FRAMES ELECTRICITY GRID PILOT Province of Zeeland, NL

AN ANALYSIS OF THE ROBUSTNESS OF THE ELECTRICITY GRID IN ZEELAND AGAINST WATER

As part of the Interreg North Sea Region project FRAMES, the Province of Zeeland has examined how the electricity grid in Zeeland can be toughened against flooding and severe rainfall, according to the Multilayer Safety principle. The Zeeland Safety Region, the grid operator Enduris, the Scheldestromen water board and the municipalities in Zeeland have been actively involved in this.

In the first instance, risk labels have been determined for about 3,800 substations and switching stations on the electricity grid. The risk label indicates how ‘vulnerable’ the station is. The measures that could be taken to strengthen it were then examined. These could for instance involve smarter choices of the locations for crucial switching stations or substations, extra protection, configuring systems inside switching stations or substations so that they are physically raised, as well as diversions in the grid routing or additional connections.

FIG. 1 Substation

THE ELECTRICITY GRID IS A VITAL FUNCTION

Keeping electricity flowing for as long as possible is crucial for the disaster management during flooding and severe rainstorms. Power failures have a major domino effect: they take our lots of other important grids and networks, such as telecommunications and drinking water. All kinds of functions in the healthcare system are dependent on electricity too. The electricity grid is therefore designated as a vital and vulnerable function.

RISK LABELS MAKE THE VULNERABILITIES CLEAR

To get an idea of the vulnerability of the grid, a risk label has been assigned to each substation or switching station, comparable to the energy label. Labels ranging from A to G, in other words. In this case, an A label means a low likelihood and little in the way of consequences if there is flooding. Whereas a G label means that there is a high risk of power failure with major consequences if the is flooding. The consequences are for instance expressed in the number of households that are left without power. The more severe the consequences, the poorer the label.

The aim of the risk label is to make clear for the various bodies who have to limit the consequences of a flood which substations and switching stations are vulnerable to floods and which are not. In addition, the label also helps give a picture of what the best measures are for limiting the damage and the consequences. All the high-voltage stations and more than 3,800 medium-voltage stations have been included in the analysis.

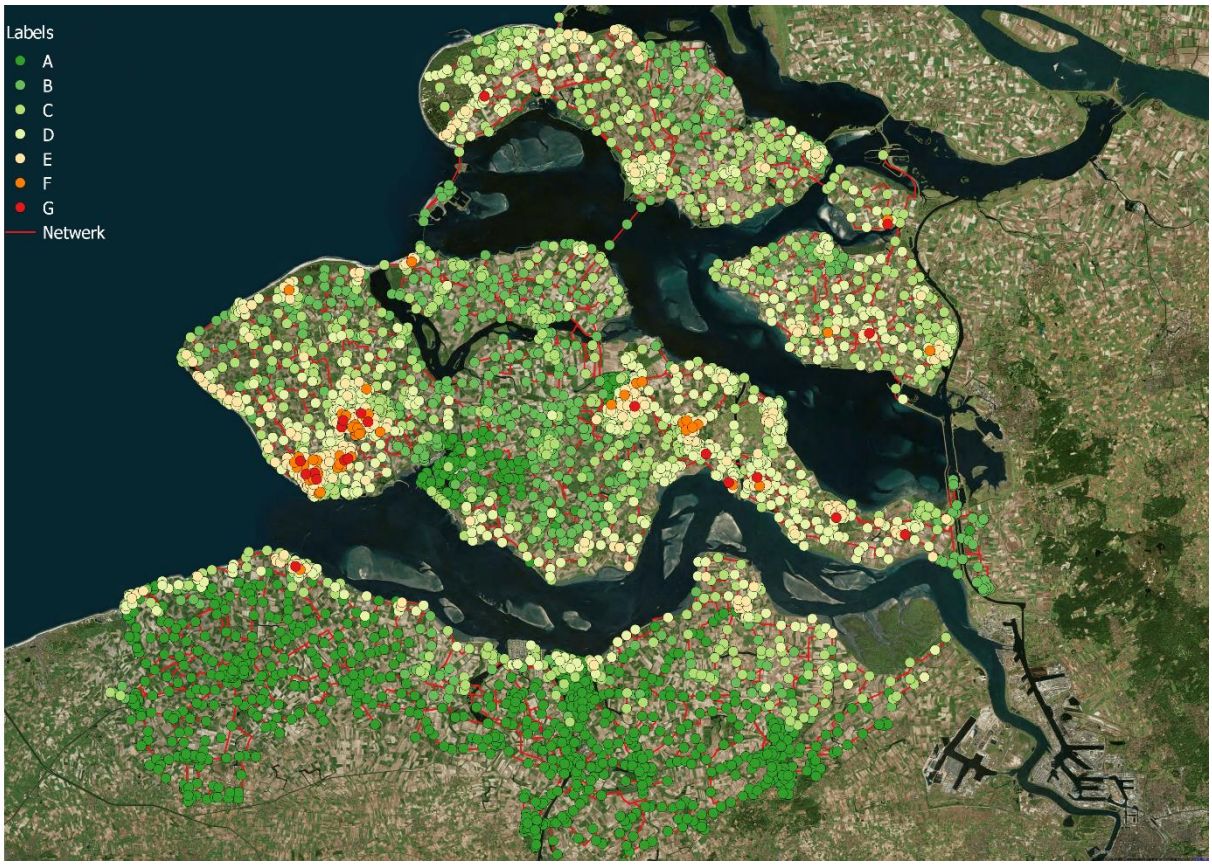

FIG. 2: Provisional risk labels for all medium-voltage and high-voltage substations and switching stations in Zeeland. The points counting for the labels still needs to be finalized.

Locations that will never end up under water during a flood can still get ‘poor’ labels, for example sites in the dune areas. This is because the analysis has also made allowances for indirect failures. Some parts of the grid can fail indirectly because a substation or switching station elsewhere is affected by flooding.

RISK LABELLING METHOD

The risk label is derived using the following four parameters:

1. Risk of failure

The risk of flooding for each switching station or substation has been determined, based on over 500 flood scenarios from the National Flood Risk Database. A detailed 3Di model was used for a pilot area around the residential heart of Kloosterzande. The study looked at whether the depth of water at a station during a flood would actually result in a power cut. A critical water level was defined for each station after measuring the height between the floor and the critical system in the station. This allowed a critical height to be determined for each station, depending on its type and the year of construction.

2. Number of connections

A grid analysis was used to obtain a picture of which switching stations and substations could fail and how many household connections would be cut as a result. That grid analysis was carried out in GIS using an advanced connectivity analysis. This made use of the extremely comprehensive grid data from Enduris (about 4700 km).

3. Vulnerable premises

Power cuts in vulnerable premises such as old people's homes, hospitals or nursing homes were also examined. These vulnerable premises are all listed on the National Risk Map or are known to the Safety Region. Only vulnerable premises where there is a potential risk of casualties were examined. A switching station or substation that would make vulnerable premises lose power when it fails will have a poorer label. After all, the consequences of the power cut are greater.

4. Direct or indirect failure

A distinction is made between direct and indirect failure. The repair work for indirect failures is easier because the object itself has not been flooded. Switching stations or substations that fail directly therefore get a poorer label.

FIG. 3 Critical height of a switching station

CONCLUSIONS

This study has shown that linking and sharing datasets between grid operators, municipalities and water boards helps create a better estimate of the impact of a flood. The estimates made are valuable for making the spatial layouts better able to cope with water and in managing emergencies. During the workshop, the risk label proved to be a good way of communicating that gave a picture of the vulnerability of the electricity grid to flooding.

The risk labels have been used for selecting the most vulnerable switching stations and substations. Systemic measures that could be taken for each station were also examined. Where the flooding depth is just above the critical depth for a station, for example, greater robustness can be achieved

with relatively small alterations. Other measures that were discussed during a workshop involving grid operators, municipalities and the water board were:

- Switching the electricity grid ‘off’ ahead of the wavefront. There will then be no short circuits, so that the power outages remain controllable and limited. The output of the analyses can be used for making a scenario for such a switch-off;
- Embankments for additional protection of crucial switching stations or substations. The Province of Zeeland is currently busy working out the standards for such dykes and embankments. The results of that analysis will be included;
- Measures for domestic connections that will make them more resilient, such as construction requirements for the height of meter cabinets or for separate electrical groups to be used for the upper storeys;
- Draw up requirements for emergency power facilities for other networks, such as surface water management and phone masts. Regulations for emergency power supplies for ten days for the drinking water mains have already been drawn up.

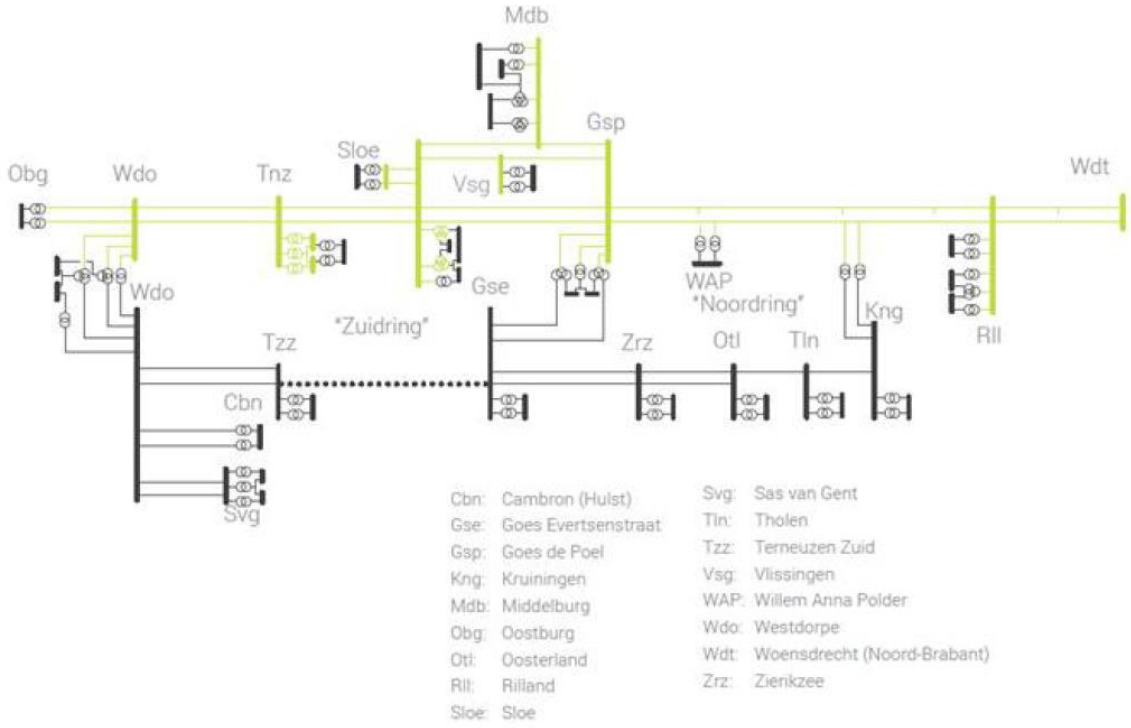

FIG 4. Electricity grid