Study Committee B4

DC Systems & Power Electronics

Paper 10940_2022

Improving HVDC Performance Data Collection and Sharing

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Background

- HVDC system reliability & availability is essential for the large inter-connected electricity markets
- For being able to increase HVDC performance, outage data need to be collected with sufficient details (e.g. reasons and origins) by the owners and experiences need to be shared within the HVDC industry
- This paper shows identified challenges today and gives some concrete suggestions for improvement relating to HVDC outage data collection and sharing.
- Only worldwide HVDC performance data collection is by CIGRE B4 AG04 (TB 590), which has long history since 1960'ies, but with limited detail level.
- ENTSO-E and the Nordic Countries have lately developed more detailed HVDC performance data collection.

How to improve CIGRE survey data quality and the level of details?

- Scheduled outages to have new sub-categories, e.g.
    1. Regular (periodic) maintenance
    2. Repair / corrective maintenance, including fault seeking
    3. Modification work (e.g. upgrade/renewal)
    4. Other (testing, warranty work, external reasons).
- Outage codes to have sub-classification, examples
    1. A.C. and Auxiliary Equipment
        i. Auxiliary Equipment
        ii. Auxiliary Power
        iii. Valve Cooling.
    2. DC Transmission Line
        i. Cable Underground
        ii. Cable Submarine
        iii. Cable Underground Joint
        iv. Cable Submarine Joint
        v. Cable End Termination
        vi. Cable Accessories.
- Outage origin (outage code) vs. actual reason is not always obvious
- Category "Other" is very open and vague
- Reason could be extracted to increase understanding → Outage code would then show "location" of the fault, where it occurred
- Reason or Cause of disturbance/outage divided into categories:
    1. Technical Fault
    2. Operational Error
    3. System Fault
    4. Excessive stress, External, Environmental
- Main disadvantage is in lacking comparison possibility with already submitted performance data history.
- How to use the category "Other" and "Human Error" is not always unambiguous and could need further guidance. Examples:
    - Loose connector at capacitor after valve maintenance – "Other" or "Valve Capacitor"?
    - Wrong label text in LVAC supply board – "Other" or "Auxiliary Equipment & Auxiliary Power"?
    - Lacking instructions in valve cooling maintenance manuals – "Other" or "Auxiliary Equipment & Auxiliary Power"?
    - A design error in the original C&P code is a human error, but still categorized as a C&P related fault.
- Other interesting HVDC system specific data that are missing today:
    - Year of upgrade/renewal (e.g. C&P)
    - Specified/Required targets for availability and max. number of outages per year

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Definitions to be clarified

- Scheduled and Force Outage classification
    - It is misleading to sum disturbances due to faults with extended durations of maintenance or other outages (testing).
    - → Extended outages should be extracted into an own category, as reason may be mis-judgement of needed outage time.
    - → In case extended duration is due to a fault.
- Forced outage definition, where the HVDC system is manually switched to “Blocked” or “De-energized” mode in a situation that required “immediate” reduction of power for safety/risk reasons, is not unambiguous versus a scheduled deferred outage
    - → Suggestion to use similar as CIGRE SC B3 classification for “Major Fault” category for e.g. circuit-breakers, i.e. manual disconnection is urgently needed (within approx. 30 min.).
- Start and end times of outages, based on last switching action is slightly vague, there can be other (e.g. market related) reason for not starting transmitting power

    - → Advice exactly when to use Converter block / De-block and CB Open / Close.
    - → Alternatively, use other terms like “Converter blocked” and “Readiness for power transmit”.
- A.C. and Auxiliary Equipment outage code content is not unambiguous. Clarification needed:
    - → that all AC equipment outside valve hall up to the AC feeder disconnector bus side at the AC substation shall be included.
- A.C. Control & Protection outage code can be interpreted differently. Clarification needed:
    - → when to use “A.C. and auxiliary equipment”, “A.C. Control & protection, “Converter or Interface Transformer” and “DC Control & Protection” or “Auxiliary Equipment & Auxiliary Power” for conventional / computer integrated(transformer on-built and Valve Cooling C&P devices and functions.
- Exactly when to use Other outage code is not fully explained. Clarification needed:
    - → “Other” to be used also in any other unexpected occurrence else than equipment failures (unknown or known reasons).
    - → Add note that when equipment failure causes (extension) of an outage, the corresponding equipment outage code shall be used.
- How to report simultaneously performed tasks can be interpreted differently. Clarification needed:
    - → Suggestion to delete the clause to report the use of a forced outage to perform deferred repair work, as it seems very unlikely to be reported, unless it extends the original forced outage time.
    - → Suggestion to clarify that re-occurrence of a trip by same reason that originally occurred is not counted, if during fault seeking one is just trying to energize the HVDC system to see what happens. E.g. ahidden control system error would probably lead to same behaviour (trip), if re-energized during fault seeking. The event would be reported as one forced outage and with the whole duration from original trip to the successful re-energization of the HVDC system.
- External events can be interpreted differently:
    - In loss of auxiliary power for the HVDC system, the reason for the trip can be a fault in the incoming MV feeder or in the MV grid. Clarification is needed to guide if the outage code shall be chosen according to “External” or to “Auxiliary Equipment & Auxiliary Power” outage code?

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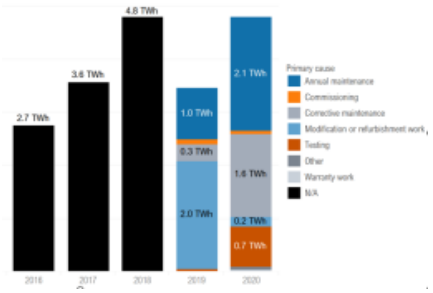
How could data collection be enhanced?

- HVDC owners should
  - systematically collect detailed outage data at least for their own asset management purposes, and
  - share their experiences by reporting at least to CIGRE SC B4 AG04 as per TB 590 (or new updates to come) and by using every opportunity when they meet other HVDC users or manufacturers.
- Suggested new sub-categories and reasons for outages will:
  - decrease the statistical relevance of some sub-categories with small frequency of occurrence
  - show trends in other sub-categories that were not possible to see earlier.
- ENTSO-E Nordic & Baltic countries have alreadyin 2019 improved the detail level of outage reporting. As an example, dividing the sheduled outages into sub-categories will give much more understanding of what have been actually causing the outages (see the graph below showing annual sum of unavailability due to maintenance):



- CIGRE HVDC performance survey participation:
  - During last two decades, the survey participation increase is less than the increase in worldwide HVDC fleet (participation % is going down).
  - Especially VSC reporting is low.
- Better utilization of CIGRE HVDC performance data
  - Historical data to be analyzed → finding long term trends.
- CIGRE survey development into suggested detailed level in future, if possible
  - two or three levels of detail to be sent:
    - Main performance data set (limited data, submitted by all owners, e.g. total FEU & SEU & no. of forced outages)
    - Recommended additional data set (enabling further analysis, submitted by most owners, e.g. outage case reporting as today)
    - Optional additional data set (enabling "full" analysis, including all sub-categories and further descriptions)
- How to increase survey participation?
  - Contradiction with the increased level of detail → Finding an optimal solution…
- How to increase experience sharing?
  - → Vendors are suggested to systematically start collecting and sharing the performance data of their delivered projects within their user groups
  - → Vendors to enhance experience sharing by using not too strict IP right clauses in their projects and/or by giving users better guidance to what kind of data is allowed to share with other users and what not.

Conclusions

- In order to increase HVDC reliability & availability, sharing of experience and performance data should be improved, including details that will show the lessons learned from the events.
- In order to achieve this, good co-operation and work efforts are needed from all HVDC stakeholders.
- CIGRE should actively keep on promoting this kind of more transparent experience sharing.