Demand response pilot results on an industrial site in the Netherlands

Michiel van Lümig
Laborelec – The Netherlands
michiel.vanlumig@laborelec.com

Marcel Didden
Laborelec – The Netherlands
marcel.didden@laborelec.com

Else Veldman
Enexis – The Netherlands
else.veldman@enexis.nl

Frits Wattjes
Cofely and Eindhoven University of Technology – The Netherlands
frits.wattjes@cofely-gdfsuez.nl

ABSTRACT

This paper describes research to apply Demand Response (DR) for reducing the load of grid assets. To implement DR, extensive knowledge is needed of asset load flows and the possibilities DR can offer at customer premises. This paper describes the approach and first results of a DR pilot on an industrial site in the Netherlands.

INTRODUCTION

This paper describes the approach and results of a Demand Response pilot on an industrial site in the Netherlands. This industrial site with 150 medium size companies, together with several municipalities, was supplied till 2012 by one HV/MV transformer of 58 MVA. After an upgrade of this HV/MV substation loads were rearranged. This study analyses the situation before this upgrade. A geographical overview is depicted in Figure 1.

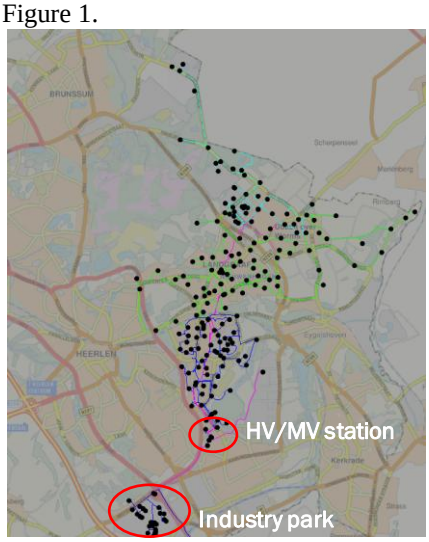

Figure 1 Overview area supplied by one HV/MV transformer (black dots are MV/LS stations)

This paper is organized as follows:
After an introduction of the project, is explained how a DR test week is performed, how data is captured and the first results are shown. Because the project is only half-way, preliminary conclusions are drawn on extrapolated results. Finally the next steps in the project are explained.

PROBLEM DESCRIPTION

An analysis in 2011 showed that one of the feeding HV/MV transformers (Tr 1 in Figure 2) at a 150/10kV substation was quite often loaded for more than 100% of the nominal load (this is the rated capacity under standard conditions as given by the manufacturer, assuming that the transformer is continuously loaded). Although this is no problem in the short term, the transformers lifetime will reduce rapidly. Following the conventional reinforcement guidelines [1], the Distribution Network Operator (DNO) increased the capacity of the substation by an additional transformer (Tr 4) and 10 kV capacity. This resulted in an investment of about three million Euros.
Besides adding capacity by upgrading the substation, other solutions might solve the problem too. In this research a DR system is tested to reduce the transformer load when needed. This DR system could postpone or prevent the required grid investments.

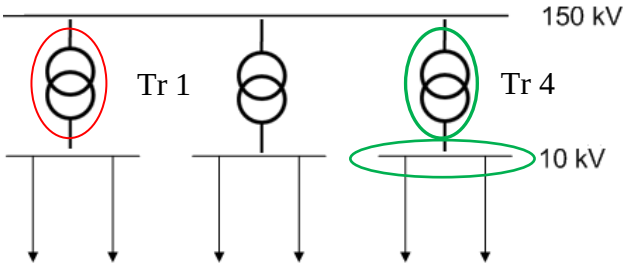

Figure 2 Simplified overview HV/MV station with added capacity

The overloading of transformer 1 during a week in June 2010 is shown in Figure 3.

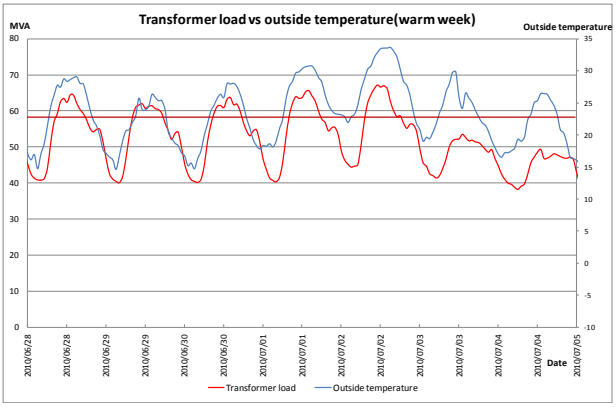

Figure 3 Loading of the transformer one week in June 2010

APPROACH

Power flow data at HV/MV level is used to forecast loading of this HV/MV transformer. This forecast is used to determine periods of high loading, which appears mainly during very hot or very cold days. During a test week in November 2014, industrial customers (who agreed to participate in the DR pilot) offered their flexibility to decrease transformer load. After this test week power flow data of the grid and the electricity consumption profiles were analyzed. The analysis give insight in the feasibility of the dispatch of DR at industrial customers premises. The focus is besides technical issues also on socio-economical issues like business models and incentives for offering flexibility.

PILOT PREPARATION

The pilot existed of several main steps, for which preparation was needed:

1. Perform flexibility audits at customers premises on the industrial site
2. Install measurement equipment in the grid
3. Forecast the moments of high (over)loading by applying/developing forecast tools

These steps are explained in more detail in the next sections.

FLEXIBILITY AUDITS

After working down from a well considered short list and organizing a workshop for the interested companies, four companies agreed to participate in this first test. Six out of 20 companies investigated were interested, but two of them could not join this first pilot because of internal planning problems. The first four in Table 1 were able to participate. The other two will be asked to participate in a second pilot this year. For privacy reasons, no names of the companies will be published. The flexible power found at these companies is presented in Table 1.

Company	Type of flex	Flex
1	Emergency diesel (+PV)	10 kW
2	Shifting production + ventilation	190 kW
3	Emergency diesel + lighting (+ 250 kW PV)	215 kW
4	Emergency diesel	80 kW
5	Shifting production	About 1 MW
6	Lighting	20 kW

Table 1 Overview available flexibility for the pilot

Two of these companies also have a (large) PV installation onsite. In the section about the "results" this will be visualized.

It was agreed that the offered flexibility could be used for at least one or two hours per demand response moment (depending on the moment, see Table 2).

MEASUREMENTS IN THE GRID

To analyse the impact of demand response on the actual power flow, measurements in the grid were needed. Three measurements boxes were installed at HV and MV level. These boxes were connected to a database in which the power flow data was stored. The data is stored per minute, based on one sample taken in a one minute interval. Also access to the energy meter data of the companies participating in the pilot was established. In Figure 4 the inside of the measurement box is shown.

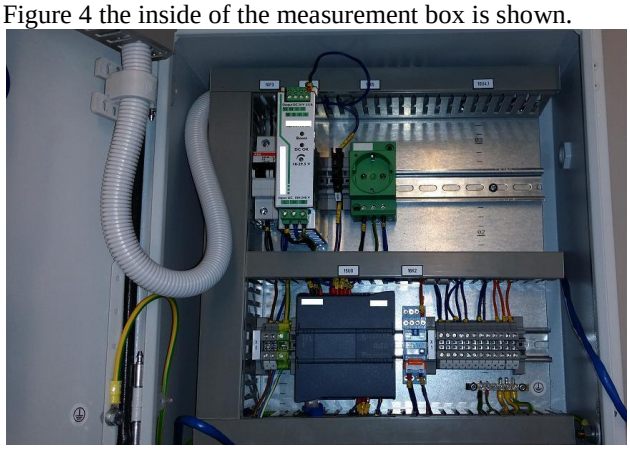

Figure 4 Measurement box for power flow registration

FORECASTING TOOL

Referring to the CIRED 2014 paper 0360 [2], a forecasting tool was programmed to forecast the moments of high loading of the HV/MV transformer.

The tool is able to forecast the load quite accurately, which is shown in Figure 5.

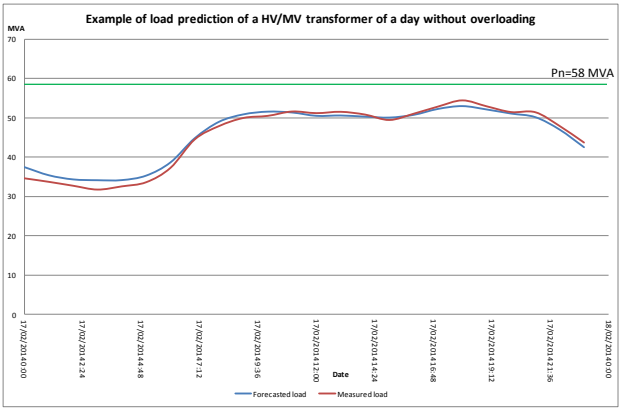

Figure 5 Comparison forecasted and actual transformer load

Using this tool and historical power flow data, the moments for demand response during the pilot week were chosen. Due to the economical crisis the transformer load is less compared to Figure 3. The moments for DR are therefore chosen at different peak moments to learn about the impact on the grid and the experience of the companies. No actual overload is prevented with the pilot. These DR moments are presented in Table 2:

Date	Time
Tuesday 25-11-2014	9h - 11h am
Wednesday 26-11-2014	5h – 6h pm
Thursday 27-11-2014	4h30 - 6h30 pm

Table 2 Demand response periods pilot week

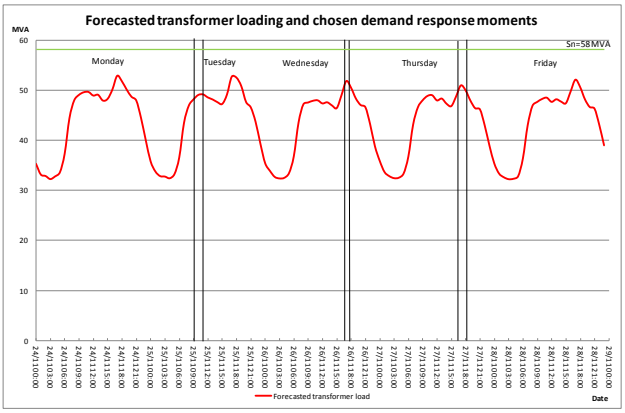

Figure 6 Forecasted transformer load and DR moments

The DR moments were communicated to the companies by email a few days in advance. Also a reminder was sent the day before operation.

PILOT WEEK EXPERIENCE

During the pilot week it was relatively cold, about 7^0C during daytime. Because temperature is an important parameter determining the grid load, this parameter needs to be accurately predicted. The wind was calm, about 3-7 m/s. Because 5,75 MW of wind turbines are connected to the transformer, wind has also a major impact on the transformer load. The forecasted weather data from a weather station close to the operating area was used in the forecast tool. The following measurements were obtained from the transformer load and wind production:

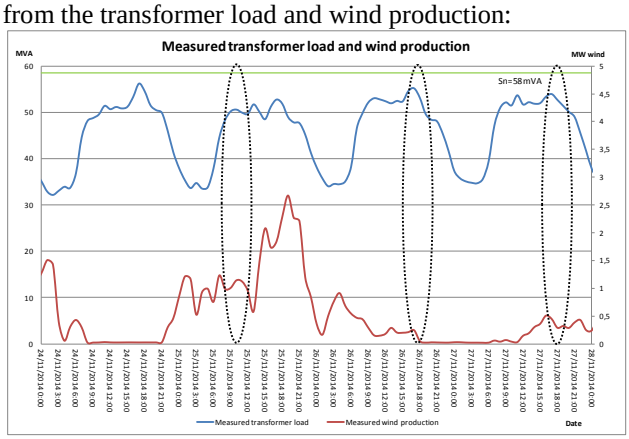

Figure 7 Measured transformer load and wind production

FIRST RESULTS

The results are obtained from the measurements in the grid and energy meter data from the participating companies and presented in Figure 8.

Company 1

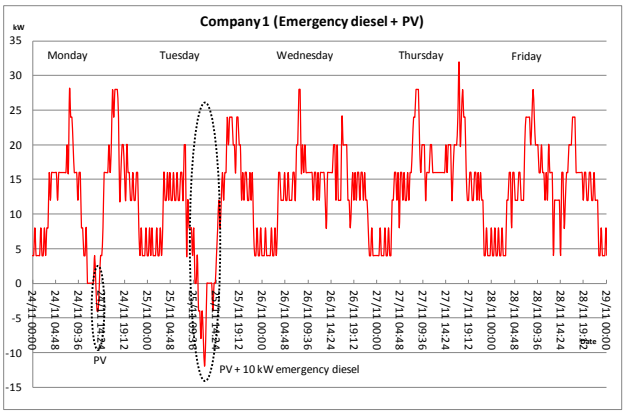

Figure 8 DR company 1

Company 1 only participated in one DR moment, at Tuesday morning from 9h-11h. The company injected up to 12 kW into the grid during the DR moment. The actual DR response was 10 kW, by starting the emergency diesel generator. The other decrease of power was due to PV production during the DR period.

Company 2

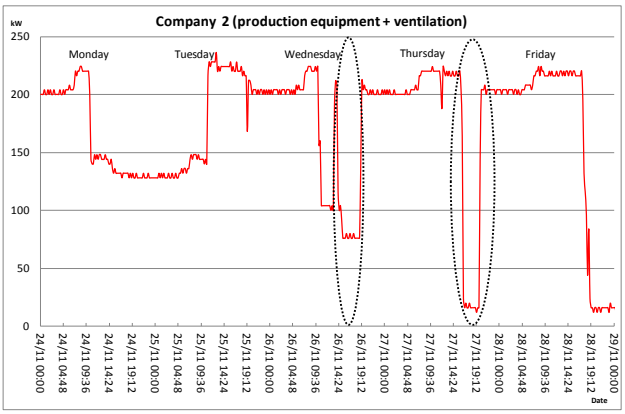

Figure 9 DR company 2

Company 2 participated in two DR moments, on Wednesday and Thursday. During the test on Wednesday, their production equipment was shut down. This resulted in a quick reduction in power of 125 kW. On Thursday the company shut their production equipment as well as the ventilation. This resulted in a reduction of 190 kW (almost the total used power). The company uses about 200-250 kW during normal operation (normally, 24/7 during weekdays).

Company 3

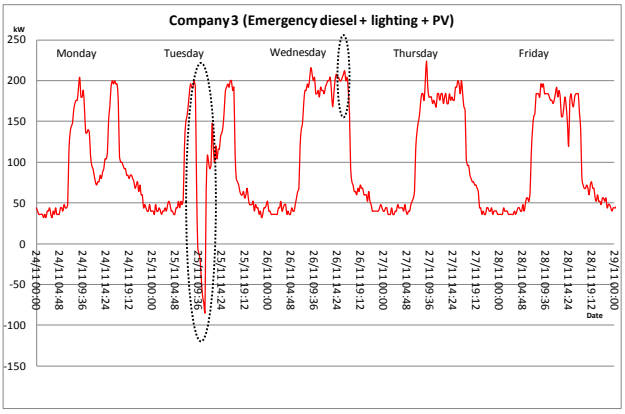

Figure 10 DR company 3

Company 3 participated in two DR moments, on Tuesday and Wednesday. On Tuesday there was PV production during the DR moment. Their PV installation is 250 kW. During the DR moment the emergency diesel generator delivered 209 kW. Together with the PV the company injected about 80 kW into the grid. During a comparable day without PV and demand response the company used about 200 kW.

Company 4

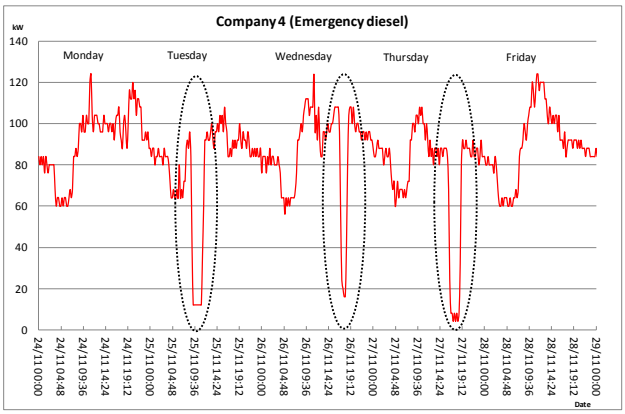

Figure 11 DR company 4

Company 4 participated in all three DR moments. The emergency diesel was switched on and the load was reduced with 80 kW during all three moments.

The effect of the DR tests were not visible on transformer level. Although the load was reduced three times, the normal load variation during one minute period is higher. This is due to the relative low power of the loads tested in the pilot.

FIRST EXTRAPOLATION OF RESULTS

To substantially reduce the load of the HV/MV transformer more flexible power is needed than is dispatched during the DR test moments. Because a reduction at peak moments of 5-10 MW is needed, results of this first test were extrapolated. The average flexibility found at the six companies is 250 kW. To reduce the load with 10 MW, 40 companies with 250 kW flexibility would be needed. Because there are more than 200 companies of relevant size, this is theoretically possible. To see what the impact would be if 40 companies are connected to the demand response system, Figure 12 is made. Here you can see the load during a peak moment (16h30-18h30) on November 24th 2010 is reduced substantially.

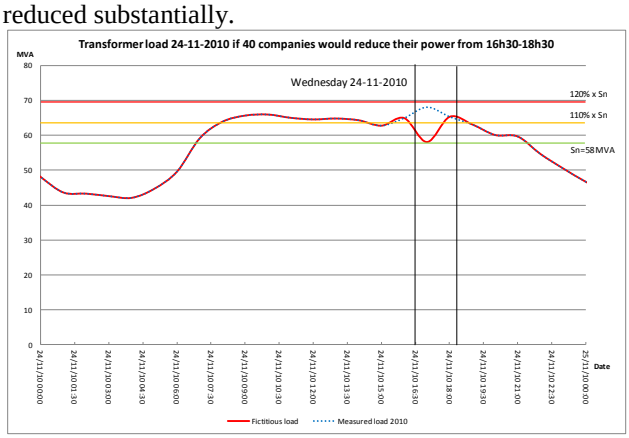

Figure 12 Extrapolation of the pilot results on data of 2010

This shows that a possible unacceptable load of 120%

could have been prevented. To better quantify and verify the extrapolated results, more data is needed and an extra test is performed this year. Further research within the project will focus on the following questions:

- Can DR in practice work to reduce HV/LV transformer load to postpone grid investments?
- Is there a business case for such a DR system?
- What has to be changed legislatively to allow grid operators to use such DR system in their long-term planning?

To answer these questions more data from the company needs to come available about their experience, costs and impact on plant operation. This test will be repeated in the beginning of 2015 with more companies and more available flexible power. The results will be prepared for CIRED 2016.

CONCLUSIONS

This paper showed with a case study that DR can be a mean to prevent grid investments. Companies asked to reduce their load experienced limited inconvenience. Extrapolation of the results indicates it's possible to reduce significantly the load of a HV/MV transformer during peak moments. The lessons learned so far are:

- Also medium size companies are willing to participate in DR programs to reduce the load of grid assets;
- The first results show enough potential flexibility is available in the investigated area to be used for DR;
- The measurements in the grid proved useful for the forecast tool and the analysis afterwards.

The further analysis of this pilot and the second pilot will take place this year and will be prepared for CIRED 2016.

NEXT STEPS

Because this was a first test, this test will be repeated in the beginning of 2015 with more companies and more available flexible power. These results will also be prepared for CIRED 2016.

ACKNOWLEDGMENTS

This two year research project (ending dec '15) is conducted in the TKI Switch2SmartGrids project 'Koempel', funded by the Dutch government.

REFERENCES

[1] IEC 60076-7, Loading guide for oil-immersed power transformers, 2005

[2] M. van Lumig et al., 2014, HV/MV transformer peak load forecasting for the application of Demand response at an industrial site, a case study in the Netherlands, CIRED workshop 2014 paper 0360