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Innovation Action

flexitranstore

An Integrated Platform for Increased FLEXIbility in smart TRANSmission grids with STORage Entities and large penetration of Renewable Energy Sources

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D7.1 Data structure and information of the selected power lines and scenario for DLR demonstrator

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Executive summary

1.1 Scope of deliverable

Nowadays an increased number of high voltage overhead lines (OHL) are heavily loaded due to the increased power flow mainly caused by cross-border trading and renewable energy sources located far from the place of consumption. The design and construction of new transmission lines is not a simple procedure due to the strict legal regulations and social resistance, not to mention the extremely high investment costs. According to this, there is a general need to use the existing transmission system infrastructure more effectively. For better exploitation, **Dynamic Line Rating (DLR) technology** could be a promising and cost-effective option. It is widely known that the transmission system's capacity is calculated based on the Static Line Rating (SLR) methodology, which means that the maximum ampacity is determined from the worst-case scenario under all-weather conditions. The main advantage of replacing SLR by DLR is that DLR uses real-time meteorological parameters - and real-time data - from the SCADA system. Moreover, it is also possible to involve weather forecast data into the calculating algorithms to assign the maximum rating of the OHLs. By using real-time weather parameters, it is possible to exploit the cooling conditions of the different environmental parameters such as wind, precipitation, or other effects (e.g. radiative and convective cooling). [1]-[4]

The aim of Deliverable **D7.1 is to introduce DLR technology at system level, moreover, to outline the required infrastructure for a DLR system realization**. As defining the recommended hardware and software background of the DLR system, all segments are considered from the line monitoring sensors to the central server.

1.2 Concept and methodology

For the calculation of dynamic line rating, real-time field data should be collected to monitor the current state of conductor and the environmental parameters in the vicinity of the line corridor. In this way, the thermal behavior of conductors can be tracked, which is the basis of the ampacity calculation. [4]-[6]Furthermore, a predetermined line rating can be calculated based on the weather forecast, which is facilitating the unification of generation scheduling and forecasted line rating. Moreover, in many cold-climate countries, atmospheric icing may cause serious damage in infrastructures including power grid equipment, such as overhead line towers and power lines, which induces demand for ice detection systems. The increased mechanical load due to the accretion can cause the power lines to collapse, which is not only dangerous to the environment but may compromise the power grid's stability, as well. **Error! Reference source not found.** To predict these events weather forecasts should be provided.

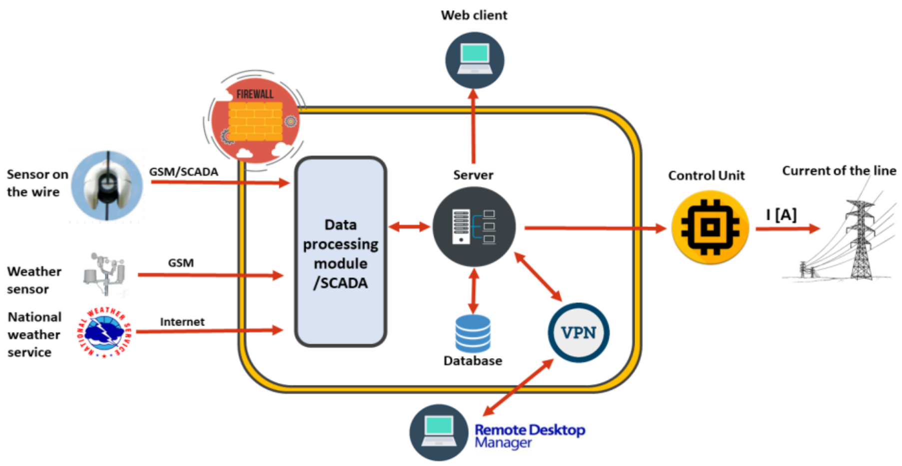

Figure 1 – System level concept of DLR technology

Nowadays, it is important to get data on the status of the system continuously. In this case, DLR sensors are indispensable during calculation and control of the ampacity. Different types of sensors can be distinguished based on their measurement methods. The most important measured parameters are the temperature and current of the conductor. During OHL monitoring another important function is **ice detection**. Ice formation can only be detected by the measurement of several other parameters, such as weather parameters and sag of the conductor. De-icing functionalities can be implemented in the expert system which aims control the temporary, regulated overloads of the specified power lines by the DLR technology.

All in all, an adequate DLR system should contain a proper amount of sensors, and also a proper algorithm that functions by using the environmental conditions, weather forecast, and conductor state data.

1.3 Key activities

The first step to build a Dynamic Line Rating system is the analysis of the selected line. In this step, the critical spans of the line are determined through calculations and simulations. The critical spans are selected under different conditions, for this purpose an extensive analysis is required. During the inquiry, the highest-level differences between the towers, the longest spans, and the various obstacles and terrain under the span are investigated. The most vulnerable spans are selected from the point of sag, based on the above mentioned three criteria. After the critical spans are selected, the sag simulation is being carried out to determine the maximal temperature of the selected segment of the line. It can be different from the designed maximal temperature, because of the aging of the wire, or the terrain conditions. The next step is the investigation of the substations and switching states on both sides of the line. During this process, the determination of maximum load available on the line is essential, because the environmental conditions across the line may require switching higher load to the line, than the actual one. Its importance is given by winter conditions when the mechanical overload caused by the evolving snow, rime, freezing rain, and ice on the conductor can be handle during the increase of the load.

1.4 Key results/Main findings

By investigating the DLR calculation methods it can be stated that international DLR models are based on the *thermal equilibrium* of the conductor, which on based the temperature and the ampacity of the conductor can be determined. Besides the technical parameters of the line and the conductors (such as catalog data of the conductor, elevation profile, gripping points of the conductors, etc.) weather data is used for ampacity calculation. Accordingly, to application of dynamic line rating on a selected overhead line, *weather parameters* need to be monitored accurately. The actual line rating and actual conductor temperature can be calculated by using locally measured parameters along the transmission line. Measurement parameters must include ambient temperature, humidity, precipitation intensity, solar radiation, wind speed, and direction. Weather forecast is used during dynamic line rating calculation, and for protection against icing events during extreme weather conditions. The most accurate available weather forecast should be selected for DLR calculations (*weather forecast parameters are becoming more and more inaccurate as the forecast period increases*). The time resolution of weather forecast is the most important parameter during the model selection, because weather parameters may change in a wide range causing inaccuracy in calculations. In case of the weather forecast the same environmental factors – complemented with icing alarm for the ice detection subsystem – should be covered as in case of measurements carried out by local weather stations.

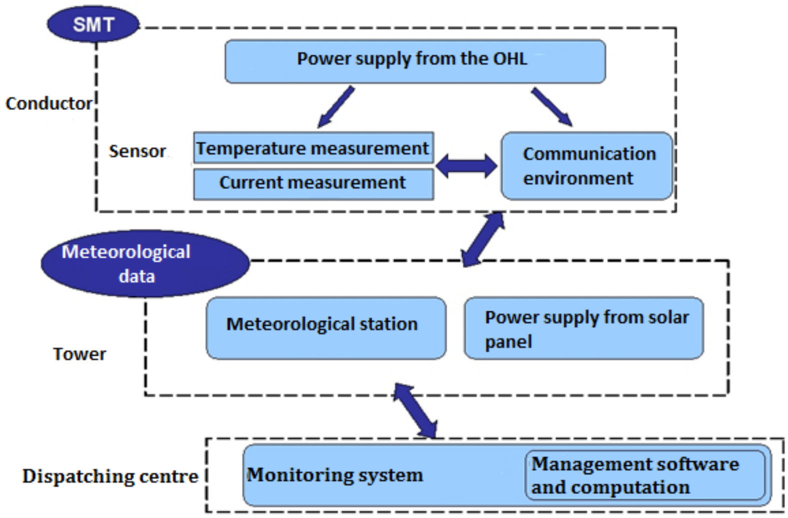

Figure 2 – Required measuring equipment in the vicinity of the power line for DLR implementation

In the Investigation of DLR technology at system level, a server should be allocated of the corresponding TSO/DSO, which will collect sensors data and run the calculation-related algorithms. The server should be supplied with the appropriate software components, such as operating systems, databases, and mathematical software components. The firewall should be able to filter the data stream in the direction of the data processing unit. The firewall should be able to transfer data between the sensors, weather stations, and national weather forecast service, and to provide remote desktop access to DLR.

BME's algorithm during the demo uses MATLAB environment and MATLAB App Designer, therefore the data processing module need to be compatible with MATLAB with the corresponding toolboxes. The data processing unit and interfaces should be able to handle the weather station, weather forecast, SCADA, and sensor data for calculations, which is updated automatically and periodically.

BME's de-icing algorithm developed in the framework of WP4 and realized in the framework of WP7 is based on the weather stations' measured data, the weather forecast provided by the national weather service, and the direct local measurement provided by the sensors placed on the conductors. The algorithm evaluates these input parameters and identifies potential icing events. This identification contains the potential place of icing (which lines and which segments are endangered).

1.5 Conclusions

Flexitranstore Deliverable D7.1 presents dynamic line rating (DLR) technology at the system level. During the realization of the DLR system an ice-detection subsystem will be realised also, which model will be developed (besides DLR algorithm improvements and development of new DLR models) in the framework of WP4. DLR system realization requires some measuring equipment installed in the vicinity of the power lines, such as line monitoring sensors and weather stations, which on based the real-time calculation can be completed. To model the day-ahead state of the line – also from transmission capacity and icing conditions point of view – it is indispensable to use the most accurate weather forecast available from national weather agencies. Moreover, the data gathering of the sensors and meteorological data is realized in the database installed on the central server, which also responsible for the calculations.

In this way a complex grid management system can be implemented to manage the transfer capacity of the overhead line, to monitor the actual state of the line, and to warn system operators for icing events. Accordingly, this transmission line management system is fostering the higher utilization of the power line under controlled conditions.

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