A REAL CASE OF SELF HEALING DISTRIBUTION NETWORK

Regulatory demands on SAIFI and SAIDI drives the need for automotive substation capable of re-energizing customers within 1 minute, without the need for fast communication and advanced DMS.

SACSe(Sectionalizing And Changeover System enhanced) uses logic, relays, circuit breakers, motor drives and only local information to deliver this functionality.

2 SACSe substations applied to a feeder yield a dramatic decrease in SAIDI and SAIFI for the feeder.

**Average outage profile**

Current SACSe consists of a Xiria RMU from Eaton Holec and a T200P RTU from Schneider.

2 SACSe substations divides the feeder into 4 fault sections.

SACSe switching with 2 substations on a feeder with a the fault downstream.

Kåre Seest Rasmussen
kaara@dongenergy.dk
DONG Energy A/S – Denmark
Using Continuous State Estimation in Grid Planning

In 2008 DONG Energy implemented the IT solution ‘SmartPIT’ that determines all line flows, transformer loads and bus voltages in the entire MV network every 10 minutes—allowing for analysis, planning and operation on actual hour-by-hour values rather than peak estimates.

DATA QUISITION FROM PRIMARY SUBSTATIONS

Primary substations are monitored with a stand-alone SCADA system.

Data imported into SmartPIT every 10 minutes are:
- Bus configuration and voltage of primary substations
- Load currents at feeder head
- Switching state (topology) in MV network

BUSINESS PERSPECTIVES

Currently, primary substations are monitored by DONG Energy in a traditional way.

The traditional approach based on energy sales has several shortcomings:

- Energy sales and peak load at feeder head is a well-known challenge.

The purpose is to:

- Predict state estimation calculations against improbable measurements.
- Notify the operator if bad measurements can be found and rectified.
- Scale measured values to correct units.
- Other logical rules.

LOAD DATA, ‘SMALL’ CUSTOMERS

Four categories of consumers with less than 1000 MWh/year, the only information known is expected energy sales for the next year.

From SAP (S), the following information about 10,000 customers is retrieved once every 24 hours:

- Expected consumption
- Load Category
- Projected connection to network

Energy sales are then converted into synthetic load curves.

LOAD DATA FROM PRIMARY SUBSTATIONS

Primary substations are monitored with a traditional SCADA system.

- MV lines
- LV lines and MV/LV transformers
- Generators
- Network structure and line weights

VALIDATION OF MEASUREMENTS

Incoming measured values are validated with the ‘3k rules’ test.

- Protect state estimation calculations against improbable measurements.
- Notify the operator if bad measurements can be found and rectified.
- Scale measured values to correct units.
- Other logical rules.

NETWORK DATA

In order to build an exact network model for the continuous calculations, network data are imported and overlaid on 24-hour data from two sources, SAP (S) and GIS:

- MV lines
- LV lines and MV/LV transformers
- Generators
- Network structure and line weights

DATA AQUISITION FROM PRIMARY SUBSTATIONS

Secondary substations are monitored using the distribution automation system Discos from PowerSense.

- Data center located in Copenhagen
- Data center located in Kolding
- Data center located in Esbjerg

The simultaneity factors of the synthetic load curves are adjusted to:

- Calculation ‘engine’ is the planning tool NEPLAN from BCP
- State estimation uses load balancing
- State estimation uses load balancing

The purpose is to:

- Protect state estimation calculations against implausible measurements.
- Notify the operator if bad measurements can be found and rectified.
- Scale measured values to correct units.
- Other logical rules.

From the information imported into SmartPIT, a full network model including all MV network branches is created.

Tree feeders are connected to medium voltage (MV) busbars.

The simultaneity factors of the synthetic load curves are adjusted to:

- Calculation ‘engine’ is the planning tool NEPLAN from BCP
- State estimation uses load balancing
- State estimation uses load balancing

The purpose is to:

- Protect state estimation calculations against implausible measurements.
- Notify the operator if bad measurements can be found and rectified.
- Scale measured values to correct units.
- Other logical rules.

CONTINUOUS NETWORK STATE ESTIMATION

From the information imported into SmartPIT, a full network model including loads and generators is built:

- Load curves are connected to medium voltage (MV) busbars
- Load curves are connected to medium voltage (MV) busbars
- Load curves are connected to medium voltage (MV) busbars

Calculated flows and voltages are transferred to SmartPIT and stored as virtual measurements. Now, the network can be analyzed, planned and operated on bases of the actual 10-minute loading of individual components.

LOAD DATA, CUSTOMERS WITH AMR

In Denmark, automatic meter reading (AMR) is mandatory for customers with an annual consumption above 50,000 kWh.

Readings are acquired once a day via SMS or dial-up lines
- Data center located in Copenhagen
- Data center located in Kolding
- Data center located in Esbjerg

The most usual types are:

- CHP (Cogeneration heat & Power) plants typically in the 100-3,000 kW range
- Wind farms; typically in the range of several MW
- Solar farms; typically in the range of several MW

By analyzing a large number of actual load curves, synthetic curves are calculated for each category, annual energy sales Q are converted into to peak load Pmax, where:

\[ P_{\text{max}} \text{[kW]} = A \times Q \text{[MWh]} + B \times \sqrt{Q} \]

Parameters A and B have been determined for all 27 categories, using:

- A = 0.8 \times 3 \times 10^6 \times \frac{1}{Q^{0.2}} \times \frac{1}{p.u.}
- B = 1.5 \times 3 \times 10^6 \times \frac{1}{Q^{0.2}} \times \frac{1}{p.u.}

These figures allow an estimation of expected and actual annual consumption.

- A = 0.8 \times 3 \times 10^6 \times \frac{1}{Q^{0.2}} \times \frac{1}{p.u.}
- B = 1.5 \times 3 \times 10^6 \times \frac{1}{Q^{0.2}} \times \frac{1}{p.u.}

The purpose is to:

- Protect state estimation calculations against implausible measurements.
- Notify the operator if bad measurements can be found and rectified.
- Scale measured values to correct units.
- Other logical rules.

TEST RESULTS

Good estimates of loads and voltages are achieved.

The synthetic load curves and the calculation methodology has been validated by comparing estimated and real loads on two feeders.

- Calculated and measured MV feeder current.
- Calculated and measured MV feeder current.
- Calculated and measured MV feeder current.

The accuracy was better than 92% before supportive Discos measurements.

- Calculated and measured MV feeder current.
- Calculated and measured MV feeder current.
- Calculated and measured MV feeder current.

The absolution deviations over the period are:

- Calculated and measured MV feeder current.
- Calculated and measured MV feeder current.
- Calculated and measured MV feeder current.

Next steps to include Discos power flow measurements on feeder branches to improve these figures.

Peter Vinder
peter@dngenergy.dk
DONG Energy A/S – Denmark

Hans Knudsen
hans@dngenergy.dk
DONG Energy A/S – Denmark