SGTech Europe 2019

Substation communication: Comparing the potential of IEC 61850 with other protocols and with conventional technology, evaluating a move to centralised automation

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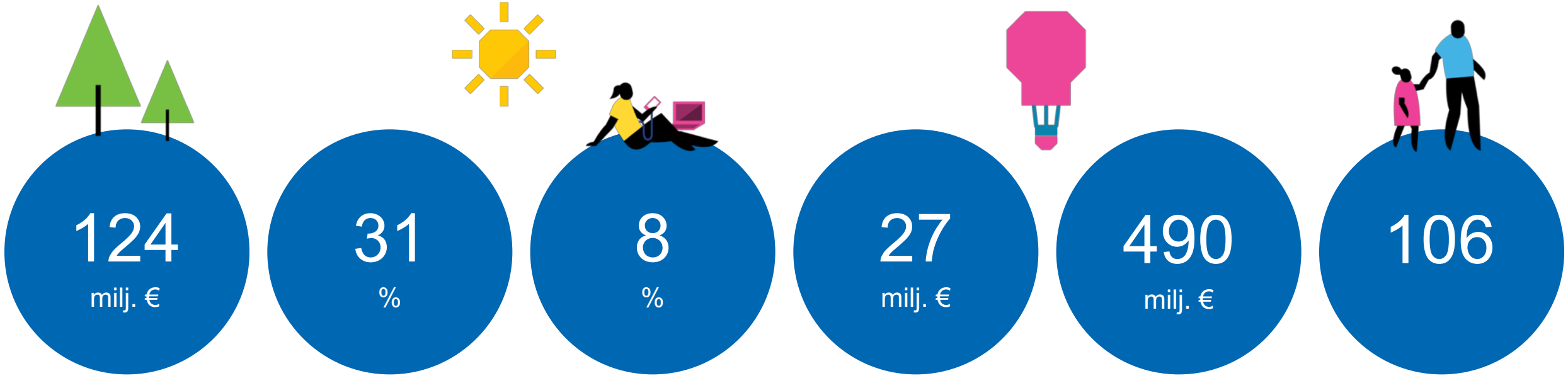
SUBSTATION COMMUNICATION: COMPARING THE POTENTIAL OF IEC 61850 WITH OTHER OPTIONS…

Contents of the presentation:

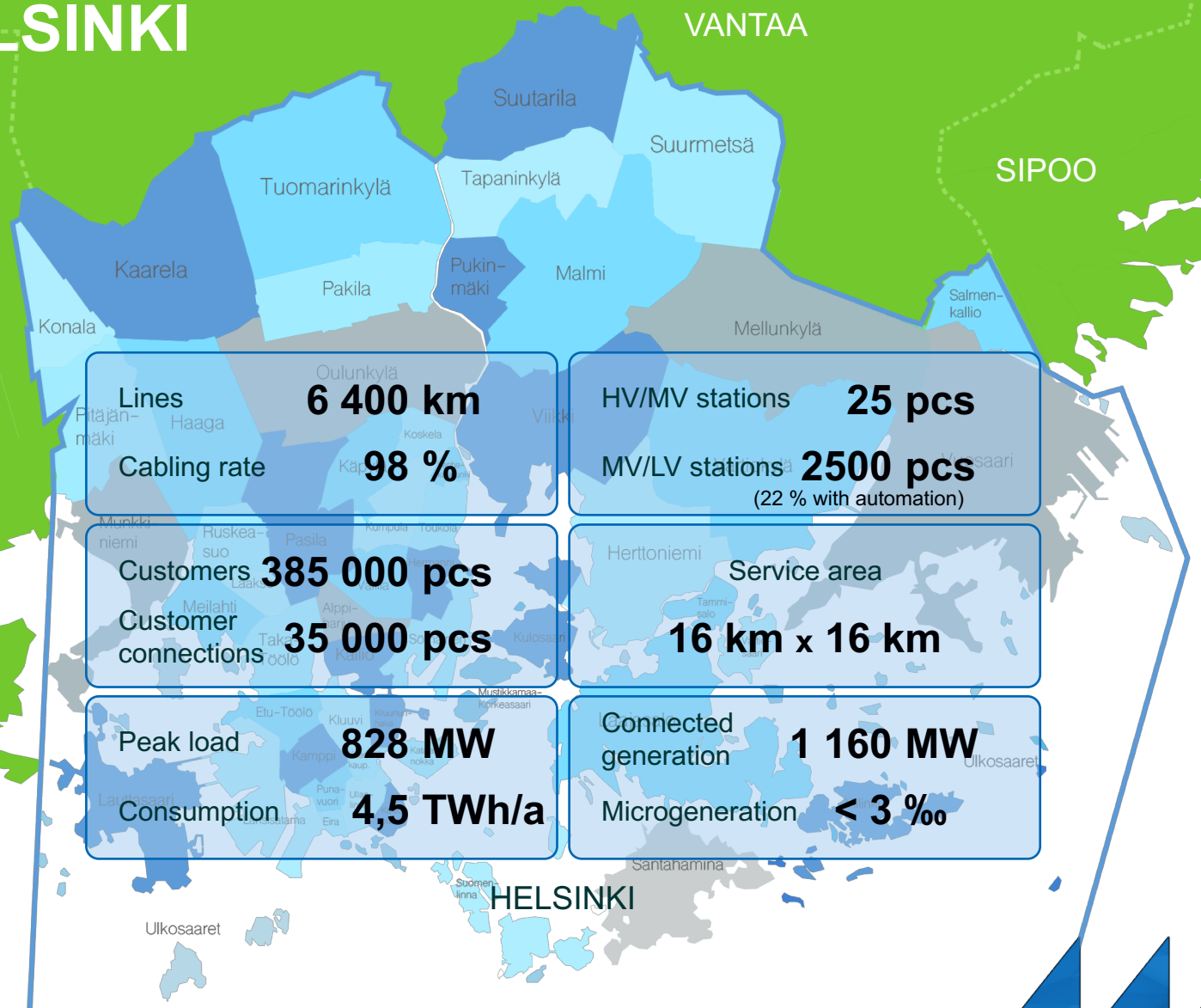
- Helen Electricity Network Ltd (Helen), basics
- Helen's operational results
- Helen's 6 new tracks to improve reliability
- Helen's milestones in substation automation
- Serial communication vs. traditional communication
- Serial communication vs. IEC 61850 communication + challenges
- IEC 61850 communication development
- Future SAS communication development
- Helen's Kalasatama closed MV ring + process bus project
- Conclusion

KEY FIGURES 2018

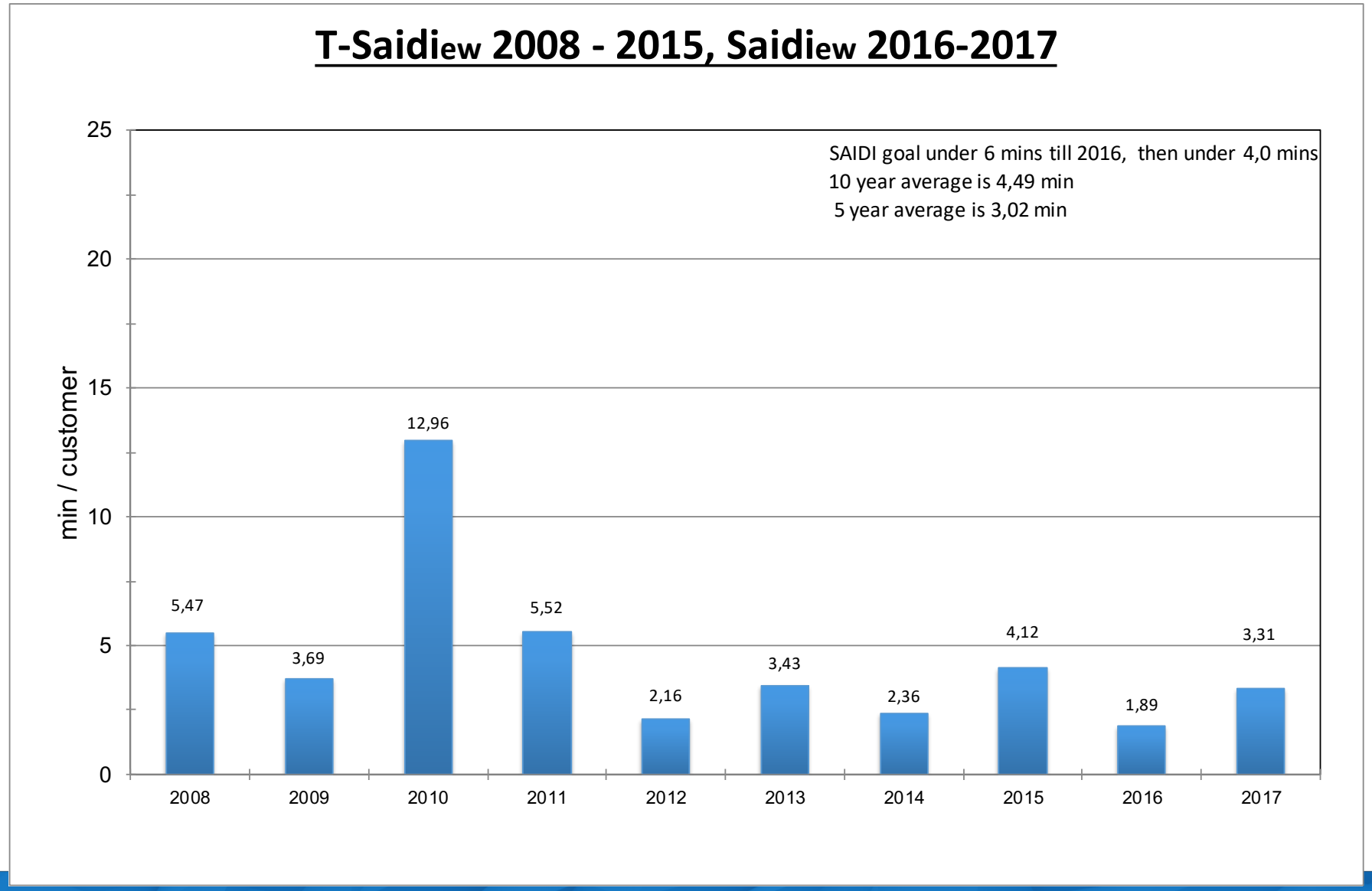


THE SUPPLY TASK IN HELSINKI

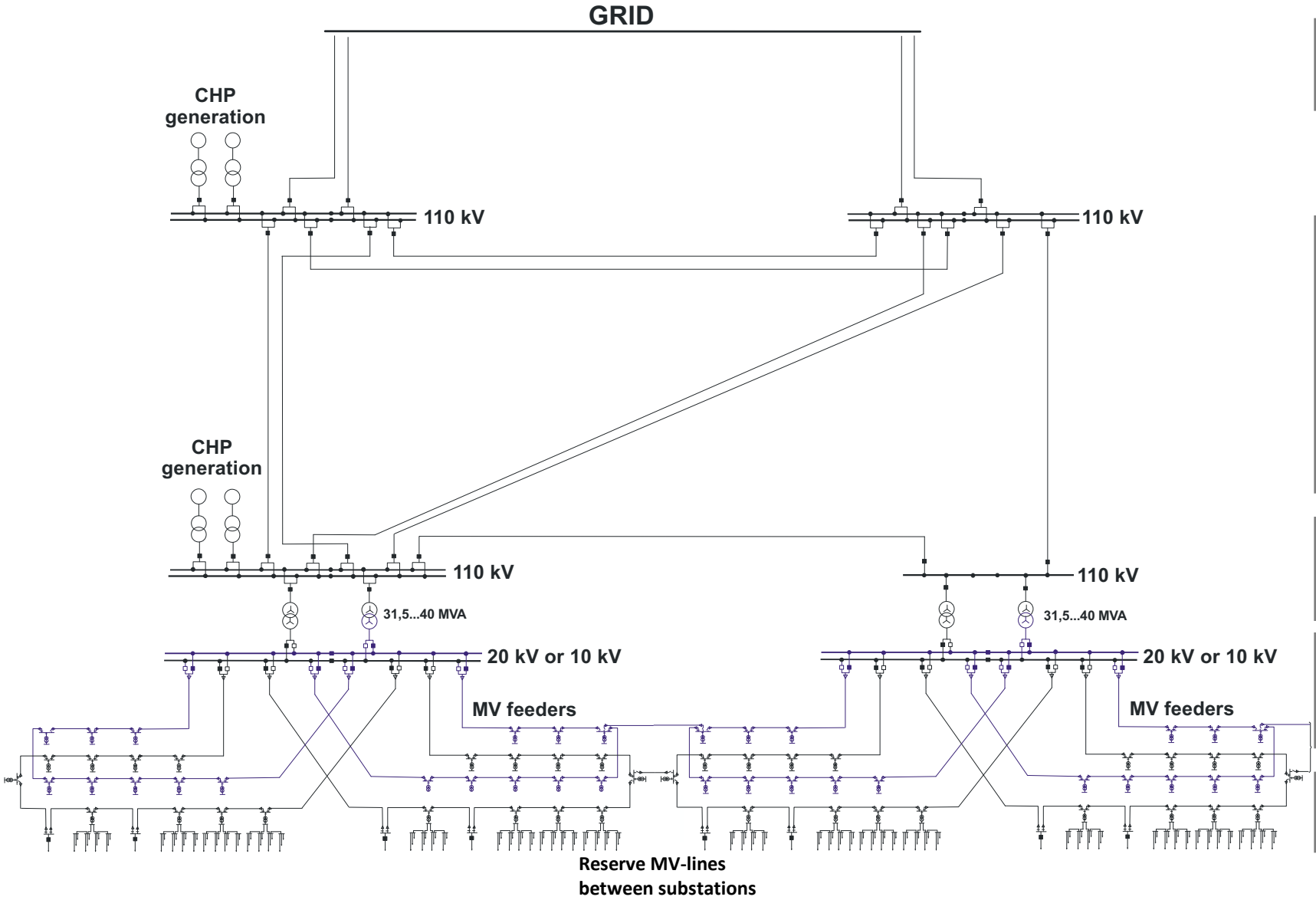
- DSO in the city of Helsinki, 3rd largest DSO in Finland
- Owned by Helen Ltd., which is owned by the Helsinki City
- Compact city-type-only network
- High load density
- High electricity consumption per capita
- Cheapest total electricity price among EU capital cities
- Best eleciticity supply reliability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



HELEN'S SAIDI$_{EW}$ 2008-2017



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

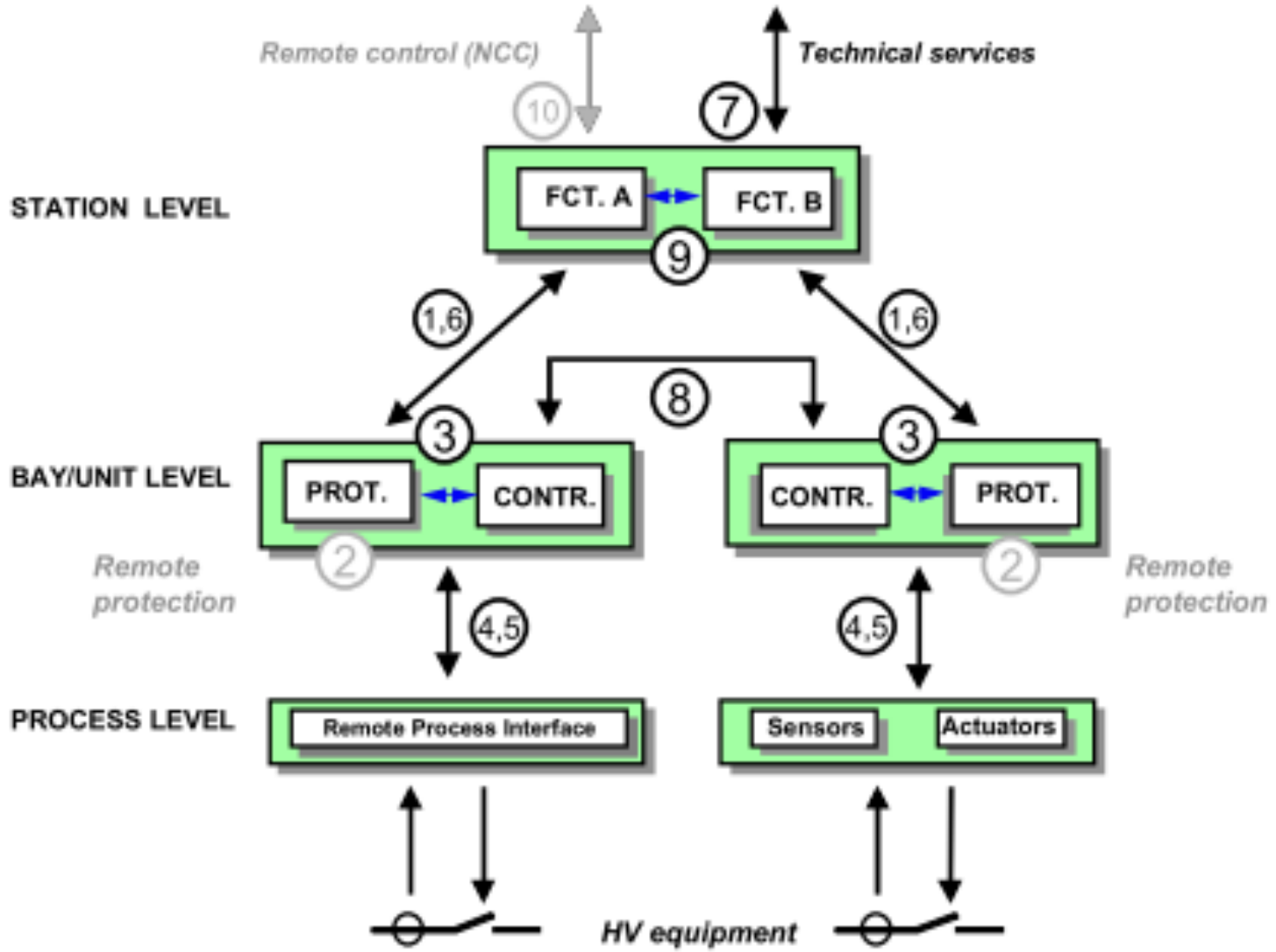
Low voltage distribution
- radial structure

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: 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 done (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

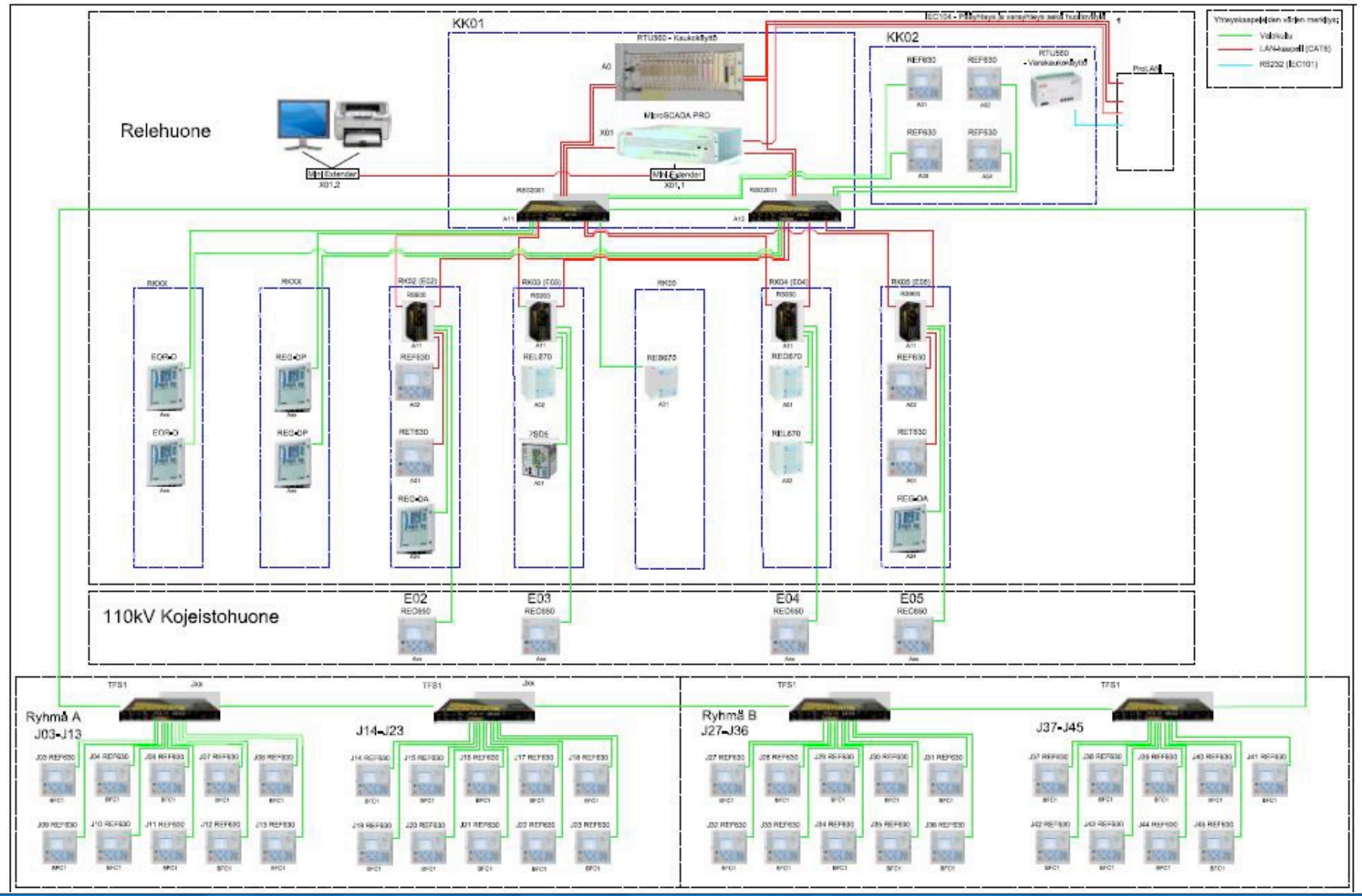
SAS INTERFACES, IEC 61850-1ED1



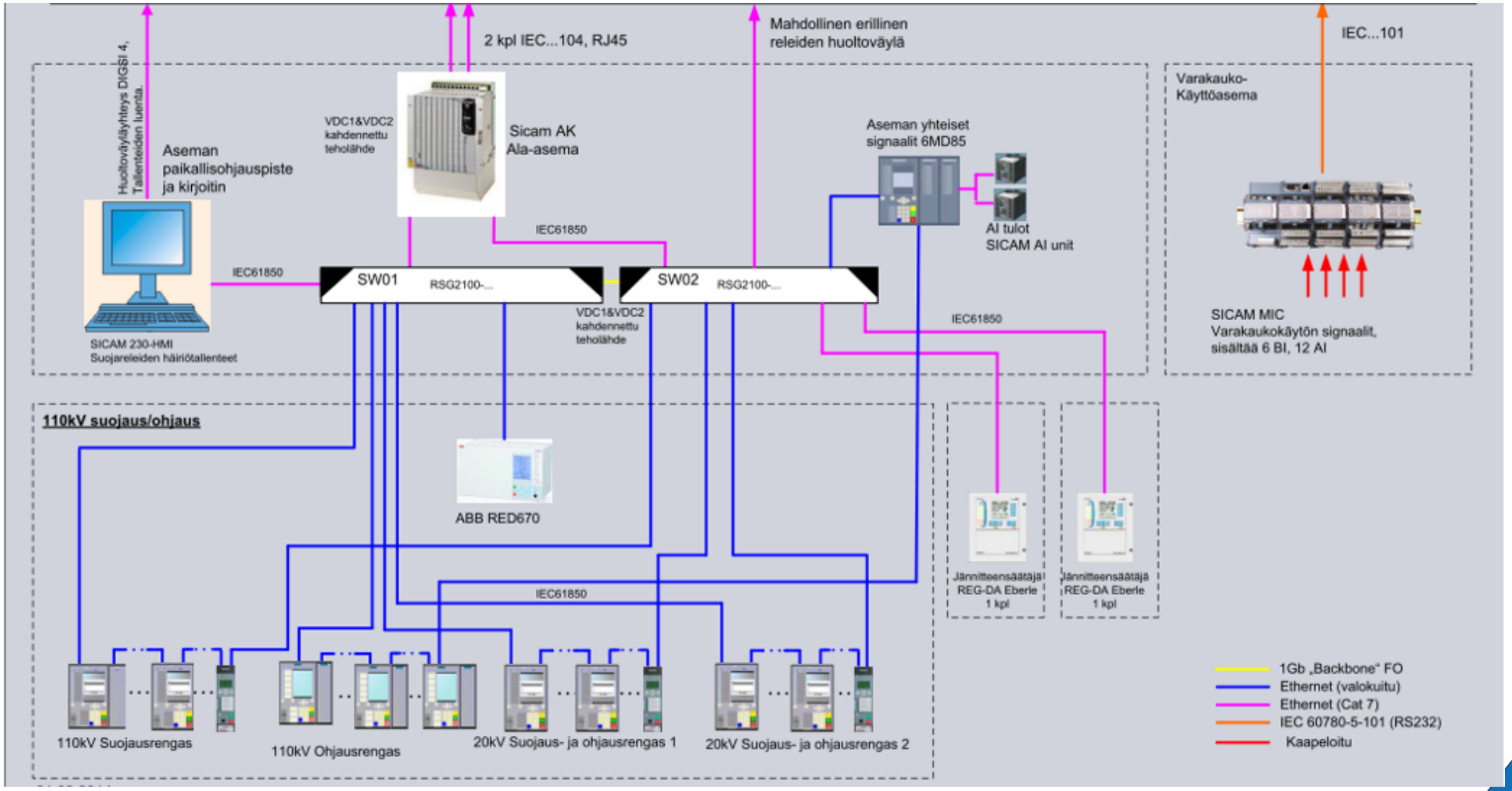
HELEN'S MILESTONES IN SUBSTATION AUTOMATION

Year	Milestone
1991	Specification of serial bus substation automation
1992	Commissioning of first station bus SAS (Laajasalo Sinaut LSA)
1997	Specification of one IED/bay for MV level + IEC 60870-5-101 remote control
1998	Commissioning of IED/bay (REF 543) MV substation in Suvilahti
2007	Specification of IEC 61850 station bus and IEC 60870-5-104 remote control protocol
2007	Specification of secondary substation automation
2008	Commissioning of first IEC 61850 station bus refurbishment in Kannelmäki
2008	Starting of secondary substation automation project (still ongoing)
2016	”Light specification” of MV substation IEC 61850 process bus
2018	Commissioning of first Unigear Digital MV stations with sensors and IEC 61850-9-2 SV communication

ILMALANTORI 110/20 KV IEC 61850 SUBSTATION AUTOMATION (ABB 2015)



PASILA 110/20 KV SECONDARY SYSTEM REFURBISHMENT (SIEMENS 2015)



SERIAL COMMUNICATION VS. TRADITIONAL TECHNOLOGY

Advantages of serial communication

- Serial station bus enables more information from process (device faults, primary faults, disturbance records) compared to copper wiring
- Decreasing the amount of copper wiring saves some money
- Station level and bay level user interfaces have more features and they are scalable compared to traditional mosaic walls, analogic measurements and status info
- Functions can be integrated in the same physical hardware → flexibility and hardware savings compared to old technology
- IED self-supervision, event- and disturbance recording and exact time stamping give added value and better reliability
- Remote connections to station and bay level devices gives better supply quality and savings (less station visit needs)

SERIAL COMMUNICATION VS. IEC 61850 COMMUNICATION

Advantages of IEC 61850

- Communication speed with serial comm. around 10-30 kbit/s, with Ethernet and IEC 61850 100 Mbit/s or more → more data faster without bottlenecks
- Using of GOOSE messages between IED's: control interlockings, protection interlockings → some copper savings and supervised signals
- Interoperability between different vendors is a default and works much better than with older protocols
- Standard includes also engineering parts (some are still demanding better general engineering tools)
- Standard has parts (data models) concerning distributed generation and plans to go to inter-substation and remote control areas too
- Process-bus technology including IEC 61850-9-2 SV communication is the new implementation area of the standard

CHALLENGES OF MODERN SAS SYSTEMS

Challenges → some solutions

- Shorter lifetimes of components (station computers) and IED's → 20 years HW lifetime goal
- Functional integration and high amount of features can cause lack of redundancy and configuration problems → training and user interface improvements
- IED software/firmware version handling problems: bug fixing vs. better features → version management (vendor + utility side)
- IEC 61850 is so complicated that utilities have to rely more on service providers → turnkey project handling
- Challenges with GOOSE configuration and documentation → GOOSE management process
- Extra training needs for engineers (specification, planning, commissioning, maintenance) → applicable IEC 61850 trainings
- Even minor IED level communication change forces also changes at station level SAS configuration → better forecasting in configuration phase
- IEC 61850 Ed1 vs. Ed2: not possible to mix the IED's with different versions at the same IEC 61850 project → separate SAS projects for different IED versions → towards Ed2 projects

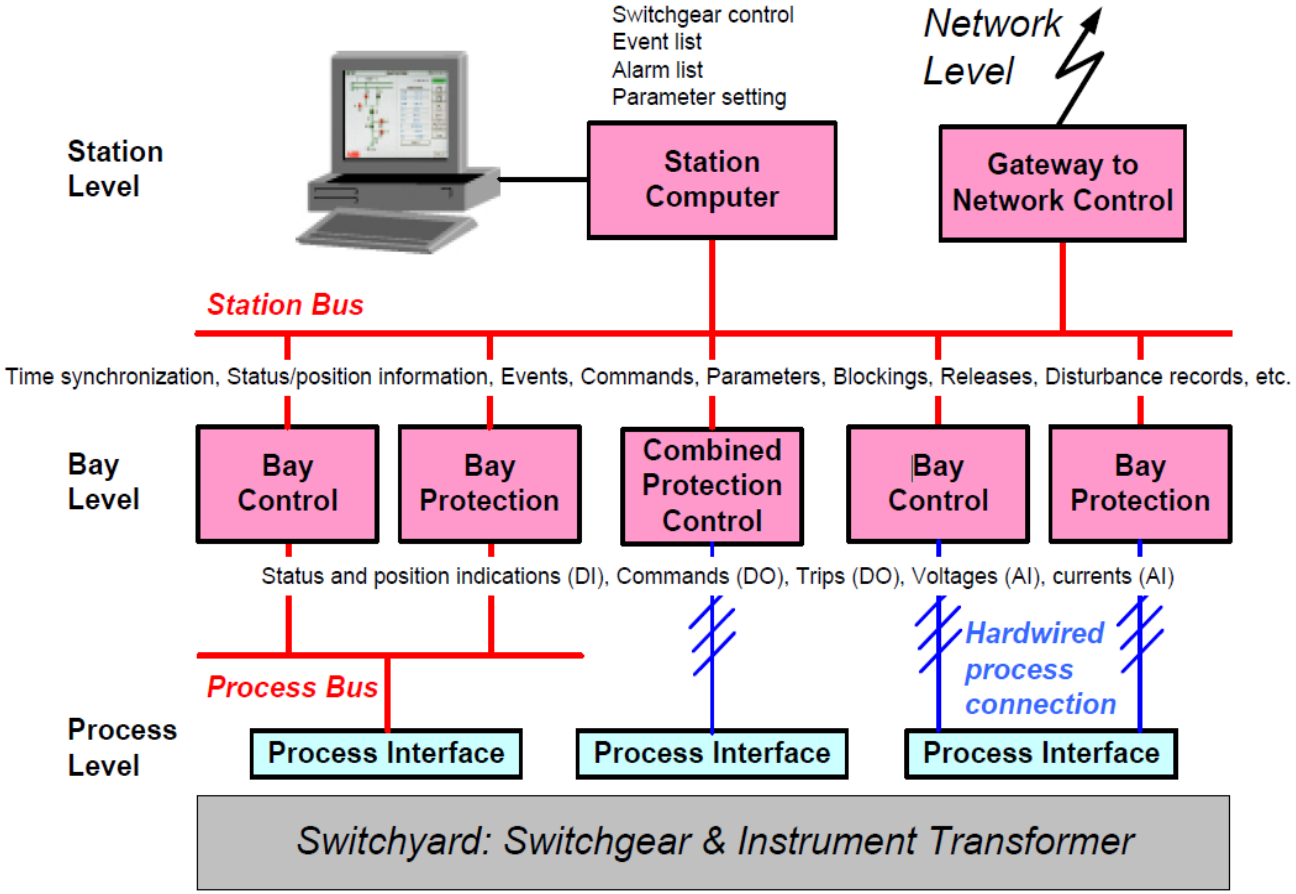
IEC 61850 COMMUNICATION DEVELOPMENT

- IEC 61850 station bus is already widely used, well proven and it works mainly well, it is future proof standard
- Using of GOOSE -messaging is still at conservative level: mostly used for control interlockings → use spreads slowly also to protection signalling area
- IEC 61850 process bus implementation is still at pilot level, mostly one bay offline pilots with one manufacturer devices (parallel with traditional installation)
- IEC 61850 process bus station level applications become more common in the future, still mainly one bay solutions, 3 main areas:
  - HV AIS solutions (with sensors)
  - HV GIS solutions with sensors
  - MV solutions with sensors
- Comparison:
  - \+ Reduction of copper wires and size (cost reduction), flexibility, safety…
  - \- Accuracy problems?, additional IED's (merging units), vendor interoperability issues

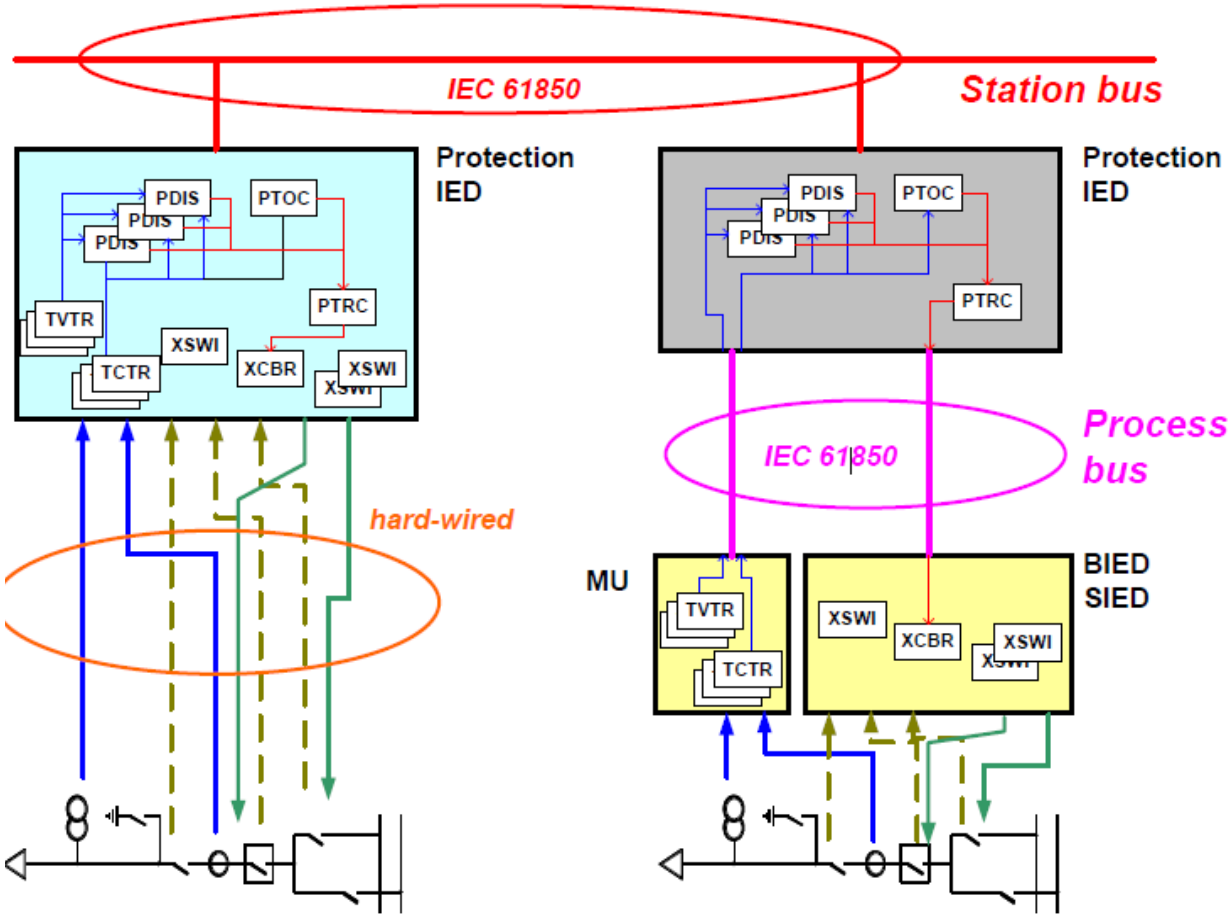
IEC 61850 COMMUNICATION DEVELOPMENT

CONTROL HIERARCHY OF SAS

SOURCE OF FIGURES: ELECTRA INVITED PAPER ABOUT PROCESS BUS, (BRAND, BRUNNER, MESMAEKER) 2011



TRADITIONAL WIRING VS. PROCESS BUS



FUTURE SAS COMMUNICATION DEVELOPMENT

What in the future:

1. Direction now at HV level: replacing of conventional instrument transformers and copper wiring with sensors, merging units, optical fibres and IEC61850 process bus communication
   - One bay solutions
   - The same IED's/bay used + extra merging unit IED's

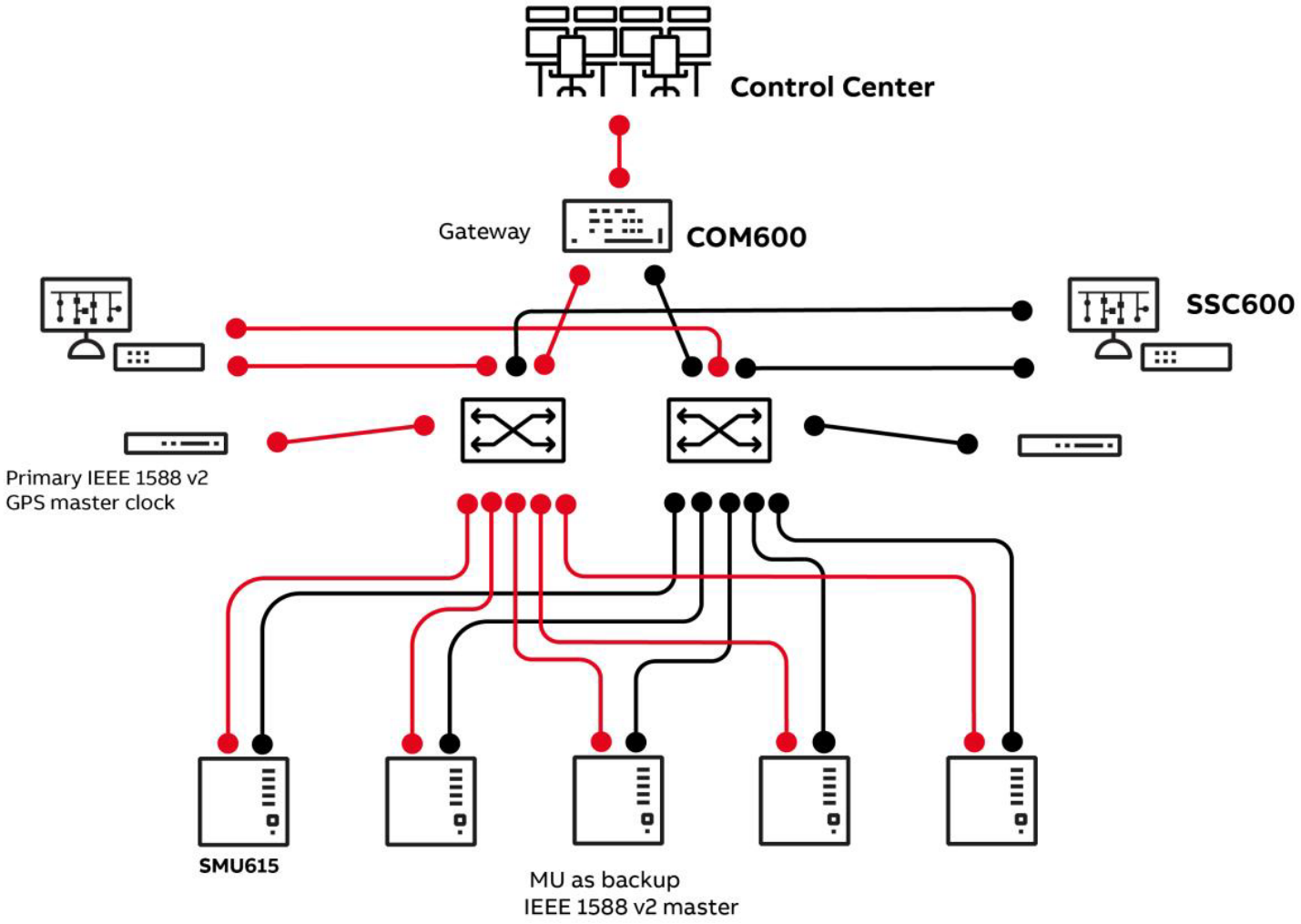
   → Not remarkable improvement
2. The needed direction is to decrease the number of IED's:
   - The same process bus should be connected to all IED's→ all IED's could get the same process data (redundancy protocol might be needed)
   - One IED/bay at HV level:
     - IED from neighbouring bay can take over all functionality in case of IED failure
     - Functionality is spread over many IED's: some main IED's and partial backup IED's
   - Physical combining of the station and process buses
   - Very demanding functionality for IED's, all vendor compatibility issues have to be solved

FUTURE SAS COMMUNICATION DEVELOPMENT

What in the future:

3. More distant future could be the automation centralisation into station level
   - >=2 computers at station level including all functionality with process interfaces
   - Less hardware → less costs, easier to update and maintain (in theory)…
   - Very demanding for computer capacity, redundancy issues (all eggs in the same basket), demanding trouble shooting…
   - Locamation's SASensor is a first example of that centralised automation, not based on IEC 61850
   - Newest example is ABB's SSC600 computer (figure next page)
   - Restrictions at the moment with previous ones:
     - HV functionality is mainly missing
     - Capacity limit for MV is 20 bays

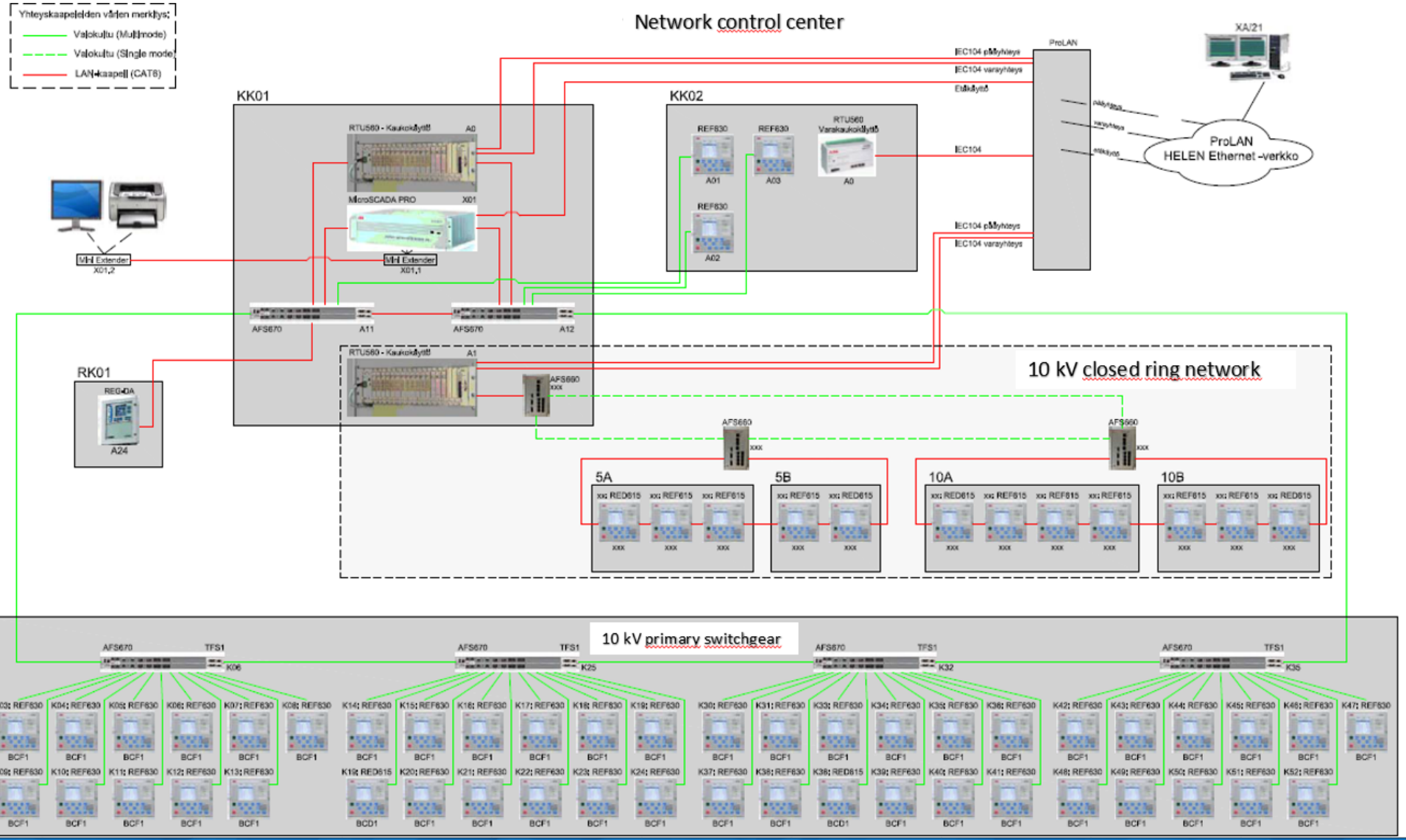
CENTRALISED AUTOMATION EXAMPLE, FIGURE SOURCE: ABB VAASA



Kalasatama smart grid area in Helsinki

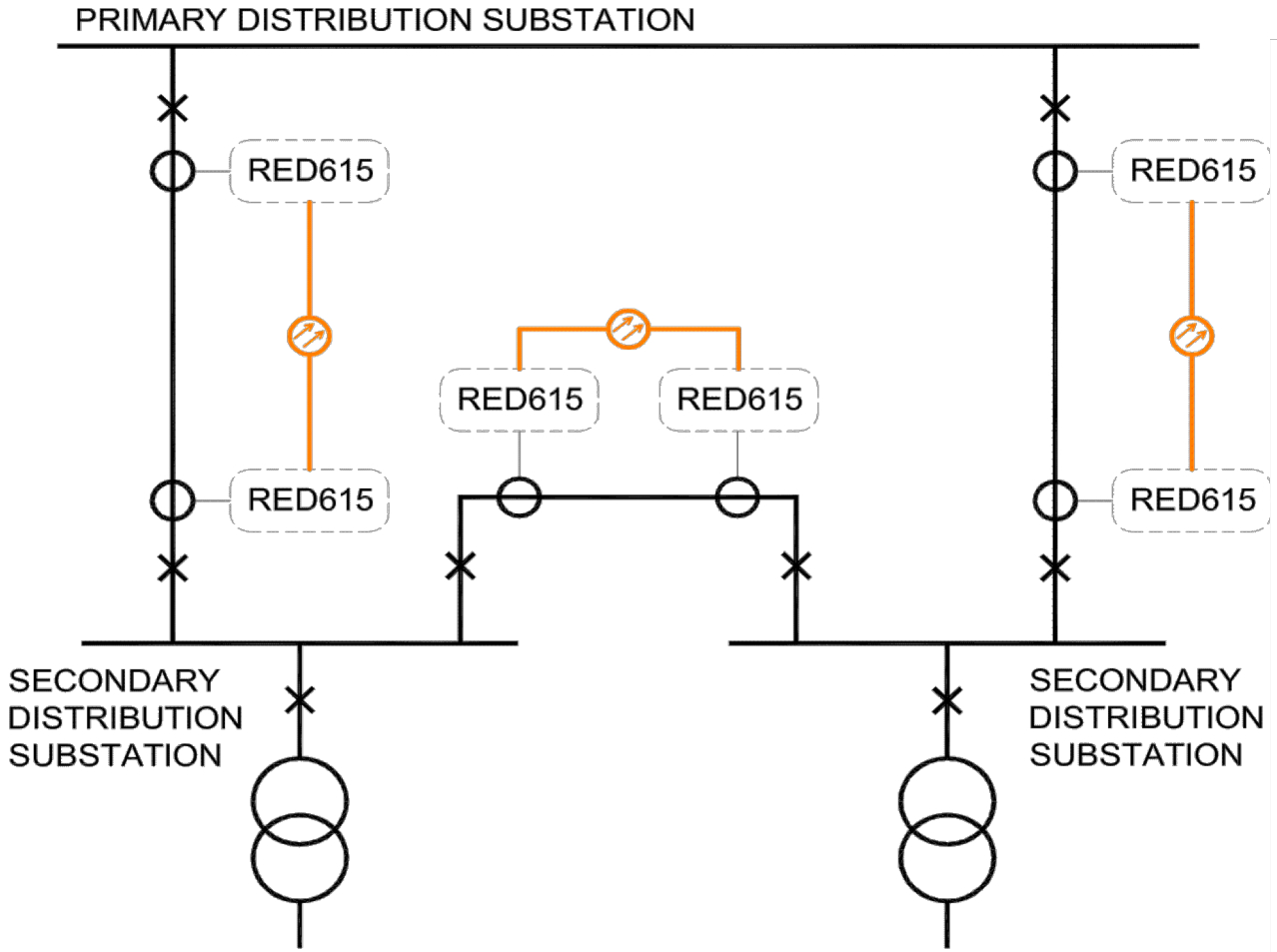
- 20000 apartments, 8000 jobs, > 20 years construction time
- Closed MV-loop with UG Digital SG's
- 1,2 MW energy storage
- Solar energy (one 340kW plant)
- Home automation

KALASATAMA (10 KV) IEC 61850 SUBSTATION AUTOMATION (ABB)

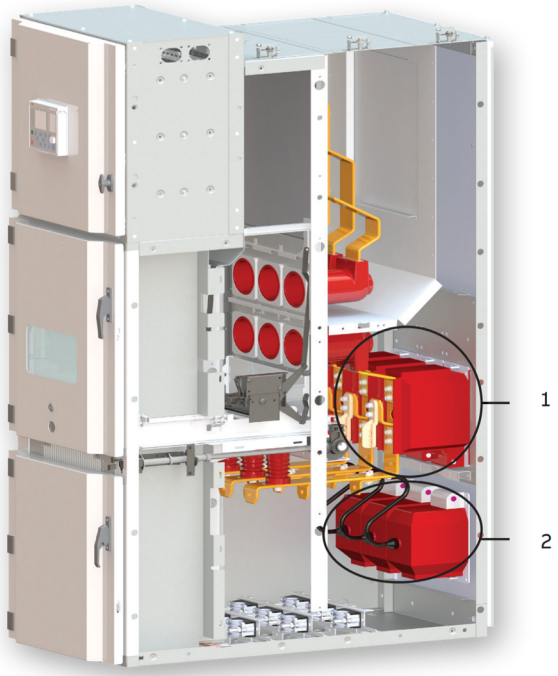


CLOSED LOOP MV RING IN KALASATAMA

Closed loop MV solution and its protection with Idiff and Ie->communication, Unigear Digital secondary substation switchgears with sensors (8+6 bays), busbar protections made with GOOSE logics, IEC61850-9-2-SV voltage measurement distribution (HSR). CIGRE 2018 paper no: SC B5-204.

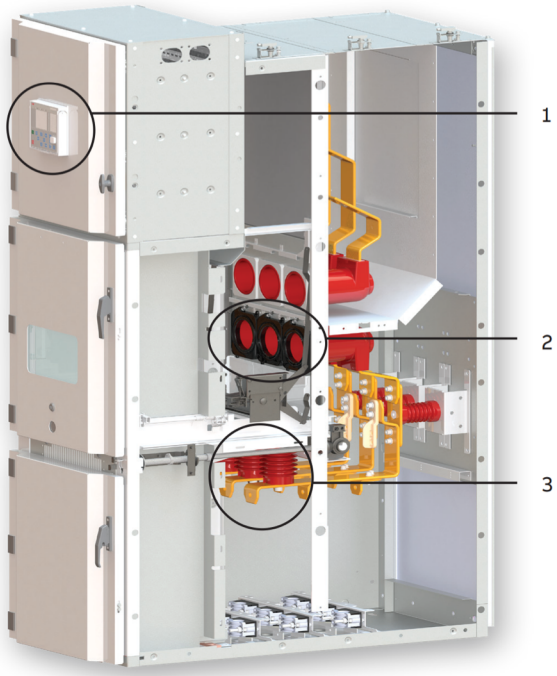


Traditional UniGear with instrument transformers



1 Current transformers
2 Voltage transformers

UniGear Digital with sensors



1 Relion® protection relay with IEC 61850
2 Current sensor
3 Voltage sensor

SUBSTATION COMMUNICATION: COMPARING THE POTENTIAL OF IEC 61850 WITH OTHER OPTIONS…

Conclusion

- The substation automation (SAS) is not the most important issue, but the service ability for customers is
- Automation is a tool to achieve those results (reliability of supply, cost effectivity…)
- SAS with serial bus gave many advantages in the 1990's and 2000's.
- IEC 61850 station bus is a must today with additional advantages vs. serial bus
- There are some challenges with SAS but they are beatable
- IEC 61850 process bus and sensors are about to come soon
- The biggest advantages of process bus would be reached with stationwide process bus (enabling to decrease the number of IED's)
- Centralised station level substation automation (some computers) could be the future?

THANK YOU!

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