INVESTMENTS IN DISTRIBUTION AUTOMATION AS A FOUNDATION FOR SMART GRIDS

Johan MORREN
Enexis / TU Einhoven – The Netherlands
Johan.Morren@enexis.nl

Han SLOOTWEG
Enexis / TU Einhoven – The Netherlands
Han.Slootweg@enexis.nl

ABSTRACT

In most cases there is no positive business case for investments in smart grids yet. Network operators can however invest in a number of applications with a positive business case, that contribute to the main objectives of a network operator and that lay a foundation for smart grids. In this paper some of these applications are discussed and it will be explained how implementation of these applications and techniques will lay a foundation for future smart grids. It will be shown that main applications require investments in monitoring and remote control of the network and that exactly these applications are the cornerstone for future smart grids.

INTRODUCTION

Although a lot of pilots are going on, real investments in smart grids are rather limited. Reasons are that there is often no positive business case at the moment, and that there are still a lot of uncertainties, such as the growth rate of generation and of new loads, on the roles and responsibilities of the different parties, and on future regulation approaches. This makes the parties involved in smart grids cautious in their investments in smart grids.

Network operators continuously strive for a sustainable, reliable and affordable network. Each of these items requires more insight in the network (currents, voltage, network configuration) and sometimes also control of the network. From the projects that are running at network operators, it can be concluded that positive business cases for these technologies are possible. Network operators can thus start today with investing in several technologies and applications, which all have a positive business-case, and which contribute to their goal to ensure a sustainable, reliable and affordable electricity distribution network. By doing so, they introduce measurement and communication equipment in the distribution network, which is a prerequisite for the introduction of smart grids. Based on these observations, Enexis, one of the largest distribution network operators in The Netherlands, has developed a vision on smart grids, in which cost-effective investments in several projects that all contribute to a sustainable, reliable and affordable electricity distribution network, also lay the foundation for the roll-out of smart grids.

In this paper it will be elaborated in more detail how a vision which in first instance focuses on the current goals of network operators (a sustainable, reliable and affordable electricity distribution network) also lays the foundation for a future smart grid with more elaborate functions. It will be investigated on which locations in the network measurements are done already, and where to have to be done in the future. This will be illustrated by several projects of Enexis which focus amongst others on Distribution Automation, public lighting and condition assessment of low- and medium-voltage cables.

SMART GRID: A DEFINITION

There are numerous definitions of smart grids. In this contribution a smart grid is defined as a network with technologies that make available information about the energy flows in the network and the state of the network, and the components that are used to build the smart grid, and that make the energy flows controllable in order to facilitate efficiently the energy transition.

A central role in this definition is given to the information that is obtained and used. Other important points are that both the components on its own and the system as a whole is considered to be part of the smart grind, and that both the current state and the future needs (regarding the energy transition) are taken into account. As can be seen, the definition is more ‘technology-based’ than for example ‘market-based’. An artist impression of such a smart grid concept is shown in figure 1.

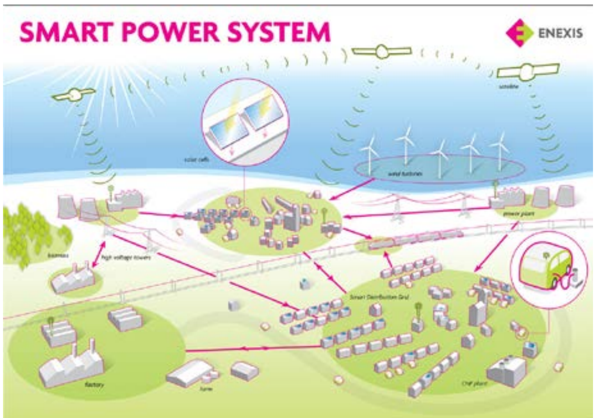

Figure 1. Smart Grid Concept

THE UNKNOWN FUTURE

One of the main reasons why most network operators do not really start introducing a smart grid, is that still too much is unknown about the future of smart grids. There are a number of important trends that can be noticed however, such as:

- Ever more renewable generation like wind and sun

- Efforts to decrease dependency on unstable regions for supply of energy
- Increase in energy consciousness of society
- More focus on cost efficiency
- Increasing dependency of society on a robust and stable energy supply
- More and more information and automation technology applied
- Energy chain split up in several parts, which requires more data exchange and ICT.

Although it is not known exactly how all these trends will develop, it can be assumed that the trends will have at least the following consequences:

- More dynamic energy flows
- Increasing electrification and (even) more dependency on electricity supply
- An increasing need for flexibility and intelligence for balancing consumption and production of electricity

Although on the one hand these consequences are quite sure, there are still a number of important uncertainties:

- <u>When</u>: this will strongly depend technological (electric vehicle, decentral energy production), economical, and societal developments;
- <u>For whom</u>: will there come more or less freedom of choice for the customer, will it be controlled by regulation or the market;
- <u>By who</u>: What will be the task and responsibility of the network operator, of commercial parties, of telecommunication companies, etc.;
- <u>In which form</u>: will technical or financial control and incentives be used, will connection capacity or transport tariffs be used, etc.

These uncertainties make that network operators still do not start investing in smart grids on a large scale. There are however a number of investments that can be done, which are less dependent on these uncertainties and do have a positive influence on the main goals of a network operator, as will be discussed in the next chapter.

EXCELLENT NETWORK OPERATION AND SMART GRIDS

Excellent network operation

Network operators continuously strive for a sustainable, reliable and affordable network. The two most important examples of this strive for excellent network operation are:

A. Condition monitoring of components and automatic fault restoration with Distribution Automation (DA) to reduce the Customer Minutes Lost (CML)
B. Insight in the loading of the network for prioritizing and determination of the right time for network expansion

Some of these items are quite common already for network operators, others are currently in the development or implementation phase. What they have in common is that for most of these items there is already a positive business case. In some cases the business case is driven by the fact that they ensure that investments in network expansion are done at the right moment, or that network components are replaced at the right moment. In other cases a positive business case (at least for society as a whole) can be obtained by the reduction of CML.
Each of the items mentioned so far, requires more insight in the network (currents, voltage, network configuration) and sometimes also control of the network. And therefore network operators are investing in more measurement and control in the network, or did so in the past already.

Prepared for the future

Besides the two goals mentioned in the previous section, network operators also strive for a third goal, namely:

C. Prepare the network for the future by offering more information and flexibility to customers.

Both society in general and customers individually ask for a more flexible operation of the network, that facilitates for example the integration of new generation and load, such as PV and electric vehicles, and flexibility like demand-side management. One of the main requirements for facilitating these new developments and wishes is (more) insight in the network.
As was discussed in the previous section, quite some measurements are done already in the network for other goals. So, the question is whether the measurements that are present already, are on the locations in the network that are required also for the future demands. To answer this question, the next chapter will describe some projects that introduce more measurements in the network.

PROJECTS

Network operators run several projects to improve their performance and to reach excellent network operation. Some of these projects which have a relation with measurement and control in de MV and LV network are presented in this chapter.

Distribution Automation (DA)

As distribution automation (DA) can reduce the outage time and the number of customers affected by a fault, Enexis started in 2011 a large-scale roll-out of DA in its MV networks which comprise 100% underground cables. With DA, sections of the network can be restored remotely within a few minutes, instead of more than an hour as is the case with manual restoration.

The working principle of the DA concept of Enexis can be explained with the schematic network diagram that is show in fig. 2. As soon as a fault occurs, the circuit breaker will disconnect the feeder. In the conventional situation, the fault had first to be located and isolated manually. When this was done, power supply to the feeder could be restored. With DA, some of the load-break switches (RMU's) and circuit breakers can be controlled remotely. Depending on whether the fault is in the first or the second part of the feeder, at least one half of the feeder can be reconnected remotely within a few minutes, resulting in a significant reduction of the customer minutes lost (CML).

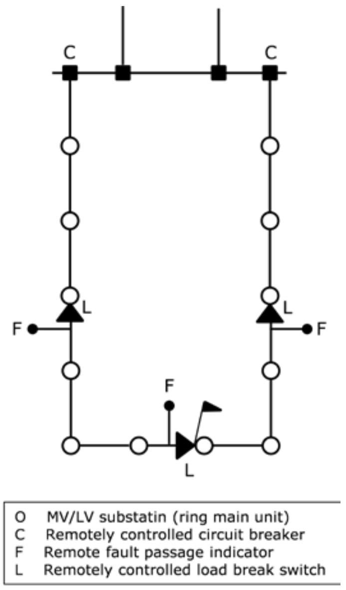

Figure 2. Distribution Automation concept

Since the start in 2011, some 1000 substations have been automated. The first results show that the effectiveness of the strategy is even better than expected. In the coming years Enexis will continue the roll-out of DA and it is expected that by 2020 more than 50% of the distribution feeders will be controlled with the DA concept. More details on DA at Enexis can be found in [1].

DA Ligth (DALI)

The main goal of Distribution Automation (DA) is the reduction of CML by remote switching. Besides that it can also be used for observation of the network. Voltages and currents in the MV-network and at the LV-side of the transformer are measured. DA is only applied at a limited number of substations however (~3 MV/LV substations in every MV ring). For the other MV/LV substations the so-called Distribution Automation Light (DALI) concept is introduced by Enexis. The DALI concepts fulfills a number of goals:

- Control of public lighting
- Fault passage indication
- Network monitoring

Control of public lighting

In general the Dutch DSOs are responsible for control of the public lighting (which is mainly owned by municipalities). Nowadays this is still done by ripple control. This system is becoming old however and spare parts and knowledge about the system are becoming scarce. Besides that one of the main purposes of ripple control, switching of day-night tariff at households, stops in 2020 because of the roll-out of smart meters.
Further, municipalities often want more flexible control of the public lighting, to reduce greenhouse emissions. For example by dimming the light, or only turning the lights on when someone comes in the neighborhood. With the current system with ripple control this is not possible. Therefore, a more flexible control of the public lighting is one of the main tasks of DALI, as shown in fig 3.g

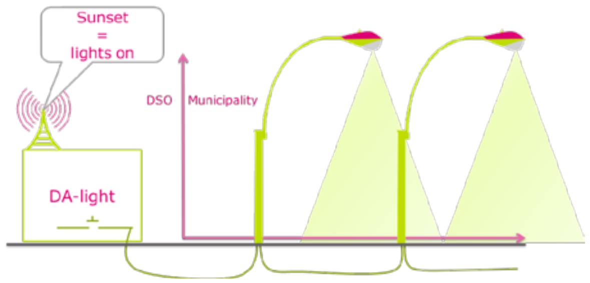

Figure 3. Control of public lighting by DALI

Fault passage indication

A first large step in reduction of CML is already set by DA. However, after one half of the feeder has been remotely reconnected again, the outage crew still has to search for the location of the fault in the other half of the feeder. Nowadays the outage crew has to visit the substations one by one to find the fault. By remote fault passage indication the time to find the fault can be reduced significantly. With DALI it is possible to send the status of the fault passage indicators directly to the control room of the network operator and to the outage crews.

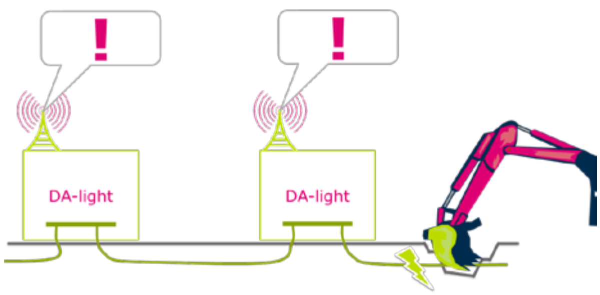

Figure 4. Remote fault passage indication

Network monitoring

Nowadays the loading of most MV/LV transformers is measured only once a year. For this measurement maintenance crews have to visit all MV/LV substations for a manual registration. The value that is measured is the highest peak that was obtained during the previous period. This way of measurement is time consuming and not very accurate. With a steady and continuous increase in loading, as was the case in the past, it might be enough, but with loads with high peak loading such as electric vehicles and heat pumps, and with an increasing share of installed PV installations, a more accurate and frequent measurement is required. Therefore DALI will measure at the LV-side of each transformer.

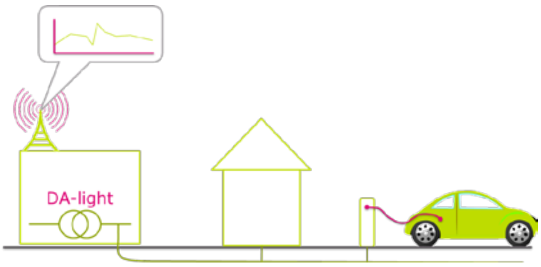

Figure 5. Network monitoring

Smart cable guard

On-line PD monitoring can be used to detect weak spots in cables, and replace them before they will fail already. In traditional on-line PD monitoring only one sensor is used. This has the disadvantage however that it is difficult or often even impossible to locate the PD's. The so-called Smart Cable Guard (SCG) system therefore uses two sensors. The two inductive sensors can be placed in two substations, which can be up to 10km from each other. From a weak spot in the cable, electromagnetic waves travel along the cable in two directions, away from the weak spot. Each of the two inductive sensors detects the travelling wave passing by. The travelling wave amplitude, together with the time of arrival, is stored. The difference in arrival time tells where the source of the travelling wave (PD or fault) is located. A detailed description of SCG can be found in [2].

MEASUREMENT IN MV AND LV NETWORK

From the previous chapter it can be concluded that on several locations in the network measurements are done already, or will be installed in the near future.
Figure 6 shows (with numbers) the different locations in the MV and LV network where measurements are possible, or in place already. With these measurement (a part of) the three goals of the network operator (condition monitoring and automation, insight in loading, and preparing for flexibility) can be achieved. The arrows show on which locations in the network these goals have to be achieved.
Measurements for condition monitoring of components and automatic fault restoration (A) are mainly done on level 1 and 2, and are (partly) in place already. Measurements for insight in the loading can be done on all levels in the network, but are nowadays mainly present at level 1, partly at level 2, and in the near future (when the roll-out of smart meters is finished) also at level 4.
Measurements to fulfill the future demand are in first instance mainly needed at level 3 and 4, and partly at level 1 and 2. At level 4 they will become available in the near future (smart meters).

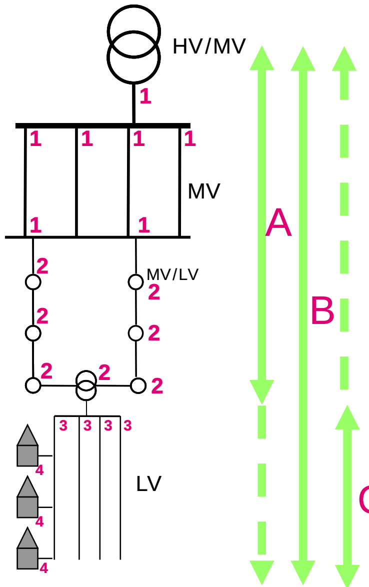

Figure 6. Measurements in MV and LV networks

It can be concluded that on most network levels measurements are in place already, preparing the network for a shift towards a smart grid. The main level where they are lacking is level 3 at the MV/LV interface, and then especially at the outgoing LV-feeders.

CONCLUSION

This paper has shown that some network operators invest in several applications already, that contribute to their goal to maintain a sustainable, reliable and affordable network. Each of these applications has a positive business-case – either for the grid operator himself, or for society as a whole. When looking to the requirements for a smart grid, it becomes clear that with these projects, an important foundation is laid already for the smart grid. So by investing in projects and applications that nowadays have a positive business-case already, network operators can lay down the cornerstone for future smart grids.

REFERENCES

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