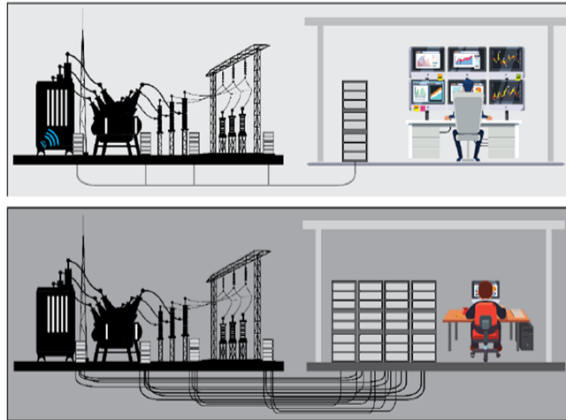CIGRE | PARIS 2022

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Engineering and Condition Monitoring in Digital Substations – an initiative to implement digital substations in the Norwegian power grid

Nargis HURZUK (Statnett), Karl POLLESTAD (Elvia), Svein Morten STRØMSNES and Kjartan ANDERSLAND (BKK)

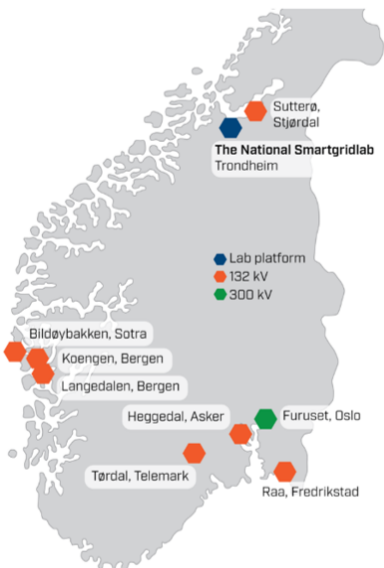Maren ISTAD, Camilla ESPEDAL and Hans Kristian H MEYER (SINTEF Energy Research)

Introduction

- Experiences from digital pilot stations and lab platform in Norway

- Benefits and challenges with digital substations in terms of HSE, reliability and expenditure

- Two examples of intelligent condition monitoring of primary components in a digital substation

    - vibration anomaly detection in circuit breakers

    - power transformer temperature monitoring using IEC61850

ECoDiS R&D project

- Supported by the Research Council of Norway (2019-2023)

- Project responsible: Statnett

- Project participants:
  Elvia, Lede, Agder Energi Nett, Tensio TN, BKK and NVE

- R&D partners: SINTEF Energy Research and NTNU

- Main goal: exploit the full potential in digital substations

- **Make substations smaller, smarter and safer**

- Several pilots built to gain experience and build competence

Sutterø, Stjørdal
The National Smartgridlab
Trondheim

● Lab platform
● 132 kV
● 300 kV

Bildøybakken, Sotra
Koengen, Bergen
Langedalen, Bergen
Heggedal, Asker
Furuset, Oslo
Tørdal, Telemark
Raa, Fredrikstad

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Expectations and experience

- Expecting higher reliability and more functionality in a digital substation
- Replacing conventional instrument transformers with low-power instrument transformers (LPITs) in digital substations
- Combining several functions in each IED
- Combining several bays in one relay cabinet, reducing total number of relay cabinets by up to 40-50 %
- Integration of more sensor systems for condition monitoring of primary components
- Expecting fewer and shorter planned outages
- Digitalization of substations may introduce new cyber-security vulnerabilities

Experiences 132 kV

- Conventional substations are less expensive than the digital substation both for a 2 feeder 132 kV AIS (air insulated substation) and a GIS (gas insulated substation)
- The difference is largest for AIS (around 10 %)
- Cost reductions are expected for future digital substations

132 kV AIS cost difference for selected elements:

Element	Cost difference in %
Relay cabinet	- 12 %
Bay cabinet	+ 30 %
Cabling	- 18 %

Identified cost reduction potential for bay and relay cabinets

132 kV GIS cost difference for selected elements:

Element	Cost difference in %
Bay cabinets	+ 2 %
Remote terminal unit	+ 4 %
Cabling	- 6 %

Identified cost reduction potential for local control cabinet

Expectations 420 kV

Estimated man hours reduction in digital substations:

Element	Man hours difference in %
Engineering	- 15 %
Installation	- 20 %
Testing	- 10 %

Estimated cost reduction in digital substations:

Element	Cost difference in %
Control building	- 6,5 %
Cable trenches	- 50 %
Foundation	- 18 %
Total area	- 2 %
Control system	- 6 %

Study Committee B5/B3
Protection & automation/Substations & electrical installations
Paper ID 10980_2022

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Circuit breaker (CB) vibration monitoring

- Most CB failures are mechanical in origin
- Machine learning for mechanical anomaly detection in circuit breaker vibration signatures
- A laboratory setup with a 72.5 kV CB was established to test machine learning
- A field installation on a new 132 kV CB is planned in one of the digital substation pilots

Transformer condition monitoring in DS

- Transformer temperature monitoring with IEC 61580 integration
- Currents, temperature and vibration in IEC61850 sample values format on the process bus
- Main challenge: exporting data out from the substation and make them available for other applications
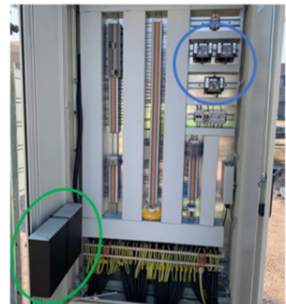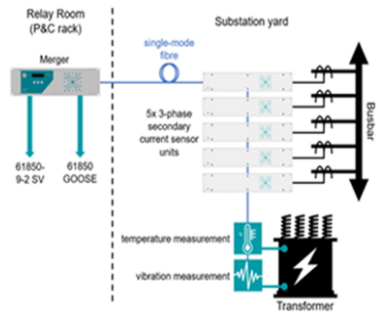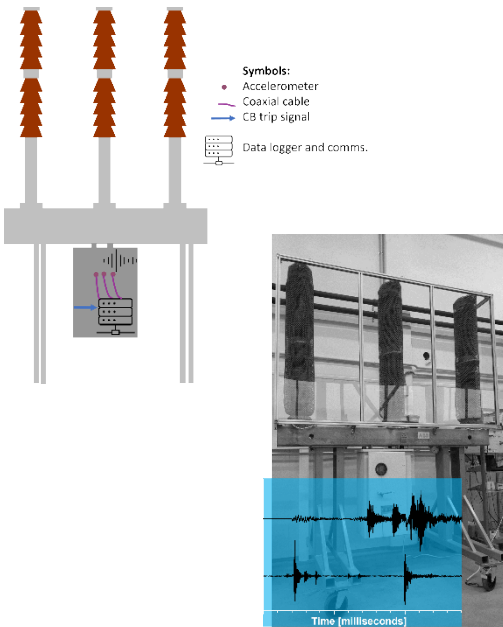
Conclusions

- The paper presents initial experiences from digital substation pilots in Norway
- It is expected that digital substations will improve reliability and provide new, innovative functionality
- Expected benefits and challenges could change with more experience and further maturity of the technology
- The R&D project ECoDiS will produce recommendations for implementation of digital substations in Norway