INTRODUCTION OF SYSTEM SERVICE MECHANISMS FOR DNOS

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ABSTRACT

Within the German E-Energy initiative the project E-DeMa is funded by the Federal Ministry of Economics and Technology (reference number 01ME08013A). In a consortium with RWE, SW Krefeld, Miele, Prosyst and the universities Bochum, Dortmund und Duisburg-Essen, Siemens is aiming for the implementation of the energy market of the future based on the integration of loads, distributed generation, Smart Metering and Smart Home. E-DeMa is looking for possibilities for the active participation of consumers with variable consumption or generation ("Prosumer") enabled through modern ICT. Siemens is heading the work package studying the impact of incentive (market) mechanisms for network usage as well as the benefits of the ICT gateways for the grid operation.

INTRODUCTION

The German research project „E-DeMa", subsidized by the federal government in the frame of the „E-Energy" programme, aims at the development and demonstration of associating up-to-date information and communication technology with the operation of electric distribution networks towards the "Energy market place of the future". Electronic meters installed at private customers (pure electricity consumers as well as suppliers operating distributed generation such as photovoltaic or micro CHP plants, altogether called "Prosumers") communicate with the central energy market place via a special gateway and a broad band data connection. The information exchanged comprises electric metering and measurement data from, as well as price signals or switching or setting commands to, the customers. The administration of functional and data services on the market platform can be bunched by one or several "aggregators".

The work package "distribution network operator related services" of this project investigates to what extent the communication structures, which are primarily implemented for market functions, can also be used for innovative applications and functionality in the area of distribution system operation. In order to increase the security and efficiency of supply, the data – being available anyway – from customers or MV/LV stations, respectively, are made accessible to the distribution system operator based on new SCADA/DMS functionality. This increased situational awareness helps to make efficient use of local system services provided by aggregators.

In online system control various measures are applicable in order to impact system loading; price signals addressing all "Prosumers" or such in a certain district (for instance supplied by a line close to overload) can stimulate to postpone the operation times of devices (such as washing machines or micro CHP units), thus relieving the power system. Also, the possibility of direct shedding of certain appliances or set-point assignment to micro CHP units by the aggregator can be contracted individually with financial benefit for the "Prosumers". In the frame of the „E-DeMa" project these aspects of innovative distribution network operation and local system services provided by aggregators are investigated, based on simulations and by means of a field test.

DNO SPECIFIC APPLICATIONS

In particular, from the distribution system operator's point of view the following functionalities are relevant:

- clearing of grid shortages and congestions;
- compensation of high renewables based generation;
- economic system operation, loss minimization.

The measurements collected during the field test will deliver a comprehensive base of statistical data on the natural behavior of prosumers (i.e. without any inducement) and, in comparison, the reactions on the pricing and flexibility tariffs. Beyond the prototypic validation in the field test, the results must be up-scaled to realistic sizes and numbers of distribution grids with hundred thousands or millions of customers, which implies the performance of extensive simulative calculations. Furthermore, the field test results will indicate if and how the legal environment has to be adapted.

An essential point is the recruitment of customers participating at the field test. In order to achieve meaningful test results, the multitude of customers participating have to be thoroughly informed and prepared in advance. 110 households out of them will be equipped with advanced communication gateways which additionally allow for interaction between the in-house control of certain appliances (washing machines, dish washers and tumble driers made by Miele), and the aggregator's system. 20 of these prosumers will also have micro generation. Furthermore, adequate tuning of stimulation mechanisms is a demanding task already in the test period: on one hand their remuneration has to deploy sufficient appeal to the prosumers, on the other hand they should not be too

expensive for the distribution system operator if they should constitute effective economic options.

SYSTEM SERVICE MECHANISMS

As a short term intra-day influence mechanism (time horizon from 15 minutes up to some hours) the distribution system operator can make use of the functionality of power flexibility. In this context set-point values are assigned to dispersed generators; furthermore, controllable devices such as washing machines and other household appliances with data interfaces or heat pumps – if present – can be selectively switched on or off.

The contracts for power flexibility can be administered and bundled by an aggregator and have the distribution system operator expect a relatively high respond rate. In the frame of the field test power flexibility with a step-width of 15 minutes will be installed and specified as follows:

- type of dispersed generator or controllable device;
- control range (minimal/maximal power);
- maximal active power flexibility which can be requested in the frame of the contract;
- list of metering identifiers relevant for the contract;
- temporal validity of contract;
- maximal number of requisitions within run time of contract (optional);
- duration of requisition (15 minutes up to some hours);
- dates and begin of requisition;
- tariff structure;
- maximal power gradient (of minor importance at 15 minutes step-width).

Approximately 1-2 minutes before a request the current active power measurement values are polled from the relevant prosumers' local data interfaces by the distribution system operator. If available, preference lists managed by the aggregator are applied, i.e. power changes are requested according this list, and only if the first request does not suffice it is reverted back to the next list entry. The ¼-hourly power set-points for the prosumers actually considered are calculated and transmitted to their local data interfaces.

Reference for balancing could be the summarized last ¼-hour active power metering values of relevant prosumers before the request was sent. For contract compliance check it must be possible for the distribution system operator to poll the actual metering values before and during the request period from the central data management system of the market place.

Since the distribution system operator will conclude the power flexibility contracts under consideration of topological coherence, he will get an indication of the impact during the request period by change of the active power measurement value of the relevant MV/LV transformer, which is transmitted to the control center every minute. The identified load change must not necessarily match exactly with the change of summarized ¼-hours metering values: while the power measurement will indicate to the distribution system operator if further measures need to be applied, the sum of metering values is relevant for proof of contract compliance and financial balancing.

FIELD TEST

The applications implemented for the field test will be sketched in the following; it is presupposed that load flow calculation is available which makes use of information transmitted from the prosumers by the local data inter-faces. The information handled are the ¼-hours metering values, collectively transmitted once a day for the last 24 hours to the central data management of the market place, made anonymous and partly aggregated.

The distribution system operator makes his day-ahead scheduling by off-line load flow calculations based on predicted loading of the particular MV/LV transformers, estimates the necessity of measures for power influencing, and decides on those to be applied according to the given potentialities (for instance to convey day-ahead pricing).

In the ideal case, the day-ahead scheduling would be sufficiently exact that an intra-day correction is not required any more; but it is expected that, from time to time, additional request of power flexibility is needed which, in the course of the particular day, is then derived from a 2-hours short term prediction; this, of course, has much higher ac-curacy than the day-ahead prediction. In account of the short term prediction the distribution system operator could come to the conclusion that limit violations must be expected. In this case it would automatically be evaluated which prosumer(s) could contribute to violation clearance and if appropriate contracts with them are existing; if so, these are proposed to the dispatcher and he could then conduct the requests.

None of the distribution system operators participating in the field test has a short term prediction yet. Therefore, for testing purposes requests for power flexibility have to be induced arbitrarily and will give evidence of the quantitative effect of impact (without real operative reason).

If, in the course of the field test, a thermal limit violation would occur allowing for a respond time of 15 minutes to initiate countermeasures, it seems improbable that this would happen exactly on such feeder where dispersed generation is installed. However, even if this would be the case, it is still improbable that the available power margin of dispersed generators would suffice to overcome the limit violation, since the power of micro combined heat-power units participating in the field test amounts to 20 kW in total only. The full power margin of all these units will be available only rarely, and furthermore the units are connected to different LV circuits.

In this respect the field test will primarily afford a feasibility

proof and allow for an evaluation of the impact mechanisms which are necessary for implementation of this kind of control in greater scale. In the course of the field test pretended limit violations are evoked by fictitious reduction of the deposited boundary values; in this way it can be checked out if the fictitious limits can be met by relevant control measures. In any case dispersed generators will receive control commands only at need; otherwise they can feed in arbitrarily.

grid extension measures, especially in those cases where the underlying power peaks caused, e.g., by massive dispersed generation or electro-mobility would occur at short periods of time in the year only.

A fully new problem will occur in connection with balancing if, for instance, the distribution system operator requests system services from prosumers which is not known to the transmission system operator.

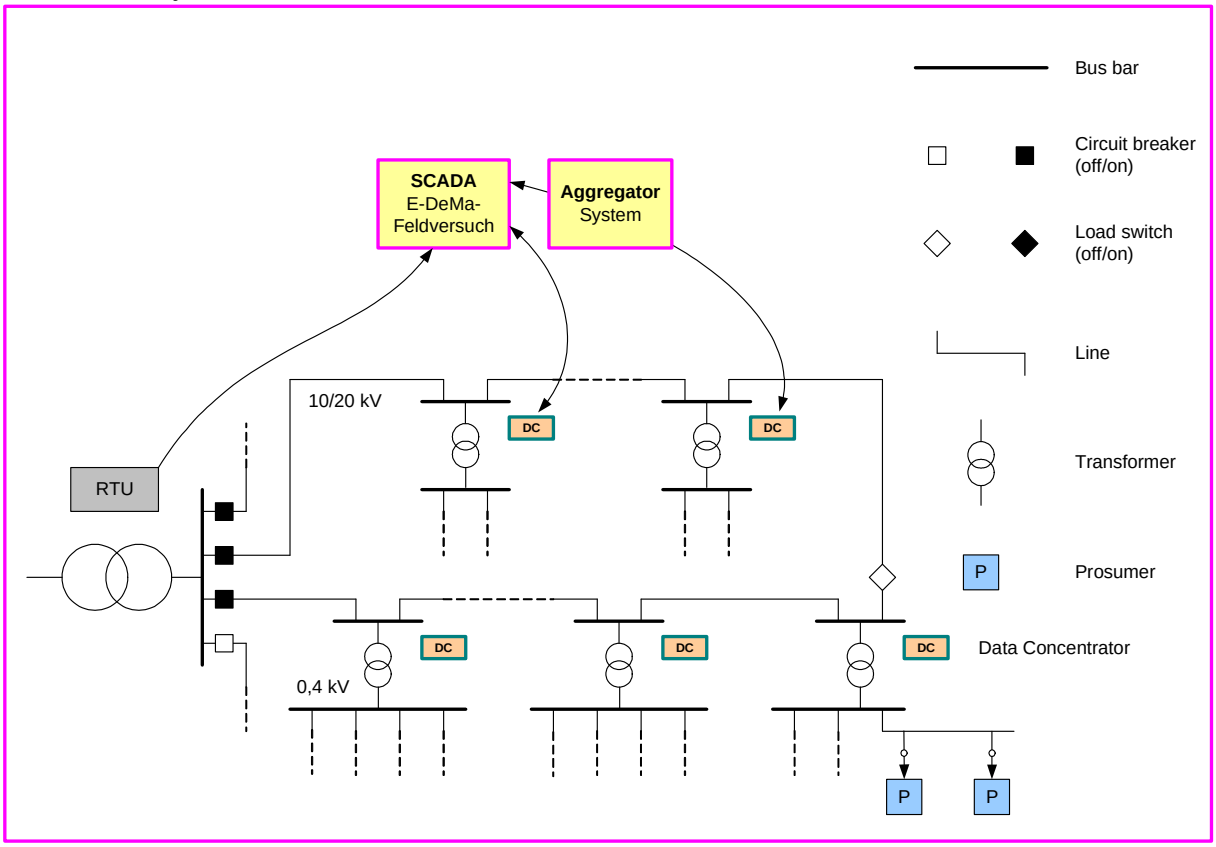

Figure 1: E-DeMa field test configuration

CONCLUSION

The data interfaces installed at the “prosumers” in the frame of the German E-DeMa project can provide the distribution system operator with information which, in terms of quantity and quality, widely exceeds the data usually available nowadays; furthermore, the distribution system operator can impact on the customers’ load performance in both indirect (dynamic pricing) or direct (power flexibility) manner. By means of simulations and partly by a field test the corresponding applications are implemented and investigated in which way these functionalities can practically be used in power system control as well as for planning purposes.

The benefit of the applications described here should in first order contribute to avoid – or at least postpone – expensive

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