Protection Settings:
Calculating, Administering and Testing – ADMO at Energinet.dk

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Abstract

This paper describes the experiences of Energinet.dk in the administration of relay settings, test documents and their management, and the introduction of the ADMO software package into the company.

Key words

administration, protective devices, maintenance, protection setting, ADMO

1   About Energinet.dk

Energinet.dk is Denmark's transmission system operator. It has been operating the entire high and extra-high voltage system in Denmark since 2011. Denmark is divided into two frequency zones, DK1 (Jutland and Funen) and DK2 (Zealand), which are connected by an HVDC connection with a transmission power of 600 MW.

For historical reasons, DK1 uses the voltage levels

- 150 kV
- 220 kV
- 400 kV

while DK2 uses

- 132 kV
- 220 kV
- 400 kV

Energinet.dk offers international connections to Germany, Norway and Sweden, some of which are implemented using submarine cables. More international connections to The Netherlands (650 km submarine cable) and the UK are planned, as is an expansion of the transmission power capacity to Germany.

The Danish system includes several offshore wind farms, for example Horns Rev 1 with a capacity of 120 MW, Horns Rev 2 (220 MW) and Anholt (400 MW).

Among the ongoing projects of Energinet.dk are additions to the wind farm portfolio with Horns Rev 3 and Kriegers Flak.

As part of its cabling program, the Danish government has also given its approval to a number of improvement projects that involve replacing overhead lines with high-voltage cables.
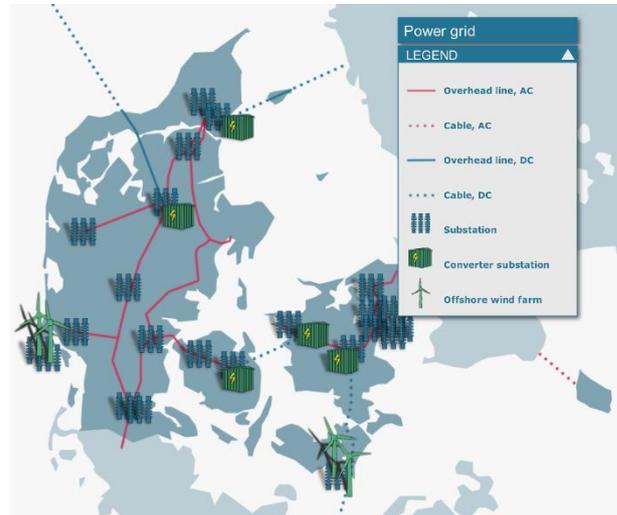
Bild 1:   The Danish 400-kV system with international connections and offshore wind farms

2   Protective Device Administration and Challenges

Energinet.dk is responsible for more than 2100 protective devices, of which approximately 900 are in DK1 and 1200 in DK2.

To date, the protective devices have been stored in a folder hierarchy on a drive on the company's network that can be accessed by all employees.

Each station has a station name (a code) and each one is subdivided into voltage levels. The folder structure is broken down hierarchically as

- Calculated (for settings that have not yet been implemented in the relay)
- In operation (relay files (dex, pcmp, etc.))
- Protection setting (basis for calculation)
- Test files (OCC)
- Selectivity calculations (short-circuit calculations)

This structure has shown itself to be far from ideal, particularly with regard to the internal distribution of tasks and quality assurance:

- Which relay was the last to be tested and when? Who did it?
- Which relay was the last to be calculated and when? Who did it?
- Has the employee in question saved the file exported from the relay to the company's network or is it still on the employee's local PC?

- Which version of the firmware is currently being used?
- What are the relay's model number and serial number?
- etc.

For this reason, Energinet.dk decided to purchase some software that would help resolve these problems. The final decision was made in favor of the ADMO Client-Server application from OMICRON.

3 Relay Settings at Energinet.dk

All relay settings are calculated in-house. The following events trigger calculation of the settings:

- Replacement of a relay in a station
- Changes in network topology (cable replacing overhead lines)
- Routine test
- Changes to operating scenarios

Various departments, such as Automation, System Planning, the Jutland/Zealand departments and System Operation, contact the relay calculation team whenever they need relay settings. The lead time from notification of the need for the settings to their implementation can vary from a few days to up to one year.

An Excel spreadsheet containing the following is used for this purpose:

- Date required
- Date of test
- Date of commissioning
- Name of employee responsible for relay calculation

Energinet.dk calculates the protection settings for

- Overhead lines / cables
- Busbars
- Transformers
- Reactors

The *PowerFactory* grid modeling software from DIgSILENT is used to perform the short-circuit calculations. These calculations are carried out for the minimum and maximum short-circuit current, while taking account of any possible grid expansions in the years ahead. These are stored in the software by the System Planning department. The minimum and maximum scenarios for each calculation year are computed using a script.

Templates have been produced for every type of relay used in the company, and these are used to document the relay settings. They contain all the settings required by Energinet.dk.

- Parameters for the individual protection functions (distance protection, overcurrent-time protection, differential protection)
- Active and deactivated parameter groups
- Intertripping (PUTT and POTT)
- Selected mode of communication (SDH, direct fiber connection)
- Default values for default settings
- Measurement supervision

The templates require regular updating to accommodate a new parameter set containing new settings.

The following diagram shows the interaction between the various departments when ordering, calculating and testing the settings.
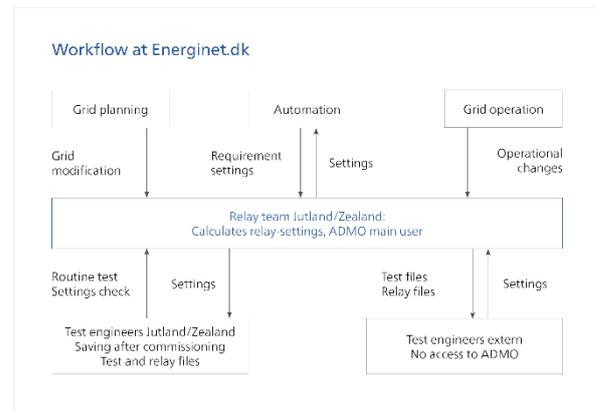

Bild 2:   Cooperation between departments

4 ADMO at Energinet.dk

4.1 Structure

ADMO enables the existing data structure outlined in Section 2 to be depicted in a clearer form.

- Breakdown by location DK1/DK2
- The "Jutland" and "Zealand" departments can be represented
- Stations can be allocated to locations and maintenance departments

Bild 3:   Sorting by locations and departments

- Stations are broken down into voltage levels and station panels
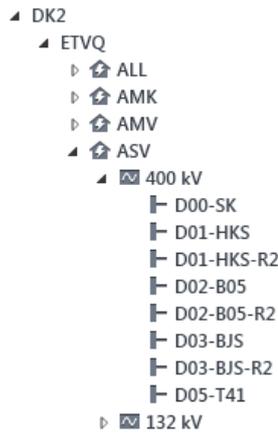
Bild 4:   Stations with voltage levels and panels

- Each relay becomes an individual object in the database with its own model number, firmware version and serial number.

Bild 5:   Sorting by locations and departments

4.2   Management of Setting Calculations

In addition to maintenance planning, the latest version of ADMO supports the handling of relay calculations.

The following can be stored in the Settings tab of the protective device in ADMO

- Setting documents (Word, Excel, images, etc.)
- Files exported from the protective devices
- Selectivity calculations

Each document contains

- A revision number
- Status (calculated, not yet active, active)

The Settings revision tool enables the planning of calculations to be carried out in ADMO.
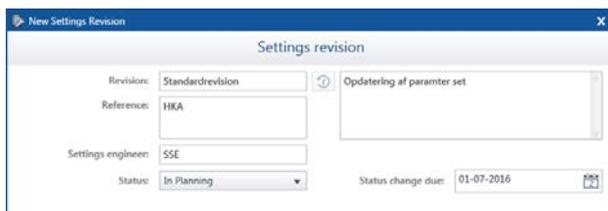
Bild 6:   Settings revision

Whenever an employee edits a settings document in ADMO, a padlock symbol appears in the field to indicate to other users that the document is being edited.

Should a colleague forget to close and release the document, the document can still be edited by another colleague – a flexible solution that has proved very useful in practice.

Attachments can also be added at the station level, a feature that can be used, for example, for the results of short-circuit calculations.

The ability to store manuals, installation programs and document templates (test templates, setting templates for individual types of relay) in the ADMO library simplifies the day-to-day work of employees.

4.3   Relay Test

Energinet.dk has different maintenance intervals for the protective devices

- Three years for electromagnetic relays
- Five years for numerical relays

ADMO allows the last test date and a maintenance interval to be stored.

It also automatically reminds the user when a particular relay needs to be tested.

Different colors are used to highlight the maintenance status of the relay.

- Green: No maintenance required
- Yellow: Maintenance imminent
- Red: Maintenance now due
- Dark red: Maintenance interval exceeded
- Purple: No maintenance data stored – cannot comment

Clicking on a relay brings up its detailed maintenance history.

Bild 7:   Maintenance history of an individual relay

The filter function in the main menu allows relays to be filtered according to their maintenance status (e.g., all yellow relays).

As multiple employees are able to test protective devices, the ability to use ADMO to allocate a task to a specific employee is a very important feature.

Energinet.dk opted for the Client-Server application, as it enables a number of users to update the database in parallel.

The option to create an offline copy of parts or all of the database allows the test engineer to use ADMO in a station that has no network access. The engineer can create new events, for example, and save the relay test files used in ADMO.

Once back in the office, the changes can be made available to all colleagues by switching from the local database to the server database. The Synchronization tool looks out for any possible conflicts.

4.4   License Management

Relay team employees, test engineers from both maintenance departments and staff in the Automation department are all registered as ADMO users and are granted access as ADMOAssetManager, which permits them to carry out all actions (creating new stations, adding and modifying files) in ADMO themselves.

Saving the files in ADMO also ensures that sensitive data can only be accessed by a selected group of users.

Plans to grant other colleagues a temporary license are being considered, though this will simply take the form of a read-only license.

External consultants, who may be engaged by Energinet.dk for several months to work on a project, can use the ADMO concept of partial local replication and structured license management to obtain access to the data they need.

5   Summary and Outlook

ADMO enables Energinet.dk to manage and plan its settings and maintenance activities more efficiently. The clear structure of the software makes the whole process very straightforward.

What we would like to see is an extension to the search options to allow us to look for specific attachments.

About the Author

Sabine Seeger studied Electrical Engineering and IT at Stuttgart University from 2004 - 2010, focusing on Electricity Grids and Systems.
Since April 2015 she has been employed as a relay engineer in the System Operation unit of the Jutland department of Energinet.dk in Denmark. One of her responsibilities is to configure the protection settings of relays for the 400 kV, 220 kV, 150 kV and 132 kV voltage levels.

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