Future GIS trends
Network and substation planning
Future GIS trends for network and substation planning

Content

- Highest reliability requirements for GIS
  - IEC 62271-203 recommendations

- Improving efficiencies:
  - Enabling underground substations and case study

- Responding to challenges:
  - Electrifying remote or hazardous areas
  - Powering private consumers more efficiently

- Lowing environmental impact
  - Eco-efficient GIS
Highest reliability requirements for GIS
IEC 62271-203 recommendations
Highest reliability requirements for GIS
Gas Segregation: Arrangements and Configurations

- More than 30 years of GIS experience
- Reliability of GIS is good
- Maintenance and failures can cause long outages
- Bad experience with some GIS designs
- Some users wanted to have recommendations in the IEC standard regarding Service Continuity
Examples of how partitioning of GIS may affect service continuity are given below.

In some arrangements the two busbar-disconnectors are separated by only one partition. In Figure F.1, the removal of the gas compartment partition at ‘A’ may require both busbars of a double busbar substation to be de-energized, with the loss of all feeders on that section of busbar for the duration of the repair.

Figure F.1 – Impact due to the removal of common partition between busbar-disconnector
In Figure F.2 the removal of the disconnector, including its partitions, at ‘B’ requires the compartments of the adjacent disconnectors to be de-gassed. This causes the loss of the associated feeders for the duration of the repair.

Figure F.2 – Impact of GIS partitioning on service continuity
Gas Segregation: Arrangements and Configurations
Annex F – Examples of Partitioning

In the example the substation has a total number of six feeders, four line and two transformer feeders. The busbars are divided by a busbar separation and linked with a coupler. A future extension is planned at the right side of the substation.

Figure F.3 – Single line diagram with gas partitioning scheme
F.5 User requirements on service continuity

It is the responsibility of users to define a strategy of maintenance relatively to the impact on service continuity and, it is the responsibility of manufacturers to design and define partitioning in order to fulfil users need.

The service continuity requirements should achieve an appropriate balance between equipment cost and the criticality of the substation in the user’s network.

The user may define some general statements that allow a quantitative assessment of the service continuity during maintenance, repair or extension. The following general statements are given as examples:

- at least one line- and transformer-feeder must remain in service during maintenance and repair;
- maximum one busbar and one feeder permitted out of service during maintenance and repair;
- the power flow must be maintained between specified feeders during extension.
F.6 Factors improving service continuity

In order to achieve required service continuity the following factors may be considered among others:

- single line diagram (number of busbars, sequence of feeders, number and position of disconnectors...);
- gas compartment: partitioning, configuration and design, number of gas compartments, additional gas buffer compartments;
- additional isolating links...;
- position of earthing switches and temporary earthing facilities;
- physical arrangement of components;
- facilities for dismantling;
- design of partitions: whether the design allows or disallows working in a compartment with the adjacent under full pressure. In addition working conditions and procedures are to be considered in order to avoid injuries to persons or damage to partitions;
- provision for on-site dielectric test (GIS and interfaces);
- necessity to carry out on-site dielectric tests after maintenance or repair;
- provision for future extensions: buffer gas compartments, appropriate disconnect facilities for extensions without de-energization of complete GIS;
- availability of spare parts, tools and skilled staff.
Gas Segregation: Arrangements and Configurations

Conclusions

Trends:

- The customer will specify requirements on service continuity
- The manufacturer shall verify the required service continuity
- Most customers will require high service continuity than today
4 basic rules

- Bay-wise gas segregation, to avoid outages of complete busbars
- Buffer compartment between busbar disconnectors to avoid shutdown of complete substations
- Buffer compartment between circuit breaker and busbar disconnectors, to remain both busbars in Service in case of maintenance or repair.
- Make strategic spares available

=> If you follow these rules, you will be fit for the future changes in IEC 62271-203 in respect of service continuity
Enabling underground substations and case study
Al Sadd Super Underground Substation Overview

- Introduction
- Challenges and requirements
- ABB experience
- ABB Al Sadd Super solution concept
- Conclusions
Categories of Indoor Substations

Over-/ Underground: Fit client purpose

Urban SS

Overground SS

Underground SS / Subterranean SS/ Subsurface SS

Semi Underground SS

Full Underground SS

On-top building SS

© ABB
September 21, 2016  Slide 14
Al Sadd Super Underground Substation

Design challenges and requirements considered

Clarity process with client leads to optimum between technical solution and overall cost

Recommendation to have concept, design and execution in one hand
Rayyan Village: Doha Land 1 & 2, Qatar

Customer need
- HV power supply as pre-requisite for new infrastructure development in Musheireb
- Substations without disturbance of the residential and commercial area

ABB’s response
- Two 66/11 kV underground substations 13 m below ground level
  - Dohaland 1:
    - 16 bays 66kV GIS 4 transformers 40 MVA,
  - Dohaland 2:
    - 13 bays 66kV GIS, 2 transformers 40 MVA
- Optimized ventilation and cooling based on heat dissipation studies
- Optimization of design based on ABB experience in Qatar and the ABB Underground substation patent
- Substation automation and auxiliary systems

Customer benefits
- Essential on-time delivery due to early design support for developer
- Minimized influence on public surroundings
Rayyan Village: Doha Land 1 & 2, Qatar

- **Doha Land 1**

- **Doha Land 2**
Rayyan Village: Doha Land 1
Rayyan Village: Doha Land 1
Rayyan Village: Doha Land 1
Rayyan Village: Doha Land 2
Lusail – Boulevard I and Boulevard II, Qatar

Customer need

- HV power supply as pre-requisite for new infrastructure development in Lusail
- Substations without disturbance of the residential and commercial area

ABB’s response

- Two 66/11 kV underground substations 13 m below ground level
- 2 x 12 bays 66kV GIS, 2 x 40 bays 11kV AIS
- 2 x 3 transformers 40 MVA
- Advanced transformer design
- Optimized ventilation and cooling based on heat dissipation studies
- Optimization of design based on ABB experience
- Substation automation and auxiliary systems

Customer benefits

- Essential on-time delivery due to early design support for developer
- Zero influence on public surroundings
Lusail – Boulevard I and Boulevard II
Lusail – Boulevard I and Boulevard II
Lusail – Boulevard I and Boulevard II
Beauregard, Switzerland

Customer need
- Replacement of 50 years old Substation
- Increased availability of local network

ABB’s response
- Construction, installation and commissioning of new underground Substation consisting of
  - 72.5 (60) kV GIS Switchgear
  - 12 (8) kV AIS Switchgear (18 Duplex feeders)
  - 2 Power Transformers 20 MVA, 60/8 kV
  - 1 Petersen coil
  - Control and protection, metering system
  - Complete auxiliary systems

Customer benefits
- Optimization of network
- Aesthetic integration of the substation building in the urban environment
- Additional use as parking space
Gouttes d’Or, Switzerland

Customer need
- Reliable power distribution for the urban area of Neuchatel
- Functional alternative to an existing station
- Electrical supply for new underground motorway

ABB’s response
- New underground substation including renaturation of the area
- 60 kV HV-GIS
- 8 kV MV-GIS
- Two transformers 20 MVA
- Selection of most compact ABB equipment enabling space optimized layout
- Space optimized access and escape routes

Customer benefits
- Space used as park and recreation areas
- Smooth architectural integration into the urban and green surrounding
- Additional use of space as parking area
Gouttes d’Or, Switzerland
Gouttes d’Or, Switzerland
AL SADD SUPER UNDERGROUND SUBSTATION
Design principles

- Space and cost optimized design due to
  - Multi storey concept
  - Functional integration and combination
  - Minimized dimensions and clearances
  - Optimized cabling and connections
- Final layout or ratings determine design in the first realization stage
- Provision of sufficient space for maintenance purposes
- Rooms for additional services

Limited space availability
- Optimized physical arrangement
- Flexible cable access
- Accessibility of equipment
AL SADD SUPER UNDERGROUND SUBSTATION

Design principles

- Minimized space occupied above ground
  - Only ventilation shafts and one staircase located overground
  - Less than 1% of complete substation volume is above ground

Area reserved for Al Sadd Super substation (100m x 160m) (100%)

Area used underground by compact ABB design (only 23.3% !!!)

Area used overground by compact ABB design (only 1.1% !!!)
AL SADD SUPER UNDERGROUND SUBSTATION

Transport of equipment

- One big main transport opening and additional small openings and shafts
  - Easy transport of all equipment
  - Minimized interfaces to the environment
  - Closed during operation
  - 98.9% of the space above substation can be used
  - Lifting area in the middle of the staircase
- Transport area for unloading of equipment and transport within the station

Transport and access

<table>
<thead>
<tr>
<th>Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensure means of escape</td>
</tr>
</tbody>
</table>

Easy transportation and logistic access of all equipment
AL SADD SUPER UNDERGROUND SUBSTATION

Access and escape routes

- Two external staircases
  - Redundant escape routes from all levels and locations inside the substation
  - One main staircase above ground and one lowered staircase.
  - Smoke free areas in staircases
- Internal staircases ensure access to all maintenance areas and cable shafts
- Optimized equipment access for maintenance purposes

Transport and access

Safety

- Easy transportation and logistic access of all equipment
- Ensure means of escape
AL SADD SUPER UNDERGROUND SUBSTATION

Power Transformers Lifting

- A 500 tons crane will be used for the Power Transformer lifting
- Integrated civil design for the 220t crane supports is considered
- Crane will be positioned close to substation opening
  - Minimized interfaces to surrounding pedestrian and car traffic
AL SADD SUPER UNDERGROUND SUBSTATION

Heating, ventilation and air conditioning

- Fresh air supply shafts integrated smoothly in the upper park area surrounding
  - Designed according to thermal loads
  - Redundancy enables operation during maintenance of ventilation system
  - Provision of sandtraps, filters, silencers and fans
  - Internal maintenance access
- Centralized ventilation area
  - HVAC and transformer cooling equipment
  - Efficient and directed airflow
- No external equipment needed

Ventilation and air conditioning

Environmental influence

- Air supply and cooling of equipment
- Control noise emissions
AL SADD SUPER UNDERGROUND SUBSTATION

Ventilation concept

Supply & exhaust air volume = 560,000 m³/h : 66,700 m³ (Total Building Volume)

- 88% for transformer ventilation cooling : 5,080 m³ = 7,6%
- 7% for transformer body cooling : 7,627 m³ = 11,4%
- 5% for HVAC unit: Supply of all rooms : 53,993 m³ = 81,0%

=> Transformer Ventilation Concept: Major design and Civil/ MEP cost influence
Alternative ways of cooling – Chilled Water System

District cooling system or cooling system of attached building
(Similar to Doha Land 1 & 2)

- Effective for cooling of transformer and building
- Reduced noise emission
- No need for own cooling plant
- Reduced building height
- Dependence on availability
AL SADD SUPER UNDERGROUND SUBSTATION
Safety and fire fighting

- All hazards can be separated from the public surroundings
- Basic safety elements are build on construction and structural resistance
- Provision of fire sections
- Ventilation area can be separated into fire compartments
- Comply with Kahramaa, Civil Defence and NFPA standards & requisments
- Further elements of fire prevention concept can be chosen risk-related
- Fire dampers in ventilation system
- Structural fire resistance according to hazard
**AL SADD SUPER UNDERGROUND SUBSTATION**

Fire safety requirements for specific areas/equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Fire Extinguishers (Hand held)</th>
<th>Fire Water System (Fixed)</th>
<th>Sprinkler system</th>
<th>Passive protection</th>
<th>Gaseous Extinguishing system (FM 200)</th>
<th>Fire Detector</th>
<th>Trans. Prevention system (SERGI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>220kV GIS</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>66kV GIS</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>11kV GIS</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Telecom</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Control Room</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>AC/DC Room</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Battery Room</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>200MVA Transformer Body</td>
<td>yes</td>
<td>yes</td>
<td></td>
<td></td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>200MVA Transformer Cooler</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>40MVA Transformer Body</td>
<td>yes</td>
<td>yes</td>
<td></td>
<td></td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>40MVA Transformer Cooler</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Aux. Transformer</td>
<td>yes</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Capacitor Banks</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Pump Room</td>
<td>yes</td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Cables (Shafts)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Cables (Basement)</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Store Room</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Toilet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>HVAC Yards</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Corridors</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Staircase</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
</tbody>
</table>
AL SADD SUPER UNDERGROUND SUBSTATION

Cable routing

- Flexible outgoing cable directions according to cable shafts arround the building
  - Easy cable installation
  - Provision of doors in every level for installation and maintenance
  - Ventilation
  - Flexible cable access
  - Shafts sized for later extensions

Limited space availability

Civil design and civil works

- Flexible cable access
- Water-proofing and dewatering
- Integration in surr. structures
Civil design

- Involvement of civil resources at earliest stage – Civil and MEP Engineers involved in all phases of the All Sadd project
- Close coordination between the ABB project team (Architects, Structural Engineers, MEP Engineers) Kahramaa and the developer
- ABB intent to execute the project with a class A consortium partner (Civil, MEP, Fire Fighting).
- ABB recommend to prepare a detailed soil investigation report already at tender stage – Report is essential for cost optimization, risk assessment and project acceleration.

Civil design and civil works:

- Water-proofing and dewatering
- Soil conditions
- Integration in surr. structures
Specific civil design & process considerations for the Underground Substation

- Excavation
  - Excavation of up to 73,000m³ soil & rock to a depth of 18m

- Soil Investigation – Results to be considered for:
  - Permanent pumping system to reduce groundwater
  - Building pit protection
  - Piling
  - Uplift protection

- Logistic & Site Management
  - Proper traffic management
  - Permanent crane and concrete pumping systems
  - Proper contractor management and work scheduling
AL SADD SUPER UNDERGROUND SUBSTATION
Integration of power transformers

- Separation of transformer coolers
- Encapsulation of transformer tank in transformer box
- Selection of adequate type of cooling
- Specialized transformer design and insulation for increased ambient temperatures
- Selection of high temperature class transformers (HTC)
AL SADD SUPER UNDERGROUND SUBSTATION

Example of noise control

- Unliked noise of the transformer and its cooling ventilation is hidden by the liked sound of the water
- The water fountains are liked as decoration in the park
- Water fountains could be integrated for water cooling of the transformers
AL SADD SUPER UNDERGROUND SUBSTATION
Design Principles: Electromagnetic Compatibility and Earthing

Integration of Underground Substations into densely urban areas results into nearness of people close to electrical equipment.

As well sensitive equipment might be installed at nearby areas of the substation.

- Magnetic flux density level has to be below specified level
- Electrostatic fields have to be below specified level
- Proper earthing
- Sufficient distances
- Overall Engineering proven by calculations
AL SADD SUPER UNDERGROUND SUBSTATION
3D-Walkthrough
AL SADD SUPER UNDERGROUND SUBSTATION
Alternative Environmental Solutions
AL SADD SUPER UNDERGROUND SUBSTATION
Alternative Environmental Solutions
AL SADD SUPER UNDERGROUND SUBSTATION
Alternative Environmental Solutions
Main features of new developed system solution

- Overall solution provided by ABB from one single partner/contractor.
- Comprehensive and tailor made turnkey solution
- Space and cost optimized design for smooth integration into surroundings.
- Intelligent transportation and access solutions for all equipment during construction and operation.
- Comprehensive safety concept
- Safety measures with highest independence from public services
- Escape route and evacuation concept
AL SADD SUPER UNDERGROUND SUBSTATION
Main features of new developed system solution

- Fire protection concept for power transformers and building
- Specific power transformer design
- Maintenance access concept
- Redundancies for highest availability and safety
- Minimized and concentrated interfaces allowing easy and smooth integration
- Efficient and optimized ventilation and air conditioning
AL SADD SUPER UNDERGROUND SUBSTATION
Time Schedule

- 24 months requested by Kahramaa will be achievable if:
  - Soil conditions known in early stage
  - DC1 & DC2 approvals available according to time schedule
  - Cable entries and routings are defined and approved in early stage
Questions

- Any further questions from your side?

- Our questions:
  - Is there a Developer involved?
  - What is expected by Kahramaa in technical bid offer?
  - Tendering Process and Evaluation. What are the next steps?
  - Does the presented concept fit into the Kahramaa requirements?
  - Do we need to go more in detail to specific issues?
  - Dry Type aux. Transformer
  - Gel Battery
Responding to challenges:
Electrifying remote or hazardous areas
Powering private consumers more efficiently
Example in USA
„City of Anchorage“
In 2009, the City of Anchorage in Alaska required a new substation to quickly address the growing demand for power.

In addition to the time constraint, the customer also required the substation to be as unobtrusive as possible as the space allocated for the project was in close proximity to a shopping center.

High site installation costs yielding request for short installation time.

Needless to say, the solution also needed to withstand Alaska’s freezing climate and frequent seismic activities.

ABB responded by providing an ELK-04 / 145 kV fully integrated GIS substation that was installed and energized in a few weeks. The substation consists of a 4-breaker ring integrated into two 40-foot containers. The local control cubicles are also fully integrated inside the containers.

The housing was built according to IP55 standard with doors and pressure release flaps.
Project Example – City of Anchorage, Alaska
Filling of SF6 gas
Project Example – City of Anchorage, Alaska
Ready for dispatch from factory
Project Example – City of Anchorage, Alaska
Site preparation
Project Example – City of Anchorage, Alaska
Installation of the first housing unit
Project Example – City of Anchorage, Alaska
Installation of the second housing unit
Project Example – City of Anchorage, Alaska
View from inside the docked units
Project Example – City of Anchorage, Alaska
Substation completed
Lowing environmental impact: Eco-efficient GIS
Eco-efficient GIS

History

- Introduction of the world’s first HV GIS in 1967
- 20 years of intense research for alternatives of SF$_6$
- Research with fluoroketones starting in 2010 at ABB
- Mixture of components of air with perfluoroketones* (C5 PFK) is an environmental friendly solution and a promising alternative to SF$_6$

*Developed by 3M
Eco-efficient GIS

Milestones

- 1967: 170 kV GIS
- 1976: ZI4, 12-24 kV GIS, first in block-type technology
- 1984: ZV2 12-36 kV, first MV GIS
- 1987: 550 kV GIS
- 1992: 145 kV GIS in prefabricated housing
- 1996: ZX1, 36 kV GIS
- 1997: Most compact 123 kV GIS
- 2008: Compact 420 kV
- 2013: JHV 1200 kV GIS
- 2014: UHV 1200 kV GIS
- 2015: Eco-efficient GIS (170 kV + 24 kV) with alternative gas
- 2016: Eco-efficient GIS (170 kV + 24 kV) with alternative gas
Eco-efficient GIS
Motivation

- ABB is committed to develop eco-efficient products which reduce use of resources and the effects on the environment throughout their lifecycle.

- Although the contribution of SF\textsubscript{6} emissions from high voltage switchgear to manmade global warming is very small, a replacement would contribute to reduction of the carbon footprint of the electricity grid. In addition reporting, monitoring and handling constraints will be simplified.
Eco-efficient GIS
Breakthrough

- New gas developed for switchgear applications in collaboration with 3M company
- Eco-efficient gas mixture, consisting of the three components:
  - Perfluoroketones (C5 PFK)
  - CO₂ or N₂
  - O₂
- The gas mixture has a very low greenhouse warming potential (GWP* <1)
- Compared to SF₆-gas the CO₂ equivalent emissions of the new gas mixture is lower by 99.995%
- The new technology will be deployed for the first time at a substation located in Oerlikon, Zurich, using a 170 kV GIS as a pilot installation for the leading Swiss utility, ewz

*GWP: The global warming potential describes how much heat a greenhouse gas traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide. GWP is expressed as a factor of carbon dioxide.
Eco-efficient GIS
Market drivers

- Increased environmental awareness and emphasis on green solutions
- Increasing climate change policies (e.g. reduction of CO₂ emissions)
- SF₆ reporting obligation and taxation in certain countries
- Availability of SF₆ alternatives
- «Energiewende» (energy transition) in Europe (renewables)
Eco-efficient GIS
Why GIS with alternative gas?

- With the new eco-efficient gas mixture, ABB’s GIS has the potential to lower carbon dioxide (CO₂) equivalent emissions by up to 50% throughout the lifecycle of the GIS
- Reduced life cycle cost due to avoidance of SF₆ taxes (where applicable)
- The new mixture is practically nontoxic* and has zero ozone depletion potential
- Safeguards investment over a long period of time
- Main issues faced by use of SF₆ avoided, such as maintaining inventory records as per local regulatory requirements and the care required during gas handling while gas filling as well as while decommissioning the equipment
- Compliance with existing /future SF₆ regulations

*in accordance to Hodge and Sterner scale class 5
According to ISO 14040, the LCA takes three major contributors into consideration:

- Materials
- Insulation gas leakage
- Electrical losses (at 50% rated current flow over 30 years)

Boundary conditions:

- Lifetime of equipment: 30 years
- Assumed gas leakage rate: 0.1% p.a. accumulated over a period of 30 years, 1% loss during handling, 1% loss during decommissioning

*GWP reduction of approximately 50% over a period of 30 years
Gas mixtures of CO$_2$ and O$_2$ with Perfluoroketones (C5 PFK) have a GWP of less than 1

- Insulation in transmission range may be covered with C5 PFK as additives to air or CO$_2$
- Insulation and arc interruption performance for HV indoor applications is close to SF$_6$ and this enables the design of cost effective circuit-breakers
- C5 PFK as a single gas component has a much better dielectric strength than SF$_6$
- C5 PFK has a boiling point of 25°C hence it needs to be mixed with O$_2$ and N$_2$ or CO$_2$
Eco-efficient GIS
World’s first pilot

- A benchmark visionary design for electrical installations - 15 meters below ground in a strikingly designed building
- 1st pilot installation with high and medium-voltage GIS with new gas mixture as alternative to SF$_6$
  - 8 bays of 170 kV GIS
  - 50 panels of 24 kV GIS
- Replacing a lower rated air-insulated substation from 1949 - increasing capacity and freeing 70% land
- Other ABB products include:
  - Low-noise, high-efficiency transformers 3x50 MVA
  - Substation automation protection & control systems

Gain operational experience in the grid
Eco-efficient GIS
Type tests

- IEC Norm 62271-203 defines the necessary type tests for GIS with voltages > 52 kV
- Key tests when changing the insulation medium in GIS components
  - Dielectric tests (high voltage)
  - Temperature-rise tests (nominal current)
  - Making and breaking capacity of switching devices (switching duties for circuit breaker, disconnector and earthing switch)
- Tests to prove the satisfactory operation at limit temperatures

All relevant type tests for the pilot installation have been successfully passed
Eco-efficient GIS
Way forward

- Pilot operation
- Gain operational experience in the grid
- Comparison of LAB results with practical results
- Collect and assess long term data

- Continuation of basic research
- Limit tests regarding thermal, dielectrics and switching
- In-depth material investigations and optimizations
- On-going investigations and quantification of the stability of the gas mixture
- Further development of the sensing
- Optimization of the gas handling tools

Launch Technology pilot

Q3/2015

Possible start product development

Q3/2017

Development

Market launch

>>>
Eco-efficient GIS
Summary

- For all HV applications there is currently no 1:1 alternative to SF$_6$. All known alternatives have limitations and require compromises as compared to SF$_6$.
- Towards regulators and environmental associations, ABB is taking a clearly affirmative position on the future use of SF$_6$ in high voltage applications. SF$_6$ remains the best insulating and switching medium for years to come.
- The industry standard will eventually converge into one alternative insulation medium, as a leading-edge technology company, ABB helps shaping that standard.
- The new technology offers more value and will have a price premium.
- Fluoroketones in HV GIS technology have these benefits:
  - GWP $\leq$ 1
  - No ozone depletion potential
  - Can be used for arc interruption
  - Is suitable for indoor applications
  - Regarding OHS no additional measures required compared to SF$_6$. (TWA* = 225ppm)
  - Main issues faced by use of SF$_6$ potentially avoided.
Eco-efficient GIS Discussion

- Key requirements from operator perspective
  - Footprint
  - Temperature range
  - Operation and maintenance costs
  - Low environmental impact, global warming potential
  - Investment costs as compared to SF6
  - Reliability
  - Retrofit
  - Others?

- Insulation media
  - Currently two promising candidates known, however, research is still intense, chance that other candidates emerge in the near future is given. Consequence for operators?
Eco-efficient GIS
Discussion

- Legislation
  - Discussions ongoing about possible ban of SF6 in medium voltage in Europe. Unclear how legislator reacts concerning high voltage. Availability of alternatives to SF6 could trigger/accelerate legislation in EU / US.

- Politics
  - Taxation of SF6 usage
  - Public pressure to further reduce CO2 eq. emissions

- Public
  - Increased environmental awareness
  - NGOs as opinion leaders
Power and productivity for a better world™