Smart Substation project
T.BUHAGIAR  RTE
L.SCHMITT  ALSTOM
V.ADDI  ALCATEL-LUCENT
RTE a European TSO

In the heart of Europe

Provides to its clients clean, sure and economical access to electricity supply

Owns and operates the French transmission grid:
- 104,000 km of EHV and HV lines
- 2,660 substations
- Peak load served > 100 GW (60+ million inhabitants)
- 8,400 staff

Financial figures
- Turnover: 4,700 million € (2013)
- Annual Investment: 1,446 million € (2013)
A private TCM network

- 20,000 km optical fiber circuits (high and low level operation)

- 140 private micro wave links (low level operation)

Technologies

Existing
- 80% 1.5GHz
- 20% 13GHz, 23GHz (1 link)

Currently replacing 1.5GHz by new 13GHz
The Smart Substation Project

- 32 M€ and 4 years project: 2013->2016

- 6 partners in a R&D consortium coordinated by RTE:

RTE  ALSTOM  Alcatel-Lucent  ERDF  Schneider Electric  neology

- French government agreement as part of a 40 Billions € Investment Plan for the future

- Part of the french program “Grid for the future”

- Only project focused on a transmission substation in France

- 2 substations selected for real size demonstrators

- First implementation of a full Digital Control System in France in 2015, with latest ICT and non conventional primary electrical equipments
1. Context elements
2. Smart substation and IEC 61850
3. Extended AREA and IEC 61850
4. WAN/LAN and cybersecurity
1. European objectives for 2020

-20 %
of CO₂ emissions compared to 1990

+20 %
of energy efficiency compared to 1990

=20 %
of final energy consumption coming from renewable energy sources
1. Energy transition
a European matter
And also a local matter

Increasing part of less predictable and more intermittent sources

New uses, needs for interactivity
A demonstrator in a RES area
New Technologies

- **Primary Equipment**
  Optical CT, Neelogy CT
  Low power VT
  Ester transformers
  Digital breakers, power transformers and disconnectors

- **Secondary Equipment**
  Process Bus
  Optical communication
  Full monitoring
  New universal HMI
  Point on wave switching
  Redundancy, cybersecurity, interoperability

IEC 61850 Global Solution

- **Control, protection, zone voltage control, metering, automation**
  All the equipment at the site
  Utilities monitoring/control (electrical, water, heating, weather, fuel tank...)
  Condition monitoring, Ambient monitoring

- **Access control, virtual fence...**

- **Dynamic Line Rating**

- **Fault Analysis and Location**

- **Settings management**

- **Teleprotection, Wide Area Automation**
Challenges

- Refurbishment of existing protection & control system for two large substations (10 Bays 225 kV, 12 Bays 90 kV)
- Innovative solutions bringing new functionality, complete substation digitizing (electrical, mechanical, environmental data)
- Manage redundancy, move away from hardwiring
- Manage inter-substation automation

Solutions

- Full DCS and protection system (ALSTOM DS Agile), process bus 1Gb/s
- Condition monitoring, real time situational awareness
- Wide Area Control Scheme, security system
- COSI-CT + COSI-VT

Key benefits

- Minimized outage time, improved equipment availability
- Increased safety, prevent cyber-security attacks
- Improved inter-changeability, enhanced flexibility and grid operability
- Increased reliability with inherent system redundancy
- Optimized maintenance, remote substation monitoring
- Reduced relay footprint 80 TE -> 40 TE, for smaller panels
What’s New at Blocaux with IEC 61850

• Virtual busbar VT
• Optical CT technology, compact CT and VT footprints
• No more copper hardwiring for command and control
• Flexibility in physical separation of instrument transformers and IEDs
• New approach for redundancy and reliability issues – self-healing
• Harmonised protection scheme for 225 and 90 kV
• External kiosks for digitising only in the yard, intelligence is centralised

• Multifunction IEDs subscribing to multiple SV streams
• New distribution of the LN in the LD for fewer devices and failure tolerance
• Permanent SV generator for remote commissioning and testing
• Permanent spare parts for automatic reconfiguration in case of failure
• Containerised substation methodology – System A, System B
What’s New at Blocaux? Operational Benefits

- Local state estimator
- Redundancy controller
- Weather-based dynamic rating for transformers and OHL
- Data historian for long term analysis (asset management)
- Digital Paralleling Voltage Regulation
- WACU and 61850 WAN for extended benefits across neighbour substations

Automatic fault analysis and location
- Fault analysis - location converted to geographical data (GPS) with tower identification
- Correlation with lightning activity
- Relay tripping time and autoreclosure delay compared to technical specifications

Healthy OHL identification
- Automatic restoration plan and relay failure identification
First full digital substation in France
Smart extends from the SCADA to the substation in a distributed way
First step toward an optimisation of IEDs
Powerful real time response to DER integration challenges
Total remote control
Concept for the secondary equipment: maintenance free

ALSTOM DS Agile HMI:
One environment for all data

Condition Monitoring

Transformer CM:
- Hotspot
- Gas
- Ageing
- Cooling system efficiency
- $T_g\delta$

Plant & Substation Monitoring:
- Environmental
- Meteorological
- Primary Equipment

Video

Full Remote Management

Cybersecure

Full Remote Management

Switchgear Control & Monitoring

Process Bus

Dynamic Line

Security, InfraRed

Switchgear Control & Monitoring

CT/VT+MU and COSI-CT/VT

European Utility Week

Rte

05/11/2014
3 – Project perimeter

Installed ENR power

Max consumption
538 MVA

Min consumption
116 MVA
3 – Project perimeter

- 15 substations
- 500 km OHL
- 12 hybrid RTU (104/61850) in the distant substations
- 32 protective relays 61850 compliant
- 5 weather stations
- 8 power transformers 900 MVA

Adjusted Area

Extended Area

90 km

70 km
3 – Project perimeter
New needs for inter substation automation

Main issues examples:
- Develop a centralized tool for the command of all the voltage regulation means (capacitors banks, tap changers, inductances, ...) available on an coherent electric cluster (15 substations, 10 transformers 900 MVA/110 MVAR, )
- Implement weather based dynamic rating for lines and transformers on the same area
- Develop tools for area fault analysis, fault locator, recovery plan...

A data transmission challenge:
- The control tower needs to collect data and has to send orders to the distant substations
- Existing vertical architecture has to be adapted by a complementary horizontal layer based on IEC 61 850 protocol → the Inter Substation network

A particular concern on cybersecurity topics for a Vital Infrastructure Operator
- Cybersecurity based on the e-bios method
- Supervised by the french national agency for the information systems security (ANSSI)
- European reliable suppliers only for the hardware and software solutions
3 – Project perimeter
New needs for inter substation automation

- Today, all the system **software is centralized in the scada**
- Transmission of the infrastructure’s data organized in a “silo” mode
- IP based TCD system (physical layer) but HNZ protocol for data exchanges (poor quality but high security and availability)
- Existing scada systems close to saturation

- RTE wants to **test a new approach based on distributed intelligence and horizontal communications** to face the new challenges related to distributed energy sources integration—> **Internet of Objects** —> Local Intelligence to solve local problems

-> the RTE smart substation project aims to **implement a local intelligence** inside the substation and to create a **local area « automatic pilot »** based on a local « control tower » in order to **increase the grid flexibility and the resilience**
TCD network high level

Data Center 1 → Backup 40 gbps → Data Center 2

20 Mbps

Market

National

Interconnexion

Regional

Emergency management system

inter-dispatching exchanges *

2 Mbps

Local DSO

Local

20 Mbps

Data Center 1 → Market → National → Regional → Regional → Regional → Regional

Emergency management system

Settlements balance

2 Mbps

Local DSO

Local

10 Mbps

Local DSO

Local

Emergency management system

Interconnexion

GRT

E1

05/11/2014
TCD network low level

Regional main  Regional backup

SCADA

Coherent electrical cluster

TCD

High
Low

Substation
Substation
Substation
Substation

GET

512 kbps

Telé-protection

master
Substation slave
Substation slave
Substation slave

IP/MPLS Network

Access control
Smart Substation new applications:
- Experimental IEC 61850 SCADA (TCD)
- IP based inter smart substation exchanges: teleprotection, automation
- IP based teleoperations/tele-maintenance, with use of video
4. Smart Substation Communication

- All Ethernet communications
- IEEE 1588 packet Syncronization
- Firewall Zones
  - Zone 1 – WAN Level
  - Zone 2 – Substation Level
  - Zone 3 – Bay Level
4. Cyber Security

The grid infrastructure is critical to the country security. Migrating to IP based technologies open new doors for potential attacks. Stronger pressure from government/security agency.

The project requires:
- cyber security risk analysis (eBIOS methodology)
- implementation of strong security policies and solutions
Thank you for your attention

For further informations:

www2.ademe.fr
www.smartgrids-cre.fr
www.alstom.com
www.rte-france.com