Nordic Workshop in Power System Protection and Control
Kalasatama Smart Grid Project

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Mika Loukkalahti
Helen Electricity Network Ltd.
KALASATAMA SMART GRID PROJECT

Contents of the presentation:
• Helen Electricity Network Ltd (Helen)
• Helen’s 6 new tracks to improve reliability
• Background for Kalasatama project
• Timetable of the project
• Technical features in the Kalasatama closed MV ring
• Experiences and conclusion
KEY FIGURES 2018

Turnover: 124 milj. €
Operational profit: 31 %
ROI: 8 %
Investments: 27 milj. €
Balance sheet: 490 milj. €
Personnel, aver.: 106
THE SUPPLY TASK IN HELSINKI

- DSO in the city of Helsinki, 3rd largest DSO in Finland
- Owned by Helen Ltd., which is owned by the Helsinki City
- Compact city-type-only network
- High load density
- High electricity consumption per capita
- Cheapest total electricity price among EU capital cities!
- Best electricity supply reliability in Europe!

### ESPOO
- Lines: 6,400 km
- Cabling rate: 98%
- HV/MV stations: 25 pcs
- MV/LV stations: 2,500 pcs (22% with automation)
- Customers: 385,000 pcs
- Customer connections: 35,000 pcs
- Service area: 16 km x 16 km
- Peak load: 828 MW
- Consumption: 4.5 TWh/a
- Connected generation: 1,160 MW
- Microgeneration: < 3% (22% with automation)
HELEN’S SAIDI\textsubscript{Ew} 2008-2017

T-Said\textsubscript{Ew} 2008 - 2015, Said\textsubscript{Ew} 2016-2017

SAIDI goal under 6 mins till 2016, then under 4.0 mins
10 year average is 4.49 min
5 year average is 3.02 min
The electricity network structure in Helsinki (in principle)

- **400/110 kV grid**
  - meshed structure and operation

- **110 kV subtransmission**
  - meshed structure and operation
  - dispersed CHP generation

- **Substations**
  - 2–3 transformers

- **Medium voltage distribution**
  - ring structure, open-loop operation

- **Low voltage distribution**
  - radial structure

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**Diagram**

- **GRID**
- **CHP generation**
- **110 kV subtransmission**
- **MV feeders**
- **Reserve MV-lines between substations**
- **20 kV or 10 kV lines**
- **MV lines**
- **31.5–40 MVA transformers**
HELEN’S RELIABILITY OF SUPPLY → 6 TRACKS TO REACH IT

CIRED 2017 paper no 1037: Helen Electricity Network Ltd’s Process Towards High Level of Supply Reliability

• The process started in 2008, from SAIDI 12 min towards SAIDI 6 min by 2015
• Six tracks to achieve the goal to halve the SAIDI-level
  1. 5 new substations with IEC 61850 automation: new capacity, 100 % substation reserves and decreasing the serving area of the old substations,
  2. Cabling of the rest of MV overhead lines from 97 % cabling level to 99,7% cabling level
  3. Substation secondary system refurbishments, >10 projects (new protection features, self supervision, fault recording, IEC 61850), 20 years life-time
  4. Fault analysing reports of all MV/HV faults and many fault simulation exercises
  5. Secondary substation automation: 600 (>22%) full automations installed, 50/year coming in the future, cost-effectivity important
  6. 20 kV network earth fault compensating → 20 kV alarming EF protection → 50% of MV faults without outage → completed in 2018
Kalasatama smart grid area in Helsinki

- 20000 apartments, 8000 jobs, > 20 years construction time
- Closed MV-loop with UG Digital SG’s
- 1,2 MW energy storage
- Solar energy (one 340kW plant)
- Home automation
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Background and specification

• New Kalasatama smart grid area ➔ possibility to test new automation technologies: closed MV-ring, sensors and IEC 61850 process bus technology

• Closed MV-loop specification for shopping center power supply instead of open loop ➔ one MV fault doesn’t cause an outage ➔ CB’s, relays and instrument transformers needed for secondary substations

• Closed MV loop needs transmission network level protection scheme: differential protection, directional EF protection with communication, busbar protection, optical fibers and IEC 61850 station bus for remote communication

Automation features

• Differential protection implemented with RED 615 IED’s, directional EF and intermittent EF protection functionality with blocking communication scheme.

• Secondary substation SC and EF -protection implemented with IEC61850 GOOSE based busbar protection.

• ABB’s Unigear Digital MV switchgears with sensors and Uo -measuring data transfer with IEC61850-9-2 SV-data via physically combined station and process bus. HSR-redundancy protocol and IEEE1588-time synch protocol used.
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Timetable for the main 10 kV substation
• Invitation for process system tenders 10/2015, contract with ABB in 4/2016, installation 3/2017, operation started 10/2017

Timetable for the closed MV ring
• Between 2010-2012 Kalasatama Smart Grid system was a part of SGEM and FLEXe research programs, Helen and ABB were involved and Kalasatama closed MV ring protection principles were pre-planned by making RTP and PSCAD simulations.
• There was a long delay (3 years) because of delayed Kalasatama construction work
• 3 primary EF tests made 12/2017-1/2018, several protection failures found and corrected, SC simulation made in Vaasa, after corrected configurations the system was accepted for use in 30.1.2018 → 2 month disturbance free period started. Some inrush current detection corrections for diff. protection settings made during the period.
KALSATAMA CLOSED MV-LOOP PRINCIPLE (SIMPLIFIED)
ABB’S UNIGEAR VS. UNIGEAR DIGITAL

Traditional UniGear with instrument transformers

UniGear Digital with sensors

1. Current transformers
2. Voltage transformers

1. Relion® protection relay with IEC 61850
2. Current sensor
3. Voltage sensor
KALASATAMA (10 KV) IEC 61850 SUBSTATION AUTOMATION (ABB)
SHORT CIRCUIT AND EARTH-FAULT PROTECTION LOGIC OF THE MV-LINES
SHORT CIRCUIT PROTECTION GOOSE-LOGIC FOR THE BUSBAR AND FEEDERS
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Experiences

• The closed MV ring was implemented to get experience on the newest automation technology.

• The main problem was that the system was the most complicated one ABB has done for MV-network, there was no experience in Finland about this kind of systems.

• The customer’s final supply need delay from 12/2017 → 2/2018 helped our commission.

• The protection simulations for used configurations should have been made already before the EF tests to avoid many primary test needs and.

• The Unigear Digital switchgear has been quite reliable, it could be the MV switchgear concept in the future (no separate VT bays, sensors etc.), but it cannot be specified directly, because of only one manufacturer at the moment.

• Sensors have many advantages (size, safety, flexibility) but also disadvantages (not yet measuring class accuracy, depending on IED-lifetime).

• After >1 year use mostly good experiences about communication, some short SMV communication errors.

• CIGRE 2018 Session paper (SCB5-PS2-204) has been written together with ABB.
Conclusion

• The closed MV ring principle is not economically viable, if there are not customers who are willing to pay higher tariffs for higher MV network costs.

• Sensors and IEC61850 process bus will come in the near future, inter-bay process bus solutions needed to decrease the amount of IED’s

• In the far future there could be only 2 computers at the station without protection IED’s, ABB’s SSC600-solution is a step towards that direction.
THANK YOU!
MIKA.LOUKKALAHTI@HELEN.FI
HTTPS://WWW.LINKEDIN.COM/IN/MIKA-LOUKKALAHTI-628BA72/

@HELsahkoverkko  HelenSahkoverkko