Experience and tendencies after 40 years outage data registration in The Netherlands

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ABSTRACT

Over the last 40 years, the registration and reporting of (unplanned) outages has become very important for Dutch network operators and the Dutch Regulator. The assessment of Network Operators is based on this data and the results are an important source for maintenance and investment policies. This paper provides an overview of the experiences, trends and developments on outage registration in The Netherlands.

The Dutch regulator benchmarks the utilities and applies a penalty and reward system.

In 2001 the findings of 25 years of outage data collection were presented [1]. Due to new legislation and the need for more detailed information the scope of outage registration has changed in time. The aim of this paper is to provide an updated overview. It reports on trends in the results (CAIDI/SAIDI/SAIFI) over the recent years. Technical background and causes are summarized.

INTRODUCTION

In 1976 the first Dutch network operators started collecting information to obtain more detailed insight in their grids and components. The focus was on electricity networks from LV to HV. Over time the number of participating companies increased [1, 2]. The detailed data analyses by grid operators enabled improved lifecycle management and replacement strategies**.**

The role of the Dutch Regulator also increased. Since 2000 the network operators have to report every year using a prescribed format and quality indicators. The annual results are used to monitor and compare the individual performance of the network operators. The aim is to maintain or improve the current quality of supply.

The Dutch regulator benchmarks the utilities and applies a penalty and reward system based on the quality of performance and a mutual benchmark of utilities (indicated by the so called q –factor). Bad data quality can have impact the network operator, but also on other utilities.

Registration and data validation plays an important role in obtaining reliable and consistent data. It also plays an important role in fast and accurate communication to customers and media during and after an interruption.

In 2001 the findings of 25 years outage data collection were presented [1]. This included an overview of the continuous improvement process and lessons learned. This paper concludes with a roadmap of future developments, of which improved quality assurance, software development and more detailed registration are important topics.

1998: Gas data included in the registration process;
2000: All Network operators are obliged to register outages, before that date it was not compulsory;
2001: Outages >32h included in the registration.
Note: these outages are scarce, mainly on LV and with a small number of customers lost. These outages have a minor impact on the results;
2003: Synchronized way of working documented in a shared manual;
2004: Introduction of a penalty and reward system as currently applied;
2004: For HV distinction in types of connection instead of connected power (in MW);
2006: Planned interruptions included in the registration;
2012: Updated definitions and standardization;
2017: Expected release new registration software.

Note: An *interruption* is a disturbance that interrupts or restricts the energy supply to a connected party. That also includes limitations in maximum available/deliverable power and incorrect phase angles (rotating fields).

Figure 1: *In time the number of DSO decreased due to merges (#DSOs ±1998 (>16, left), 2015(8, right))*

SCOPE OF REGISTRATION

What is monitored and how are the results related to regulation?

The indicators to quantify the number and duration of long interruptions are:
CAIDI : Customer Average Interruption Duration Index (min);
SAIDI : System Average Interruption Duration Index (min/year);
SAIFI : System Average Interruption Frequency Index (1/year).
Another important parameter is CML:
CML : Customer Minutes Lost.
(1 customer * 60 minutes = 60 CML
60 customers * 1 minute = 60 CML)
In the Netherlands *large disturbances* are defined as incidents that cause over 2.5 million customer minutes lost.

In the Netherlands there is no quality regulation implemented on transmission level. The distribution level has a scheme based on the combination of rewards and penalties. Each DSO is compared to the average valuation of the quality of supply and is given reward or penalty depending on whether it performed above or below average. The scheme is based on SAIFI and CAIDI indicators and provides an incentive to each DSO for delivering the optimal level of continuity of supply. This way each DSO has to balance between efficiency and quality to reach an optimal level of quality.

Economic compensation levels in the Netherlands distinguish between the voltage levels where the interruption was caused and customers' connected capacity.

A detailed comparison of national levels of continuity of supply across Europe is complex as registration methods, definitions and network characteristics differ per country. The overall planned and unplanned interruptions as minutes lost (CML) per year in the Netherlands are amongst the lowest in Europe [3]. This is mainly because almost all MV and LV grids consist of underground cables.

DATA REGISTRATION AND VALIDATION

Over time the network operators and the regulator have developed a process of data registration and validation.

Each network operator inserts failure and interruption data into a local database. The number of affected connections is determined. Outages counted by different network operators might have a common cause. To avoid double counting data is shared. The development of support software used by most network operators has made this process easier.

The results of all network operators are gathered annually, processed and reported by an independent party. A consistency check is carried out on compliancy to the agreed formats. If necessary, corrections are made by the responsible network operator. After confirmation, the data is included in the national database and national figures are derived.

Comparison of the data happens annually. Here, major incidents and data deviations from the agreed registration process are discussed.

Based on the data, the independent party writes a national report. This report with anonymised data is submitted to the regulator and made publicly available [4]. Each network operator also submits its confidential data to the regulator.

Quality Assurance and training

Uniform registration and quality outage data is important (e.g. on cause/component/duration) for each network operator. Because many different technicians enter the data, a special e-learning program was developed and all participants have to take an exam.

The regulator requests that audits are carried out by an independent auditor. The network operators have to show that the described process is well implemented.

RESULTS AND TRENDS OF REGISTRED OUTAGE DATA

Over time the definitions and registration methods changed. This makes a detailed comparison difficult. For example, the total amount of affected customers used to be estimated, whereas now affected customers are exactly counted. However, over the past 10 years no major changes have been made to the registration. Therefore we present the results over this period in detail. Older data is used to illustrate trends.

Table I presents the results of the interruption indicators over different time periods:
- The most recent year (2015);
- The average over the last 5 years;
- The average over the last 10 years;
- The average since the start of the registration.

Per indicator, backgrounds are listed explaining trends.

Table I: CAIDI, SAIFI and SAIDI over various time intervals.

Indices	2015	Average 2010-2014	Average 2006-2015	Average 1976-2015
CAIDI [min]	**75.3**	**79.0**	**77.1**	**72.0**
EHV	98.5	91.7	49.7	*
HV	23.2	35.5	40.5	40.7
MV	69.6	79.8	81.8	76.7
LV	154.0	156.5	149.4	167.3
SAIDI [min/year]	**32.9**	**25.4**	**26.7**	**23.6**
EHV	12.2	0.1	0.8	*
HV	2.2	2.7	3.6	4.0
MV	12.6	16.2	16.5	15.5
LV	5.9	6.4	5.7	4.0
SAIFI [1/year]	**0.436**	**0.321**	**0.346**	**0.327**
EHV	0.124	0.001	0.016	*
HV	0.093	0.077	0.089	0.099
MV	0.181	0.203	0.202	0.202
LV	0.038	0.041	0.038	0.026

**registration EHV started in 2006*

CAIDI
- For EHV the average duration from a customer's perspective (CAIDI) is determined by a small number of incidents, resulting in fluctuations over the years.
- As from 2012 the CAIDI included the monitoring of rotating fields for 3 phase LV connections. This resulted in a slight increase of CAIDI at that time. The value has been constant over the last few years.

The CAIDI has decreased over time due to faults in MV grids. This reduction in duration is mainly due to:
- automation and remote switching in the MV grid;
- the process of determining the location of a fault and re-energizing the healthy parts of the grid [6];
- navigation tools reducing travel time for technicians.

SAIFI
The interruption frequency SAIFI gives an indication of the number of faults. Faults in the LV grid occur most frequently. Since the number of affected customers is relatively low, the impact is small. An interruption in the MV grid has more influence on the SAIFI.

Reliable data on the cause of interruptions is available since 1998.
Faults due to digging are the main cause of failures in the MV grids. The large-scale deployment of new fibre optic networks in the Netherlands has led to additional interruption durations due to digging (2007-2009). To reduce the faults due to digging activities:
- The geographical position of cables is registered in more detail in a database.
- All contractors are obligated to perform a check before digging activities start. Penalties can be issued in case of incidents.

Statistics are also made on component level (Figure 2). The majority is related to cables and joints. Therefore a number of preventive measures have been taken:
- Poor MV cable joints were preventively removed. These activities started in the '90s.
- First generations XLPE cables defects were investigated in a common research program, resulting in preventive measures.
- Specifications and quality assurance have been improved as part of the purchasing process.

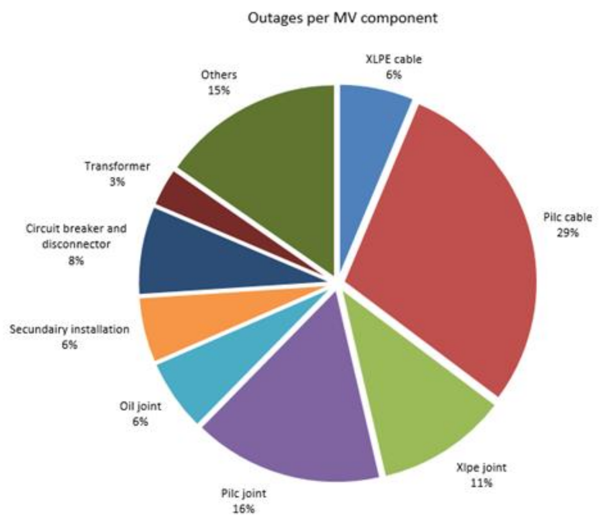

Figure 2: *Percentage of outages per MV component (2015)*

The data is used for the risk-based asset management process. It offers more insight in the risks and enables more effective investments. Also, more focused inspections and tests can be carried out, e.g. testing of protection devices and circuit breakers.

The measures resulted in a decrease of the SAIFI in recent years, despite the aging networks (Figure. 3).

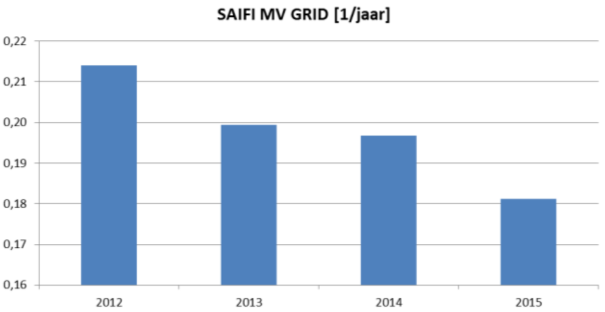

Figure 3: *SAIFI MV in the period 2012-2015.*

SAIDI:

- The average interruption duration SAIDI has fluctuated between 20 and 36 minutes in the last years.
- The *fluctuations* of the SAIDI are mainly due to large disturbances in the HV and EHV grid (see Figure. 4). In 2015 a single outage contributed almost 12.2 minutes to a SAIDI of 32.9 minutes. There is no trend.
- General faults in MV grids contribute most to SAIDI. The values for LV and MV do not differ much over the years. They add up to the average 20-25 minutes (figure 5).
- Figure 5 gives an overview of the impact of the type of faults on SAIDI. The category "Others" is composed of small contributions e.g. due to failures of components, protection or other external causes. Although the exact figures differ, the top-3 categories are similar for MV and LV.

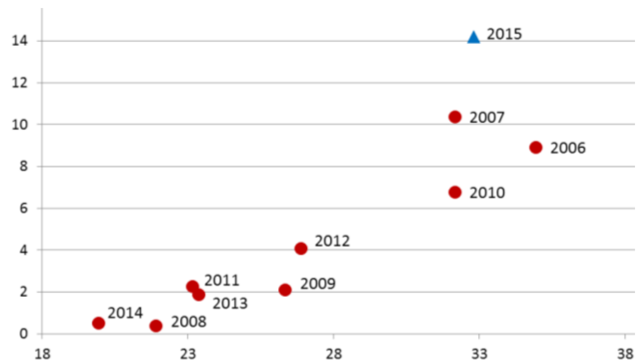

Figure 4: *SAIDI (min/year) due to large disturbances (y-axis) as part of the total Dutch SAIDI.*

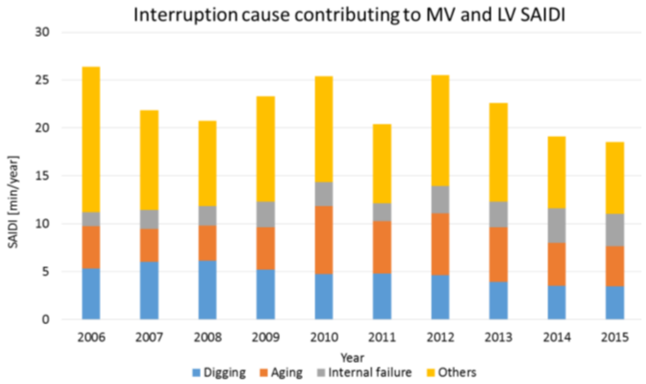

Figure 5: *SAIDI due to MV+LV (min/year). The colours indicate the cause of interruptions.*

DATA QUALITY AND SOFTWARE

The demands and financial consequences with respect to the amount of data, the data quality and data processing imposed new requirements on the registration processes and tools. The collection and reporting of data involves many people. This might lead to differences in interpretation accuracy when registering outage data. Also, incorrect entries could occur, for example, when a start time appears later than the end time. To align the insertion and validation of data, a common software tool called NESTOR has been developed. It includes modules for:

- the insertion of data,
- the user interface;
- data validation;
- reports;
- import/export of data;
- registration manual [5].

The business processes for data registration/storage differ per network operator. Data is often used for internal processes with DSO specific requirements. Each network operator has its business processes and IT platforms. NESTOR is used differently by various operators; the incorporation depends on the IT environment.

FUTURE

Although the companies are compared in the evaluation of the regulator, they also cooperate to minimize disturbances and their impact. This will continue in the future.

Software and registration tools

The technology and software architecture as applied for NESTOR is becoming outdated; the current tools are stand-alone installed applications. Today's ICT architecture prefers more web-based and multi-user applications. The user and regulator also prefer these new registration requirements.

The software that is used for registration is being updated in the coming years. The business processes and corresponding IT-environment/platform differ per network operator. This makes centralized operations and maintenance a difficult job. Therefore the architecture is likely to change by decoupling of activities. This simplifies the maintenance from the central office.

New software development might give the following challenges:

- New/updated requirements need to be made and agreed upon by all network operators. This is likely to cover all modules mentioned before. Some parts of the software have developed historically and not everything is documented.
- The user interface is important to reduce time to insert the outage-data and to prevent errors.
- Import/export of data: formats need to be agreed and implemented by all network operators.
- The tool is developed by a third party. The new architecture could also require changes on the side of the network operators.
- Testing of the various components is time consuming. In particular the validation and reports require a check on numerous combinations of data.

However there are also options for simplification:

- Nowadays some reports might no longer be required.
- Data that contribute to the assessment of the network operators have to be 100% accurate. For some parameters less accuracy (e.g. 90%) could be required. Examples are "cause" and "component" of the interruptions.

Other developments

The effects of the measures mentioned above are partly nullified by new developments.

Introducing more ICT devices into the networks could lead to other types of failures. The expected lifetime of equipment could be shorter as software/firmware/protocol updates become more frequent or are no longer supported. Technological improvements reduce the risk of human errors, but during the implementation there is an increased risk of outages due to human errors.

The energy transition to more renewable energy sources is changing the power flows in the grids. This requires modifications and re-enforcements, introducing more outages.

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