axis.

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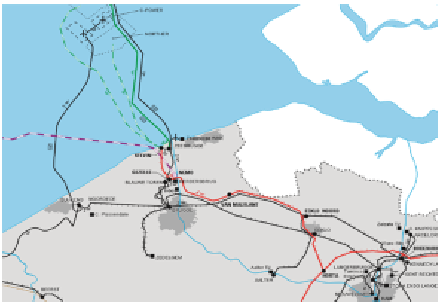
Stevin – Horta axis



Risk inventory primary risks

1 Tower/foundation failures due to extreme environmental loads (wind and ice).

2 Instability of V-brace suspension due to accidental environmental loads.

3 Intentional human acts of vandalism or terrorism.

4 Unintentional human acts

5 Flashover due to accidental environmental loads.

6 Maintenance strategy (not) aligned with higher reliability requirement.

7 Unforeseen generic material defects leading to common mode failures

8 Changes in the direct environment of nearby infrastructures.

Risk inventory secondary risks

9 Temporary restoration, using Elia's ERS system, not possible/ takes too much time. In case of conductors and towers failures caused by exceptional/accidental loads or events.

10 Final restoration takes too much time. In case of conductors and towers failures caused by exceptional/accidental loads or events.

ELIA's ERS system

- Contains 28 towers ((16* RA (Running Angle) and 12*AT (Angle Tower).
- Maximum possible span length about 180 m for the 4*707AMS-2Z conductor
- Angle tower and suspension tower with height extensions require 1 tower body per phase.
- The ERS is not designed and tested using the ACCC-Z Antwerp conductor or a HTLS as used in the Stevin Horta axis.

Restoration of the worst-case length (4 km) is possible within a week considering flat terrain without extraordinary obstacles or infrastructure crossings under the condition that:

- Additional equipment is needed for the 2*ACCC-Z Antwerp / 4*707AMS-2Z conductor transition.
- The installation of structures for horizontal configuration of the phases is trained.
- Enough spare AMS conductors are in store for 5 km (one circuit 380 kV) ERS.

Emergency Restoration System (suspension tower)

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Example of primary risk assessment: environmental loads

- The new structures of Eeklo Noord – Stevin are designed following criteria which differ from the usual practice in Belgium (NNA EN 50341-2-2).
- The existing structures of Horta –Eeklo Noord are re-designed following criteria which differ from the usual practice in Belgium.
- These approaches results in a failure rate which is lower than for the existing 380 kV lines in Belgium. One order of magnitude for new structures and half order of magnitude for existing ones . This is considered as low as reasonably possible.

Example of secondary risk assessement

- For risk 9 (Temporary restoration not possible/ takes too much time) a site exploration was executed using Google maps. All line sections were checked for the use of the ERS system on the following criticalities:
    - Availability of space for locating ERS tower with guy wires;
    - Crossing with other critical infrastructures;
    - Demanded height of the conductors;
    - Section length longer than 4 km.
- In total 6 critical locations are identified for which a baseline plan was prepared to check the feasibility for (timely) installation of the ERS.
- It was concluded that for these sections enough basic assets are available. Remaining criticalities are the availability of potential ERS spots and the interfaces with other infrastructures.
- The following prevention measures are required:
    - Prepare detailed restoration scenarios for specific critical situations.
    - Purchase additional spare AMS conductors (35 km) in order to be able to install 4,8 km of ERS. 60 km is needed, and 32,4 km is available in store yet.
    - The installation of structures for horizontal configuration of the phases should be trained.

Example of assessement of a critical location for ERS

- The example location is relative complex due to the surrounding infrastructure which includes a 150 kV line as well as the protected trees lining the canal.
- The ERS route crosses underneath the 150 kV line and then over the canal in successive spans which warranted the use of special structures to obtain sufficient clearance. Each structure carries one phase.
- After crossing over the canal structures there have sufficient space and are the standard ones.
- Special structures were also required to cross back over the canal. The heights of the structures were influenced by the height of the protected trees as indicated in the survey data.
- After the design stage a site- inspection was carried out at each tower location to ensure the feasibility of our ERS line design. Access roads, possible (future) tree & bushes obstructions were checked. For each ERS tower location a site plan was made

Profile drawing example critical location