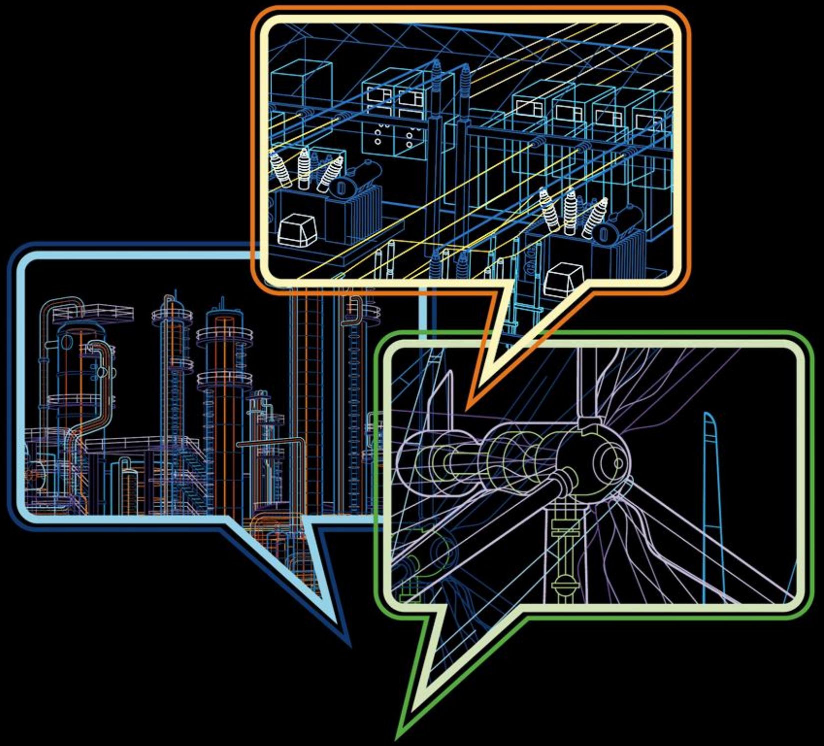


ABB Automation & Power World: April 18-21, 2011

WPS-115-1 (presentation code)
Global technologies for substation applications

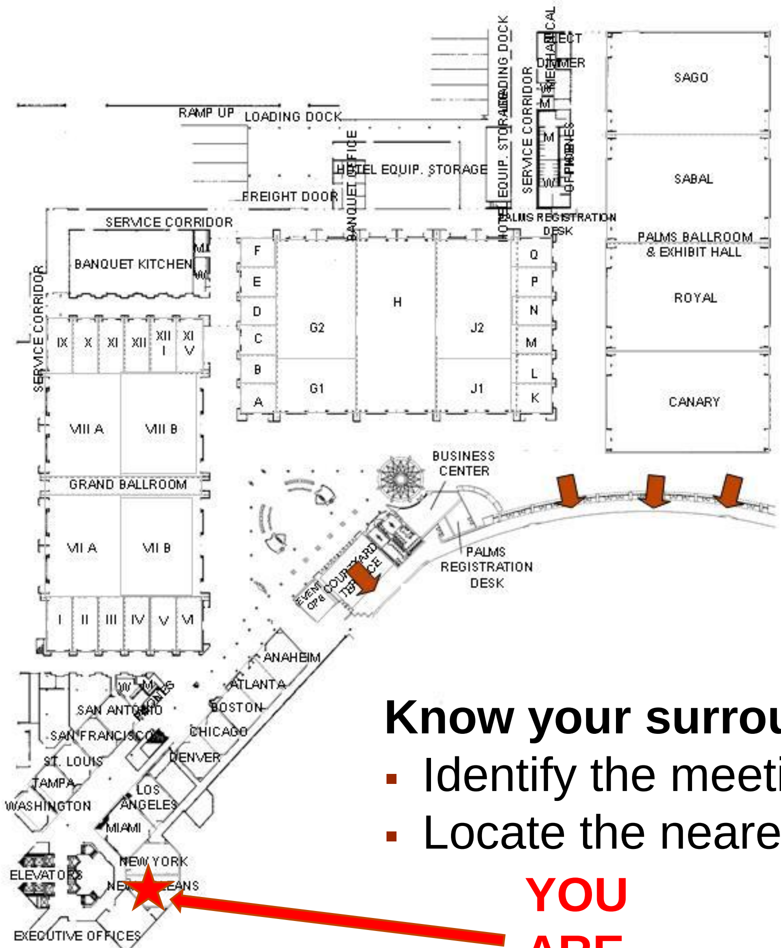
WPS-115-1 (presentation code)
Global technologies for substation applications

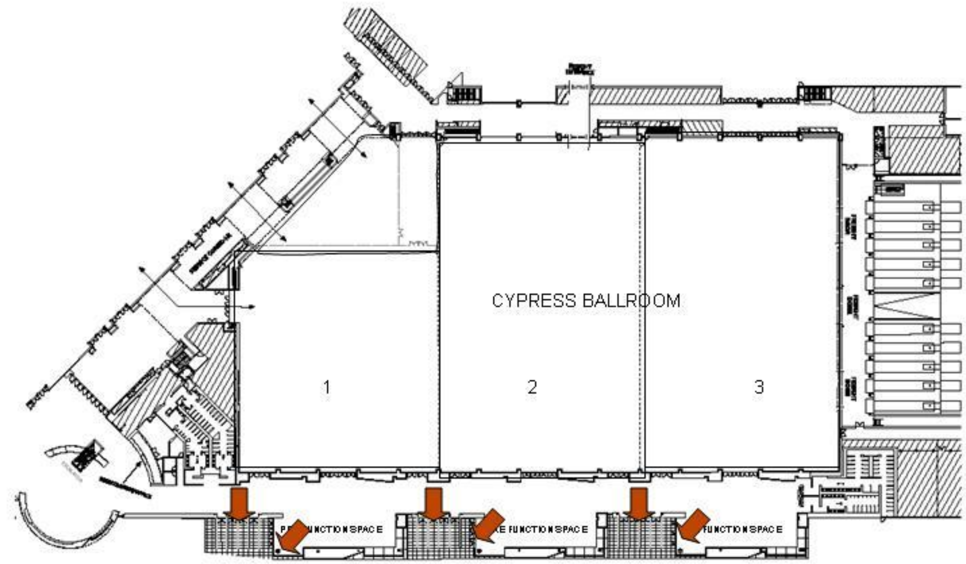
- Speaker name: Scott Andries, P.E.
- Speaker title: Business Development Mgr.
- Company name: ABB
- Location: Raleigh, NC, USA

Your safety is important to us
Please be aware of these emergency procedures

- In the event of an emergency please dial ext. 55555 from any house phone. Do not dial 9-1-1.
- In the event of an alarm, please proceed carefully to the nearest exit. Emergency exits are clearly marked throughout the hotel and convention center.
- Use the stairwells to evacuate the building and do not attempt to use the elevators.
- Hotel associates will be located throughout the public space to assist in directing guests toward the closest exit.
- Any guest requiring assistance during an evacuation should dial "0" from any house phone and notify the operator of their location.
- Do not re-enter the building until advised by hotel personnel or an "all clear" announcement is made.

Your safety is important to us
Convention Center exits in case of an emergency





Know your surroundings:

- Identify the meeting room your workshop is being held in
- Locate the nearest exit

YOU ARE HERE

Global technologies for substation applications
Research & History

Technology Research

- According to Stephen X. Hawkings* – *"the laws of physics, and in particular of electricity, work the same in the US as it does in the rest of the world."*

* Stephen X. Hawkings is in no way related to Stephen W. Hawkings, the world renowned theoretical physicist; and is in reality a pen-name for Scott Andries

ABB

Global technologies for substation applications
Technology – HV Circuit Breaker

Definition of Dead Tank

- Interrupting enclosure (tank) is at ground potential
- Current enters/leaves tank via standard bushings

Applications (used preferentially in U.S.)

- Any
- Advantage: low-cost current transformers (CTs) on bushings

Global technologies for substation applications
Technology – Live Tank Breakers

Definition of Live Tank

- Interrupting enclosure (tank) is at line potential, supported by insulator columns

Applications (used preferentially in Europe+)

- Any
- Advantage: Smaller footprint & weight

Global technologies for substation applications
Technology – Live Tank Breakers

Definition of Circuit Switcher

- Similar to Live Tank Breaker, except:
  - Duty Cycles: O or C-O
  - Operating Times: Slower
- Confusion – Live Tank Breakers

Typical Applications:

- Transformer Primary Protection

Global technologies for substation applications
Technology – Live Tank Breakers



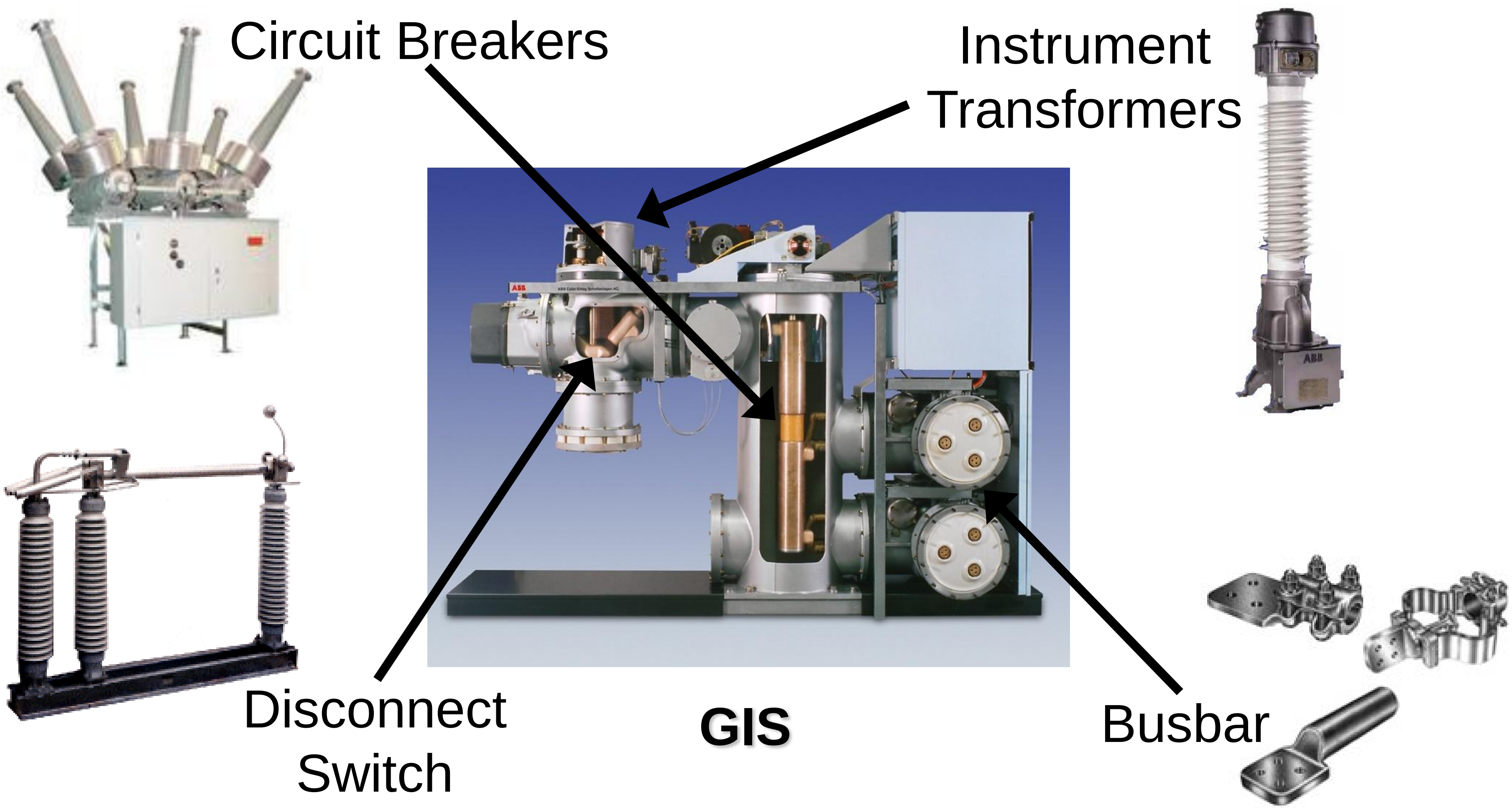
Conventional Solution

- Dead Tank & Circuit Switchers

Innovation

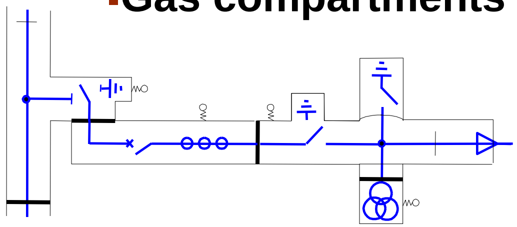
- Large Transmission – Utilize both live & dead tank breakers
- Distribution Substations – replace older under-rated (kA) circuit switchers; new designs in lieu of circuit switchers

Global technologies for substation applications
Technology – Gas Insulated Switchgear

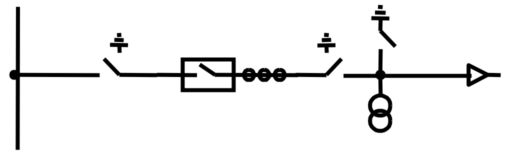


Global technologies for substation applications
Technology – Gas Insulated Switchgear

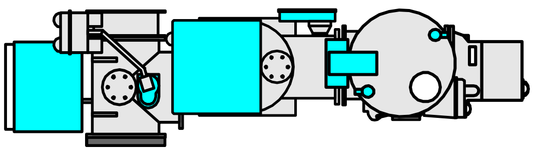
- Gas compartments



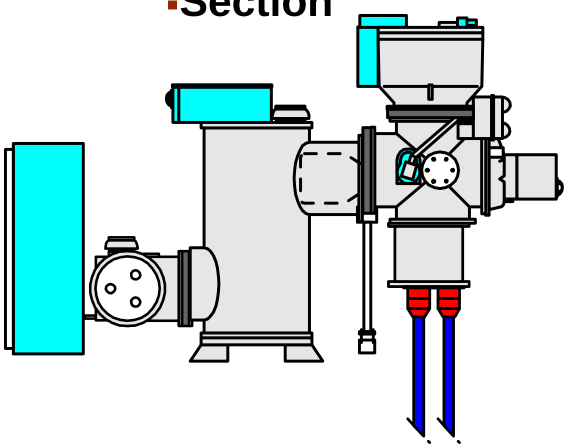
- Single line

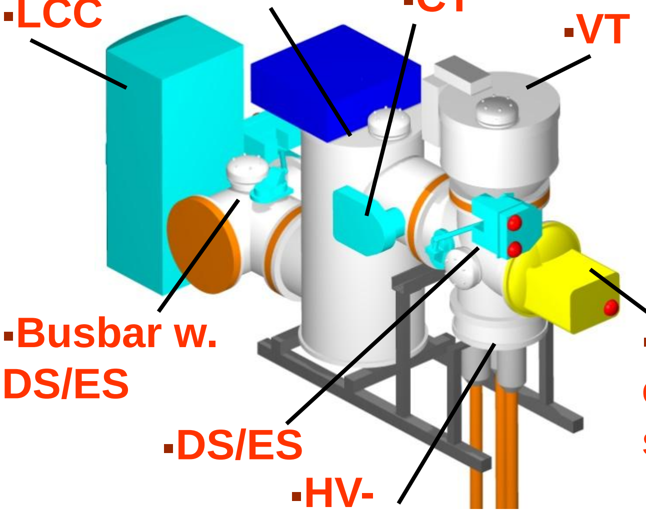


- Plan view

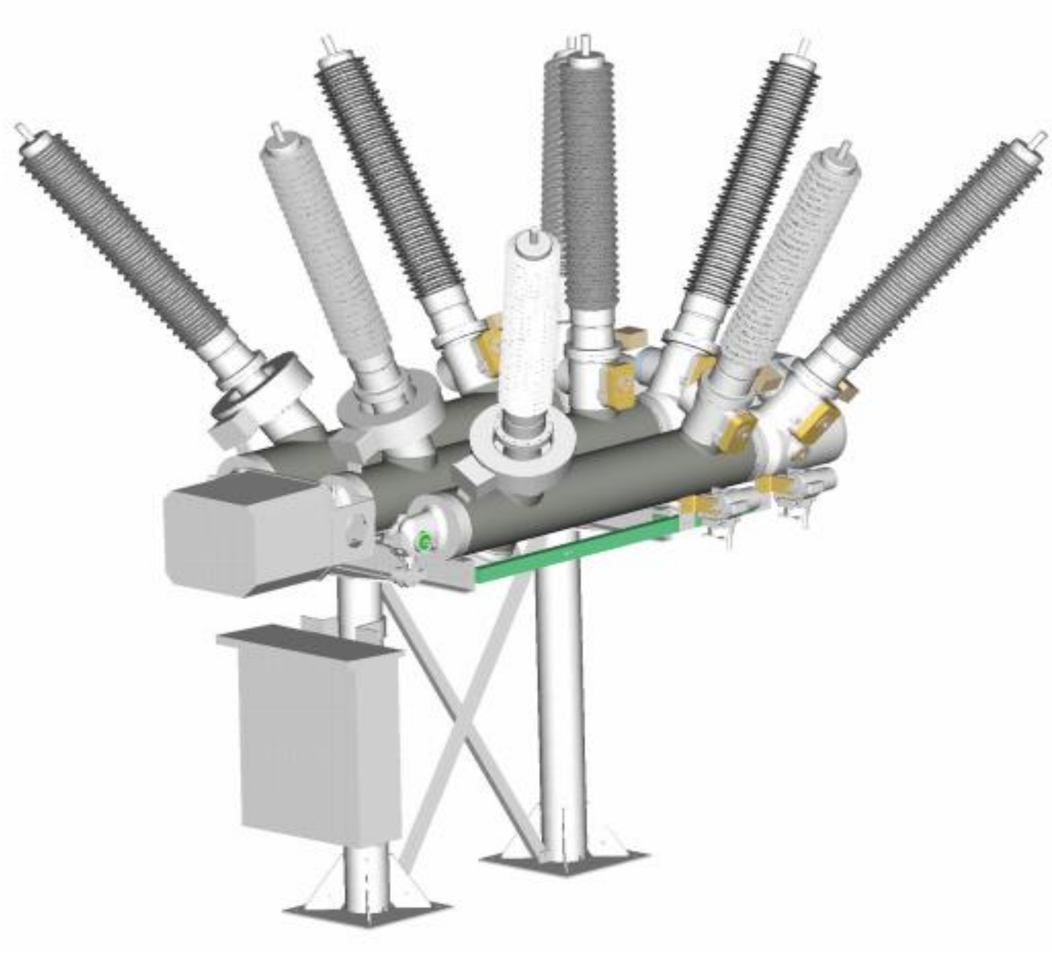


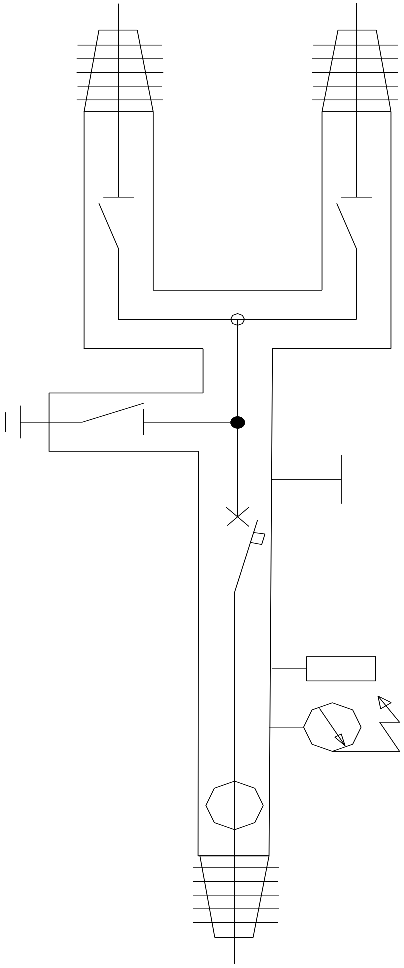
- Section



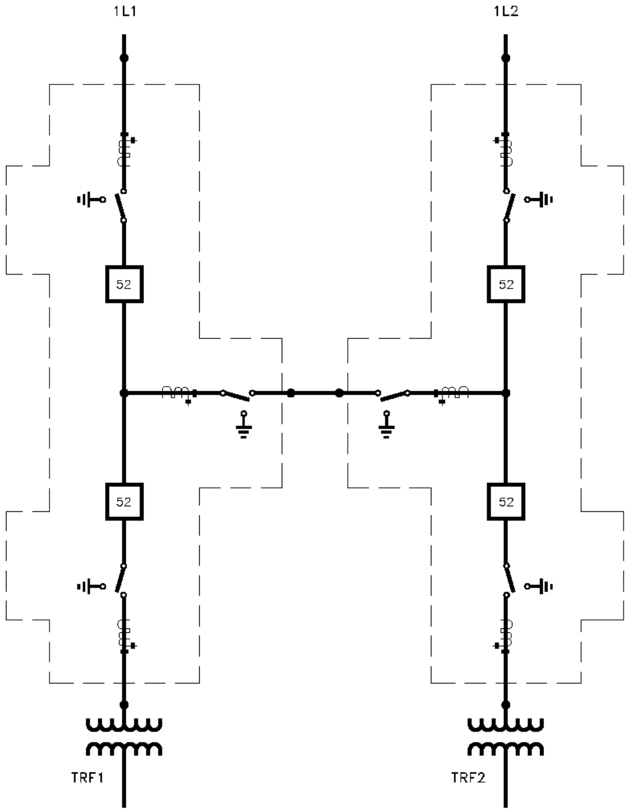


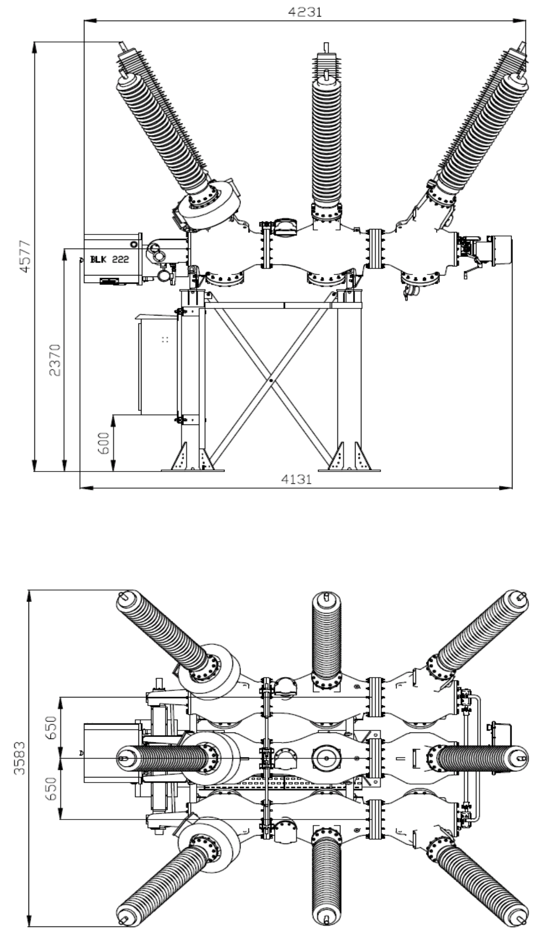
Global technologies for substation applications
Technology – PASS (Plug and Switch Service)





Global technologies for substation applications
Technology – PASS (Plug and Switch Service)





Global technologies for substation applications
Technology – PASS (Plug and Switch Service)

2 PASS Modules

4 Conventional AIS Bays

Global technologies for substation applications
Technology – PASS (Plug and Switch Service)

Conventional Solution

- Air Insulated & Gas Insulated Switchgear

Innovation

- PASS Switchgear
- 2-3 Terminal Applications (Taps)
- NERC Reliability Standards (breaker failure contingency)
- Mobile Transformers

Global technologies for substation applications
Technology – Disconnecting Circuit Breaker (DCB)

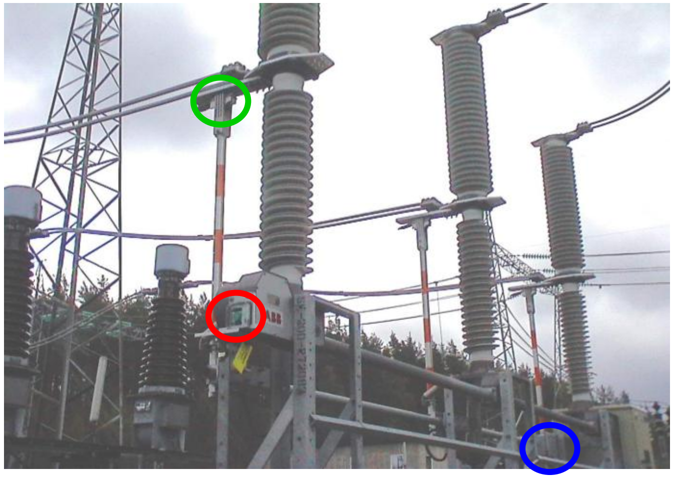
Conventional live tank breaker that has been modified to also serve as the disconnect switch

Closed (normal circuit breaker)

Open (normal circuit breaker)

Disconnected (mechanical lock-out and electrical interlocking)

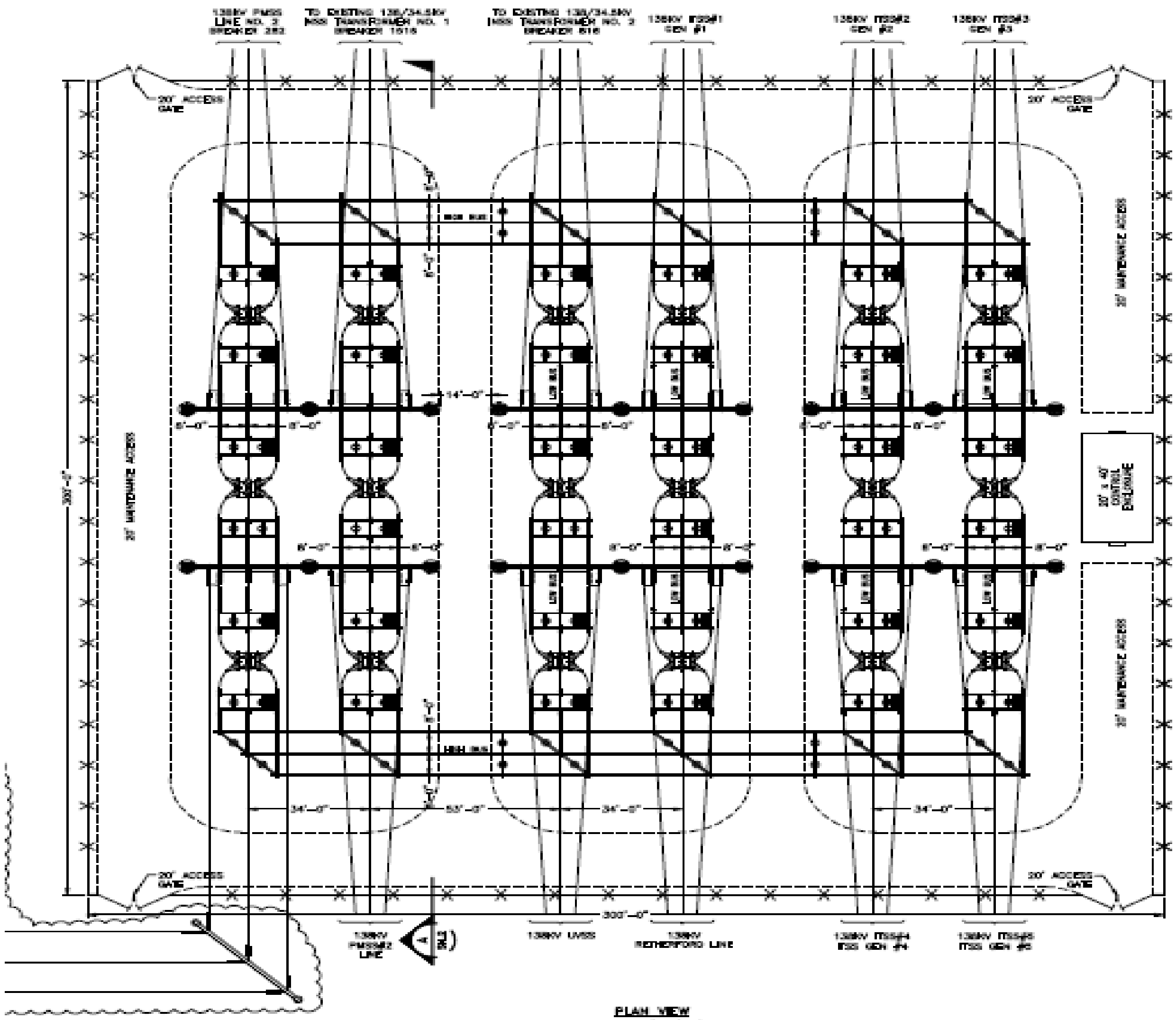
Global technologies for substation applications
Technology – Disconnecting Circuit Breaker (DCB)



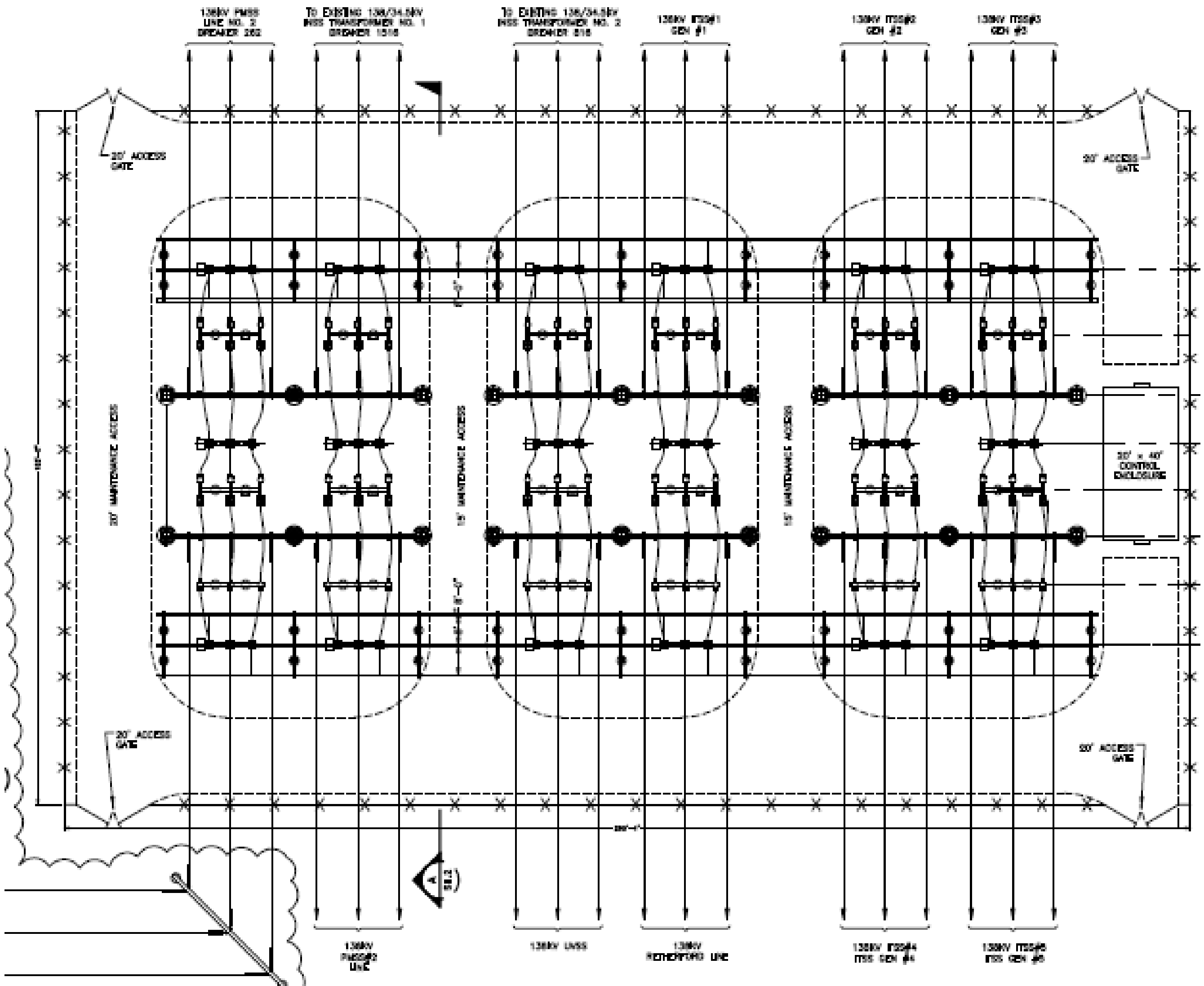
Un-blocked Blocked

- DCB Mechanically locked in disconnected position
- Closed earthing switch assures primary de-energized instead of open DS as in traditional AIS
- Earthing switch motor-operated from remote

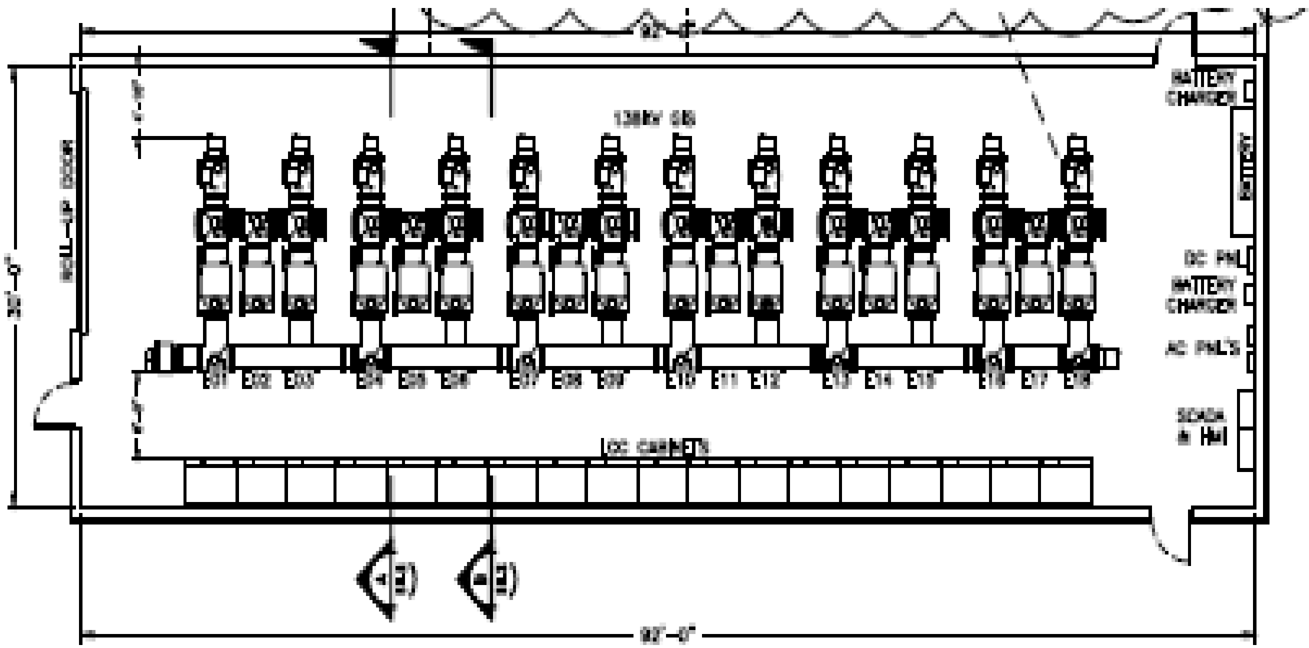
Global technologies for substation applications
Making substations smaller



Global technologies for substation applications
Making substations smaller

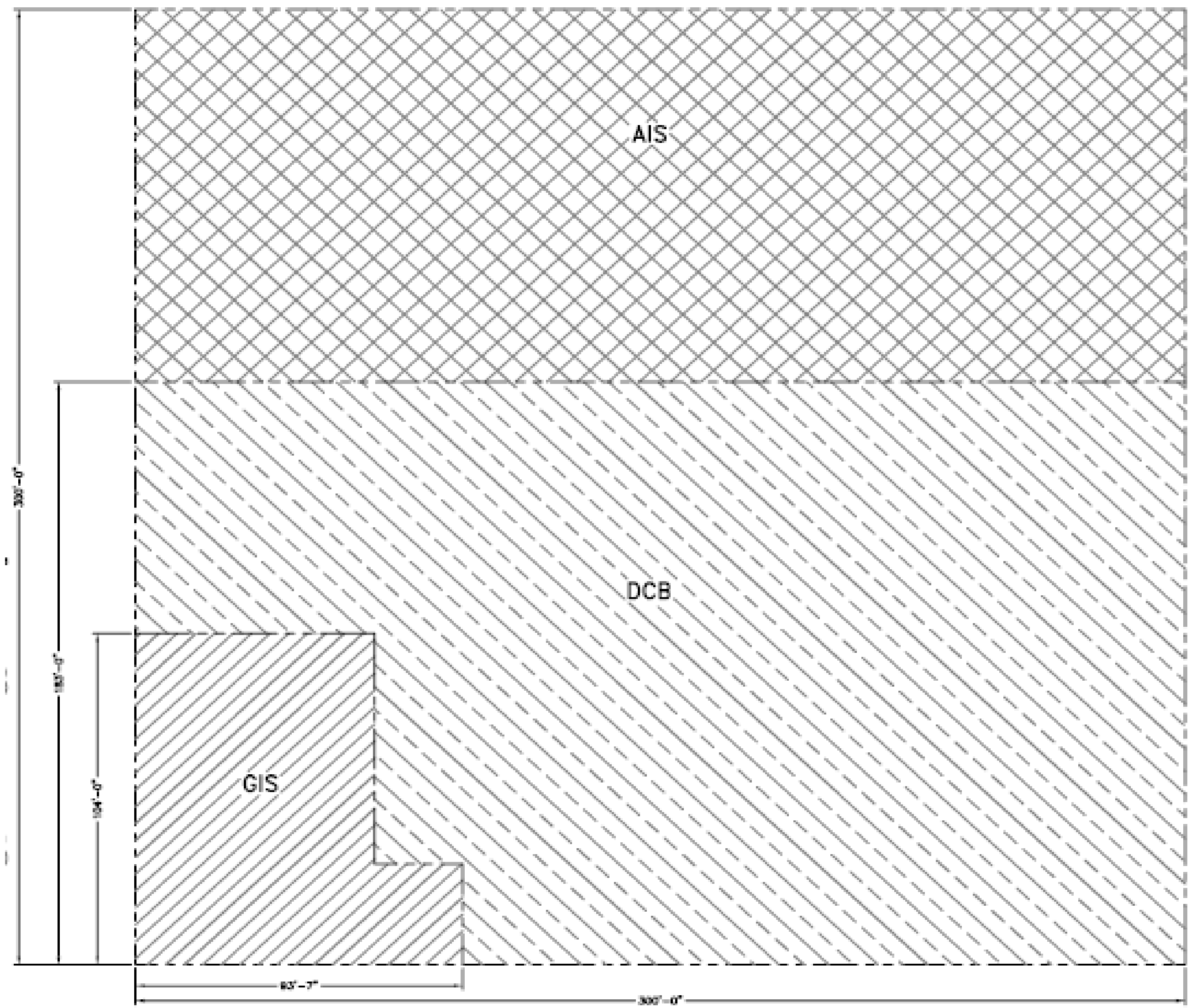


Global technologies for substation applications
Making substations smaller

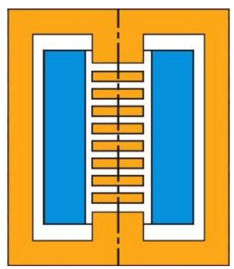


PLAN VIEW
SCALE: 3/16"=1'-0"

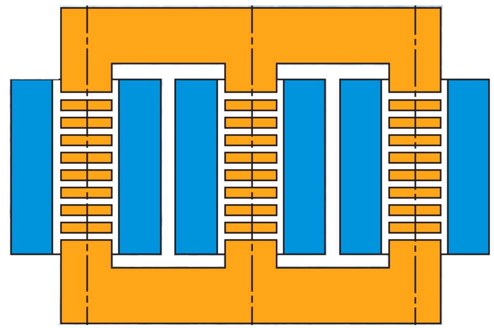
Global technologies for substation applications
Making substations smaller



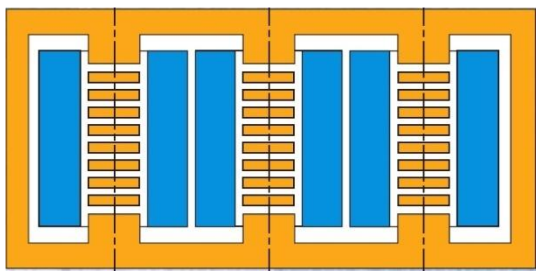
Global Technologies for Substations
Technology – Shunt Reactors



1-phase



3-phase three legs



3-phase five legs

Conventional Solution

- 3 single-phase units

Innovation

- 1 three-phase unit; 5 leg/limb design for single pole reclosing or operation
  - 20% equipment cost savings
  - Additional EPC cost savings: foundations/installation

Global Technologies for Substations
Technology – Variable Shunt Reactor (VSR)

An

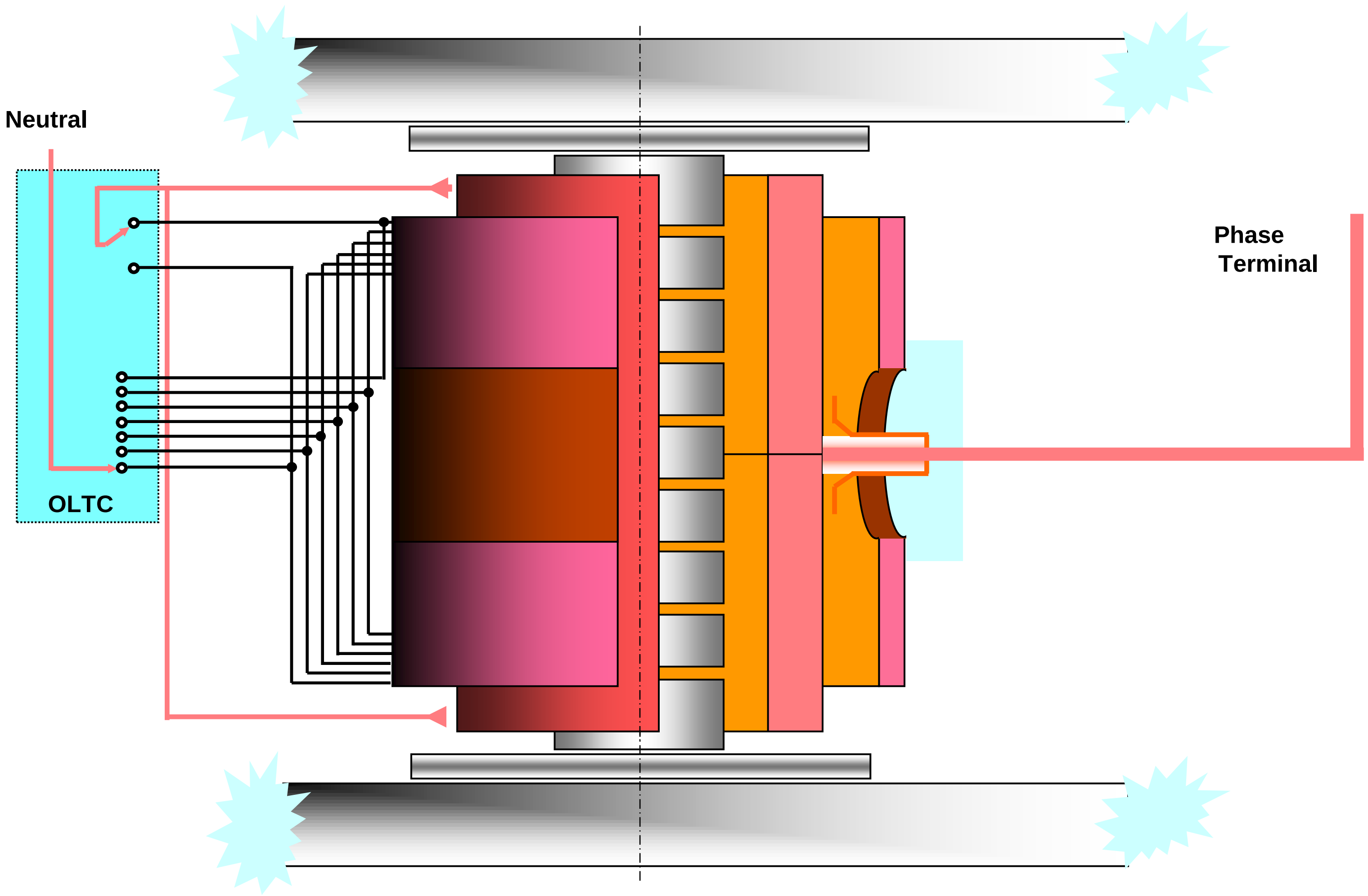
Unconventional

Reactor

Built With

Conventional

Technology



Global Technologies for Substations
Technology – Variable Shunt Reactor (VSR)

Conventional Solution

- 2 banks of 3 single-phase units (6) or 2 three-phase units (2)
- Improved reliability over high voltage air core reactors

Innovation

- 1 Variable Shunt Reactor
  - Eliminate frequent switching of reactors; reduce voltage step change
  - Lower price and losses than 2 unregulated units; smaller footprint

Global Technologies for Substations
Technology – IEC 61850

IEC and IEEE joined forces in 1999 and defined…

IEC 61850 "Communication Networks and Systems in Substations"

- IEC 61850 – first global standard in the Utility field
- Developed by 60 domain experts
- Supported by all major vendors
- Very fast acceptance by the market… *except in the US, but picking up steam*

Global Technologies for Substations
Technology – IEC 61850

Introduction and overview	Part 1
Glossary	Part 2
General requirements	Part 3
System and Project management	Part 4
Communication requirements	Part 5
Communication model (Data model and Services)	Parts 7-1 to 7-4
Substation Configuration Language (SCL)	Part 6
Conformance testing	Part 10

Part 8

- Part 8-1 : Mapping for MMS-TCP/IP-Ethernet
- Part 8-x : for Future Use

Station Bus

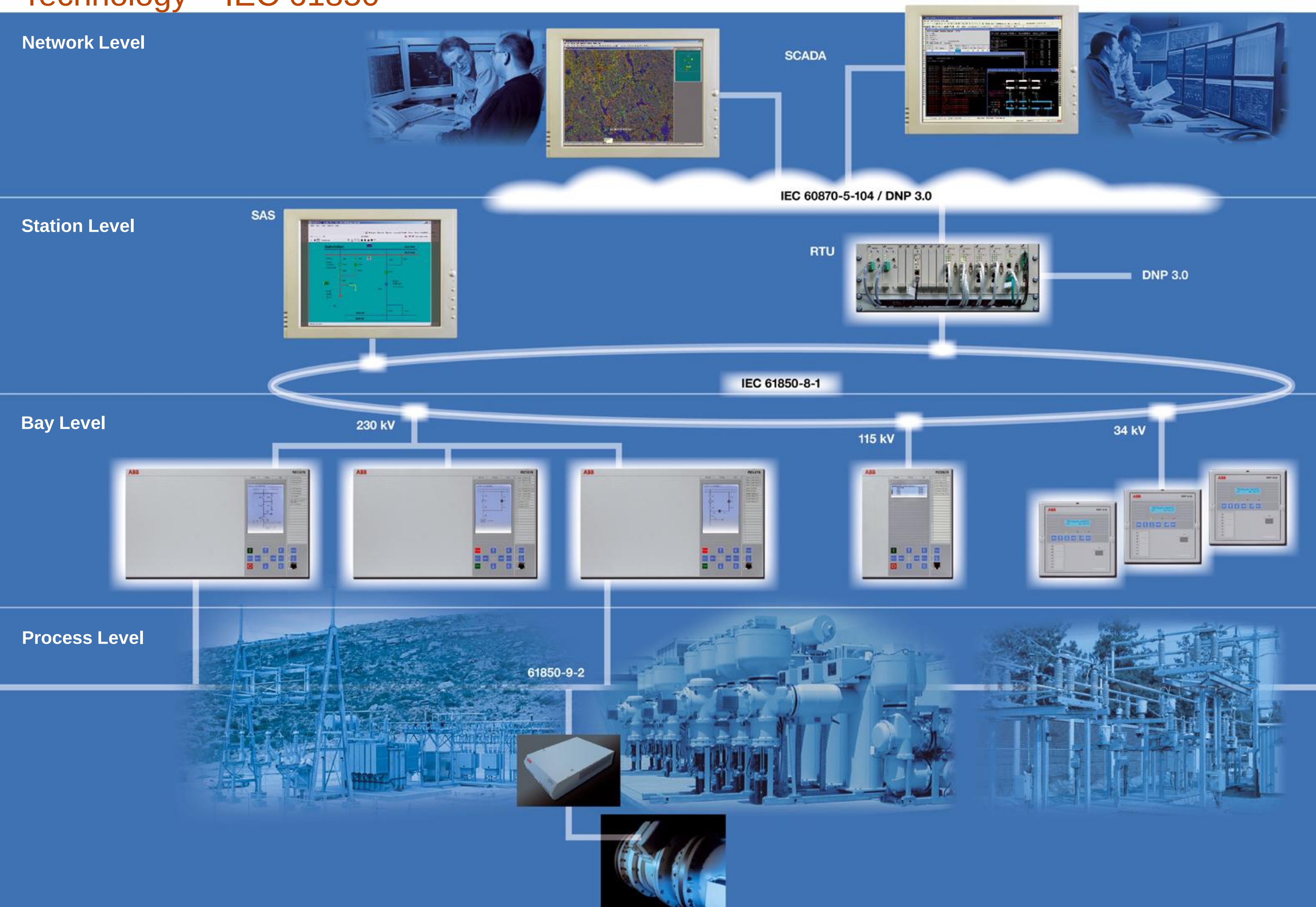
Part 9

- Part 9-1 : serial unidirectional point-to-point
- Part 9-2 : Mapping on IEEE 802.3(Ethernet)

Sampled Values (Process Bus)

Global Technologies for Substations

Technology – IEC 61850



Global Technologies for Substations
Technology – IEC 61850

TERNA SICAS Program for 380/220/150kV S/Ss, Italy

Large-scale standardization of IEC 61850-compliant solutions

Creation, homologation and supply of:

- 40 type-tested bay control and protection solutions
- High-quality user interface, standard logics and sequencer
- Incorporation of 3rd party IEDs and units with IEC 61850 communication interfaces

Efficient project implementation

EGL 380kV Laufenburg Substation, Switzerland

The world's first HV substation with IEC 61850-compliant SA

Stepwise retrofit of seven out of 17 bays:

- New control and redundant protection
- Gateway to existing station HMI
- Integration of 3rd party Main 2 IEDs with IEC 61850 communication interfaces

Sustainable concept for easy migration of remaining bays/station HMI.

DEWA Frame contract, Dubai

Supply of 20 IEC 61850-based SA systems

State-of-the-art systems for new 132/11 kV S/Ss:

- Short lead times realized by highly qualified project team
- Redundancy concept, independent key components and physically separated communication networks
- Proven technology and functionality

Safeguarded investment into interoperable systems for any make of switchgear.

CANADA

Teck Cominco, Waneta S/S 230/63kV

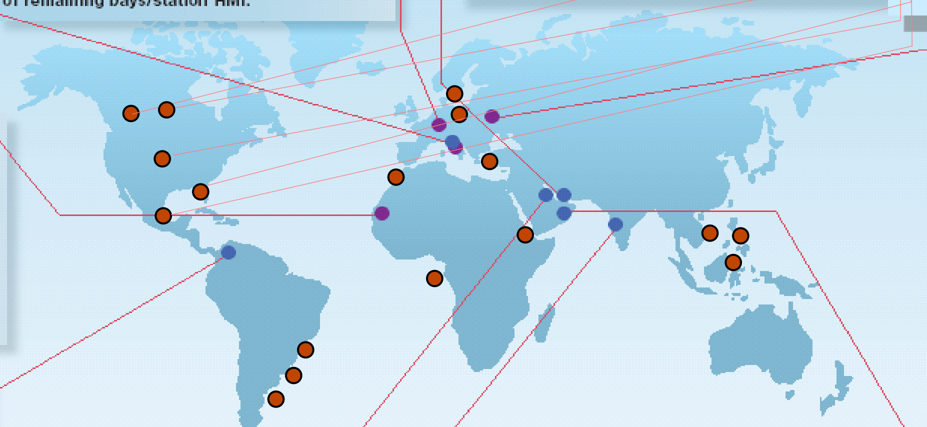
EPCOR East Industrial S/S 240/25kV

Manitoba Hydro S/S 230 kV

USA

TVA Bradley S/S 500/161kV

Formosa Plastics S/S 138/13.8 kV



Senelec's Hann 90/30kV S/S, Senegal

Refurbishment of Senelec's most important substation

- New IEC 61850-compliant bay control and protection
- Redundant station level system
- Integration with Network Control and Dispatching Centers

Future-proof solution for existing 90kV AIS as well as new 30kV GIS

NEK refurbishes its HV S/Ss Dobrudja & Varna, Bulgaria

The first 400/220/110 kV S/Ss to be refurbished obtain IEC 61850-compliant SA

- Different configurations: double busbar, 1½ c.b., ring
- Redundant station servers and operator workstations in hot standby mode
- Integration of some 70 new REx670 IEDs and four REB500 numerical busbar protection systems
- Integration of 110 kV signals via RTU as well as existing REL521 line protection

Optimal life cycle management through future-proof retrofit concept

ENELVEN's and ENELCO's Soler & Médanos S/Ss, Venezuela

IEC 61850 is key to the utilities' strategy for SA throughout their grids

- Uniform system architecture with redundant station level for high availability
- Redundant Ethernet ring with switches for direct connection of all control & protection IEDs with IEC 61850 communication interface
- High-quality operator interface with proven applications for control and monitoring of the entire 138/24 kV & 115/13.8 kV S/Ss

Enhanced efficiency with harmonized SA systems for new and retrofit substations

MEW's Financial Harbour, Sitra & Buquwwah S/Ss, Bahrain

The three 220/66/11 kV GIS substations will strengthen the grid and increase the reliability of the power supply

- Redundant Station HMI with redundant, independent gateways
- One product family, REx670, for Control and Protection
- Bay/Section control unit REC670 for all three voltage levels
- REB500 busbar and breaker failure protection

Six new HV substations for PGCIL, India

400/220 kV GIS S/S at Maharanibagh, 400/220 kV AIS S/Ss at Bhatapara, Fatehbad, Raigarh and Rajagarh, 400 kV AIS S/S at Bina

PGCIL's new substations will be controlled and monitored by IEC 61850-based SA systems featuring:

- Redundant Station HMI using MicroSCADA Pro
- One product family, REx670, for Control and Protection
- REC670 bay control unit for all voltage levels
- REB500 numerical busbar protection system with IEC 61850 communication interface
- Integration of 3rd party Main 2 IEDs on IEC 61850 platform

220/132/33kV S/S for Sohar Industrial Area, Oman

Automation with verified IEC 61850 implementation for new GIS substation

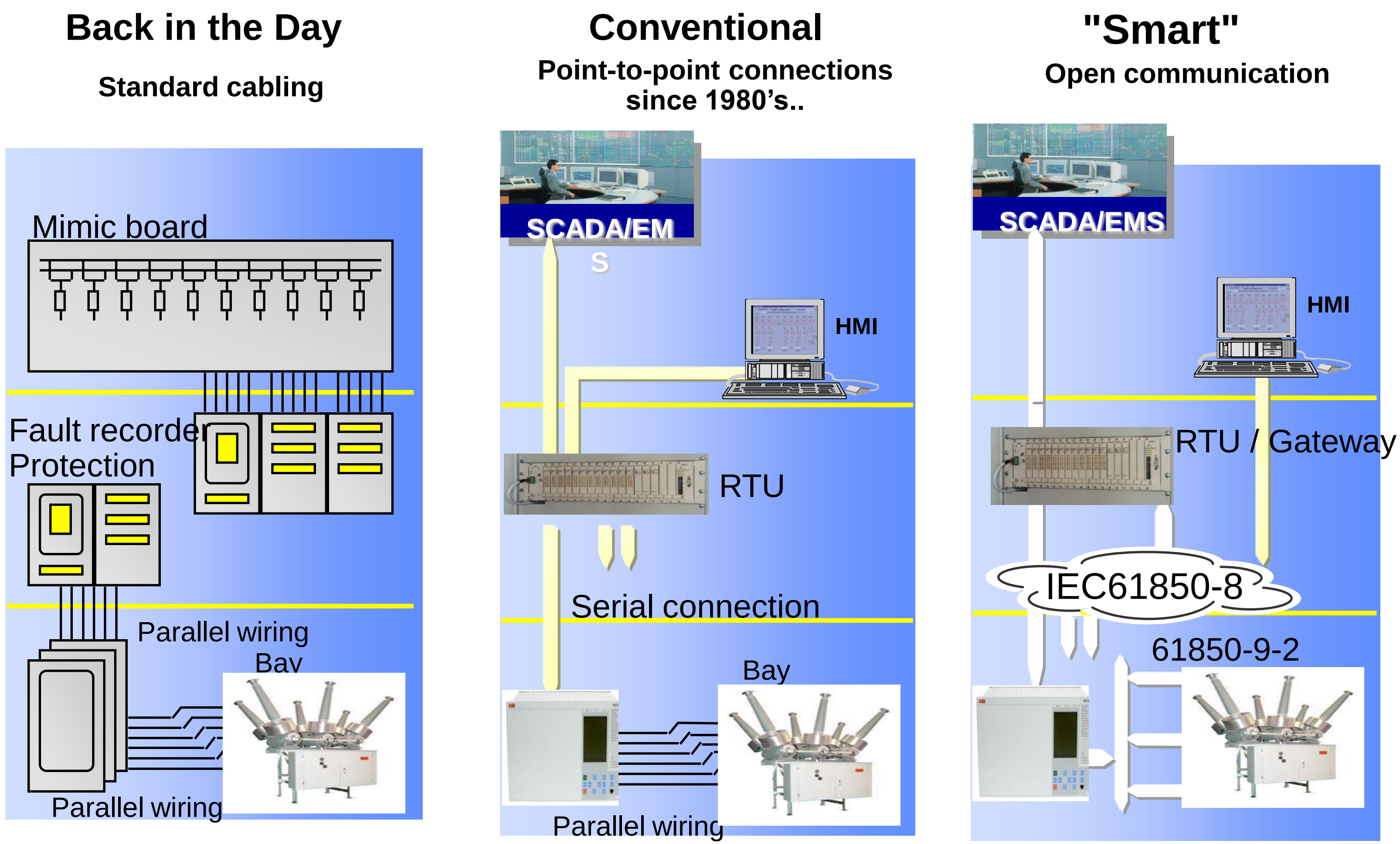
- Redundant Station HMI
- Scaleable bay control unit REC670 for all three voltage levels

Enhanced operational efficiency and safety through optimized solution

● New installation

Overall ABB involved in > 300 IEC 61850 projects

Global Technologies for Substations
Technology – IEC 61850



Global Technologies for Substations
Power supply for urban environments

- Inner-city substation concepts
- Smoothly integrated into urban surroundings – invisible and safe for the public
- Enables high voltage levels near to load centers for high quality power supply

Indoor Substations

- Integration into buildings
- Architectural incorporation into existing or new developed urban areas

Underground Substations

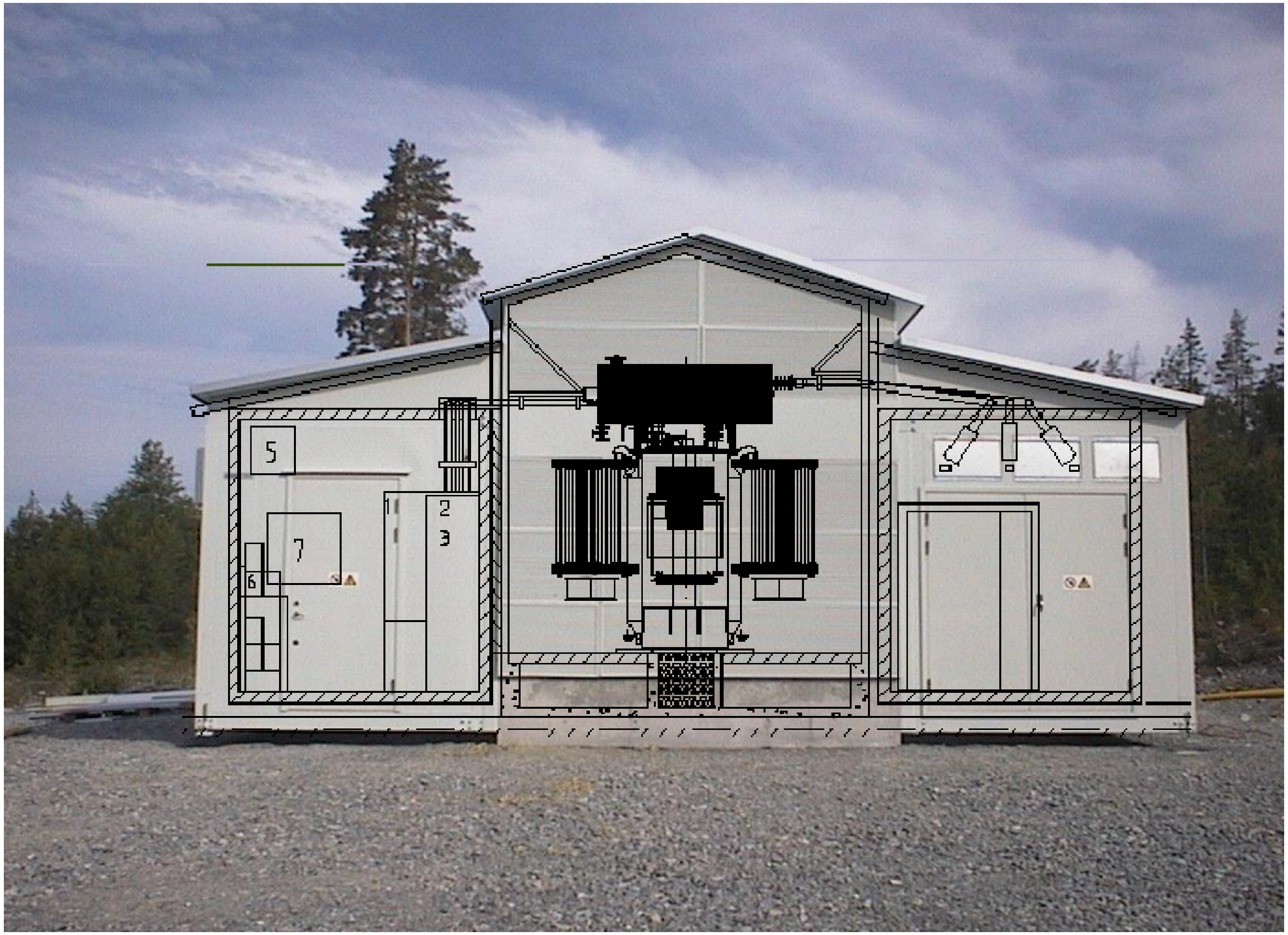
- Whole substation underground

Global Technologies for Substations
Technology – Invisible Substations (Indoor)

- High availability
- Low cost for preparation of land
- Pre-fabricated
- Short erection time at site
- Low maintenance cost
- Can easily be moved
- Environmental friendly
- Personnel safe

ABB

Global Technologies for Substations
Technology – Invisible Substations (Indoor)



Global Technologies for Substations
Technology – Invisible Substations (Indoor)

- Modularized solution
- Voltage range 34.5 – 161kV
- Withdrawable Circuit Breakers

Global Technologies for Substations
Technology – Invisible Substations (Indoor)

Global Technologies for Substations
Technology – Invisible Substations (Indoor)

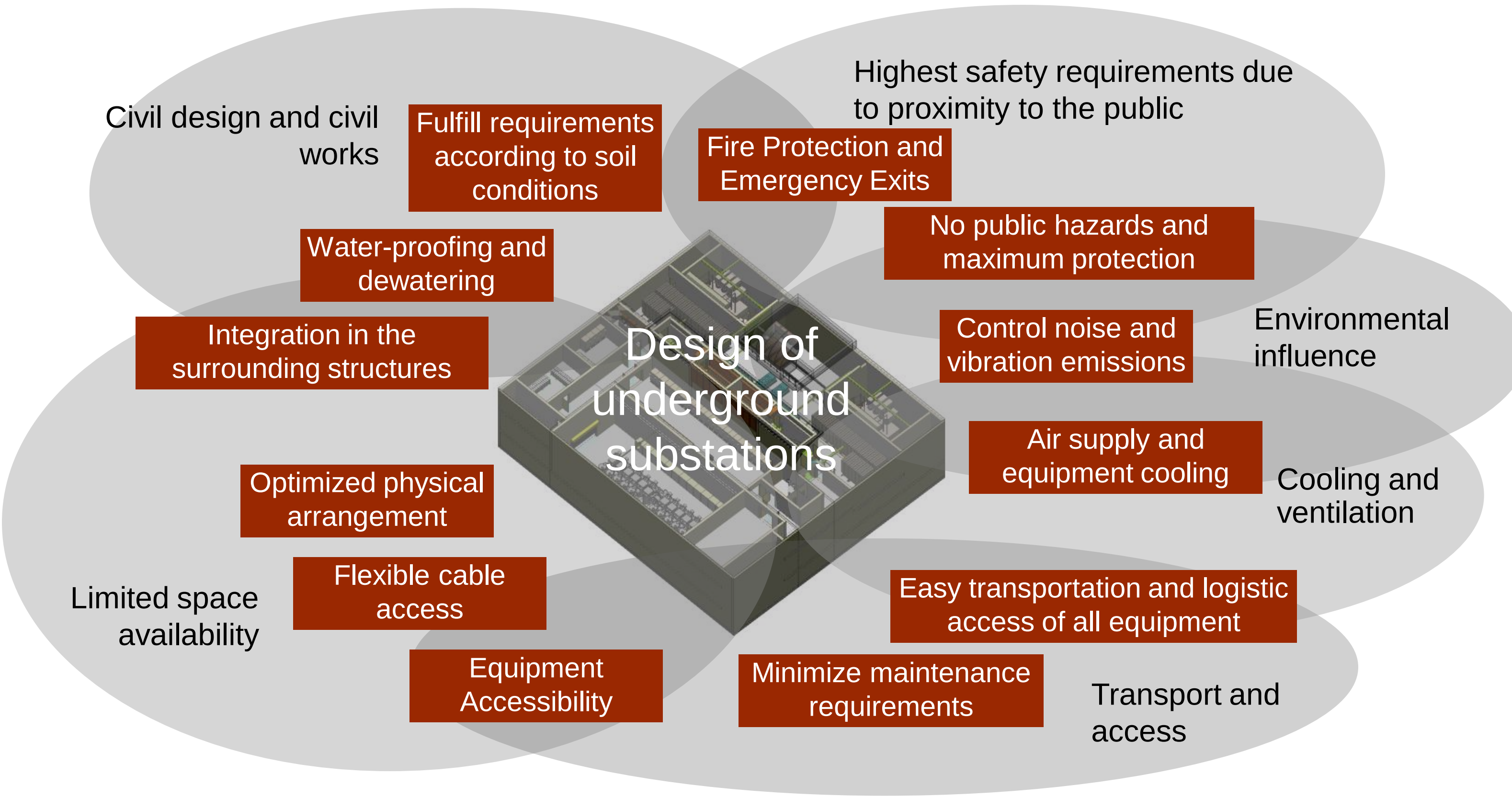
Global Technologies for Substations
Technology – Invisible Substations (Indoor)

Global Technologies for Substations
Technology – Invisible Substation (Underground)

- Below a building or building complex
- Underneath parks or green space
- In a parking deck
- At traffic circles or under road crossings
- Into other public places (airports, sports complexes etc.)

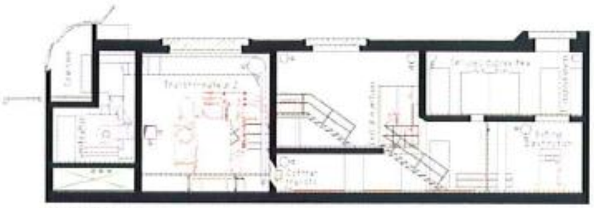
→ The ABB underground concept is free to be integrated into any urban complex

Global Technologies for Substations
Technology – Invisible Substation (Underground)



Optimum technical solution and overall cost

Beauregard, Switzerland



Customer need

- Replacement of 50 year 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

Lusail – Boulevard I and Boulevard II, Qatar

Customer need

- HV power supply as pre-requisite for new infrastructure development in Lusail
- Substations could not impact local 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 sytems

Customer benefits

- Critical on-time delivery met developer needs
- Zero influence on public surroundings

ABB

Lusail – Boulevard I and Boulevard II

Gouttes d‘Or, Switzerland

Customer need

- Reliable power distribution for the urban area of Neuchatel
- Replacement of the former station

ABB‘s response

- New underground substation
- 60 kV HV-GIS
- 8 kV MV-AIS
- Two transformers 20 MVA
- Selection of most compact ABB equipment enabling space optimized layout
- Space optimized access and escape routes

Customer benefits

- New space for park, recreation and parking areas
- Smooth architectural integration into the urban landscape surrounding the site

Gouttes d‘Or, Switzerland




Heidelberg UW Altstadt, Germany

Customer need

- Advanced power supply and distribution in an area within Heidelberg historic district

ABB‘s response

- Integration of all substation euipment into a historic building
- 110kV GIS
- Flood protected installation

Customer benefits

- Station invisible to the public and compliant with historic district requirements

Global Technologies for Substations
Technology - Economic Evaluation of Designs

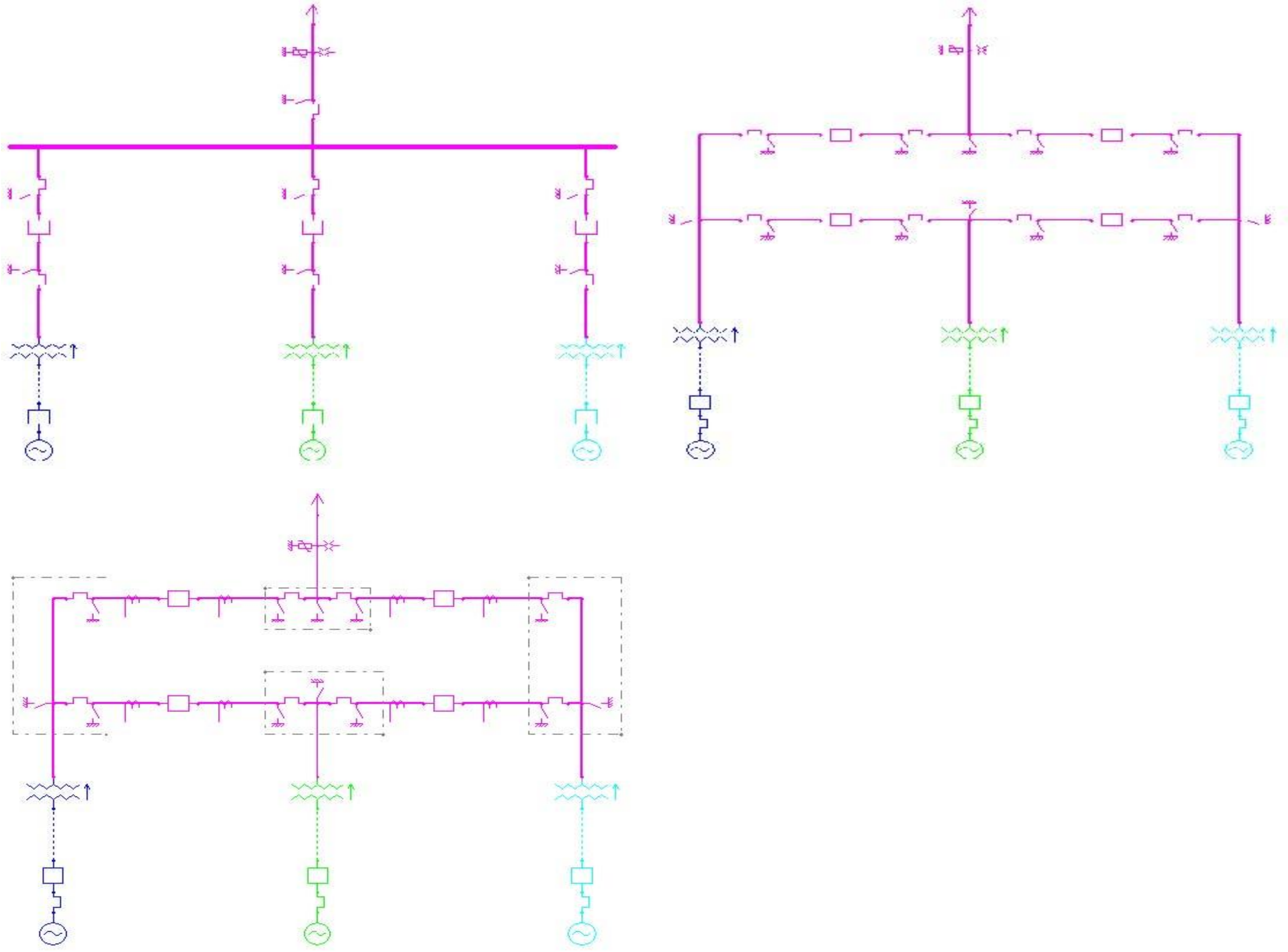
Parts of an Economic Evaluation of Substations

- Reliability Analysis
- Predict the Total Project Cost
  - Initial Costs
  - Operation & Maintenance Costs
  - Cost of Power Interruption
- Optimize Reliability vs. Cost
- Factor in Intangibles (safety, aesthetics)

Analytical Software Tools

- SubRel™
- SubRank™
- ETAP

Global Technologies for Substations
Technology - Economic Evaluation of Designs



Global Technologies for Substations
Technology - Economic Evaluation of Designs

TABLE 1. TRANSMISSION LINE RELIABILITY

Configuration		Stochastic	Determined	Total
AIS Collector Bus	OF	0.2115	0.8	1.0115
	OD	0.7479	6.4	7.1479
AIS Ring Bus	OF	0.1176	0.4	0.5176
	OD	0.3047	3.2	3.5047
GIS Ring Bus	OF	0.0176	0.0667	0.0843
	OD	0.1039	0.9338	1.0377

Maintenance Failure

Global Technologies for Substations
Technology - Economic Evaluation of Designs

$$LCC = IC + [FC + VC] * \left[\frac{(1+p)^n - 1}{p * (1+p)^n} \right]$$

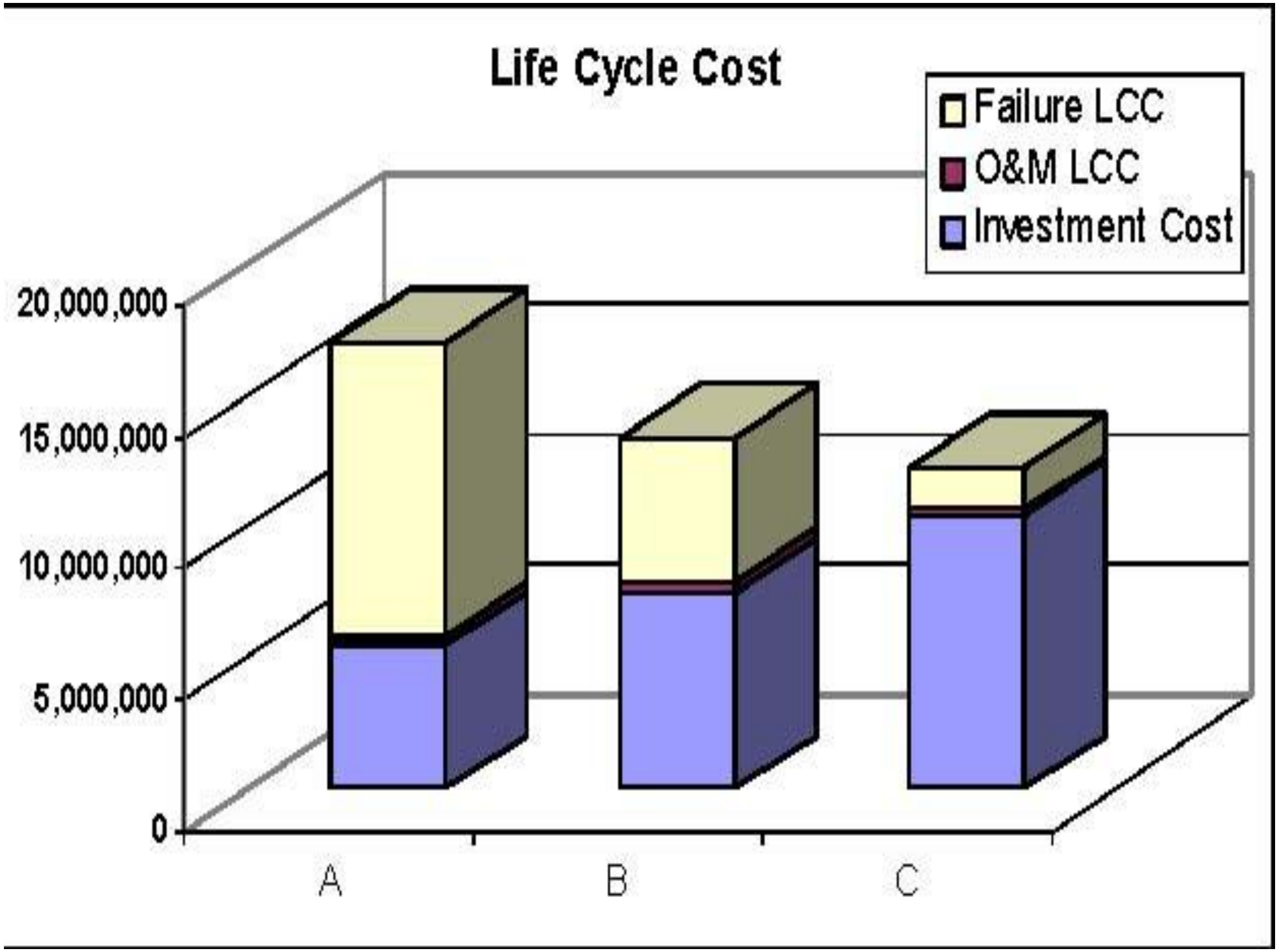
where:

LCC	=	Life Cycle Cost
IC	=	Investment Cost
FC	=	O&M Cost, i.e., fixed annual cost
VC	=	Interruption Cost, i.e., variable cost
n	=	substation planned life time
p	=	Interest rate

SubRel™

- Interruption Cost
  - Cost of Interrupted Energy $/kWh – Duration
  - Cost of Interrupted Power $/kW – Frequency

Global Technologies for Substations
Technology - Economic Evaluation of Designs



Global Technologies for Substations
Summary

- Footprint – space savings – making substations smaller
- Reliability, Availability, & Maintainability
  - Indoor vs. Outdoor (shell protection)
  - Less Equipment
- Safety and Security
- Environmental & Permitting (aesthethics, sound)
- Closer to the Load Centers
- Complements Underground Cables
- Life Cycle Cost Effectiveness

Customer Training at the Marriott World Center
Power Systems Substations

4/19/2011 - Tuesday	Time	Code	Location	Title	Presenter
Session 1	9:30 AM	EPS-124-1A	Technology & Solution Center (Theater #1)	Logistics planning for large substation projects	Scott Andries
Session 2	11:00 AM	CPS-143-1	Denver Conference Room	Substation alliance concepts: Case Study	Bob Reymers
Session 3	1:30 PM	CPS-114-1	Denver Conference Room	Gas insulated switchgear technology evolution: Case Study	Bob Reymers
Session 4	3:00 PM	EPS-144-1A	Technology & Solution Center (Theater #1)	Substation design fundamentals: How substations are designed and deployed in the market place	Tracey Evers
Session 5	4:30 PM	WPS-115-1A	New Orleans Conference Room	Global technologies for substaion applications: Worldwide view of substaiton technology	Scott Andries
4/20/2011 - Wednesday	**Time**	**Code**	**Location**	**Title**	**Presenter**
Session 6	8:00 AM	EPS-144-1B	Technology & Solution Center (Theater #1)	Substation design fundamentals: How subtations are designed and deployed in the market place	Tracey Evers
Session 7	9:30 AM	WPS-100-1	San Francisco Conference Room	AC substation grounding for safety: Detailed review of design steps related to substation grounding	Mike Eads
Session 7	9:30 AM	WRE-102-1A	Tampa Conference Room	Electrical balance of plant for renewable energy (Renewable Energy: Product Applications Track)	Melvin Brown
Session 8	11:00 AM	WPS-135-1	Grand Ballroom 5	Rigid bus design for AC substations: Electro-mechanical considerations for substation design	Paason Rojanatavorn
Session 9	1:30 PM	WPS-137-1	Denver Conference Room	Shake, rattle and roll: seismic design considerations for substations	Paason Rojanatavorn
Session 11	4:30 PM	WPS-115-1B	Grand Ballroom 11	Global technologies for substation applications: Worldwide view of substation technology	Scott Andries
Session 11	4:30 PM	WPS-138-1	Grand Ballroom 12	Shore-to-Ship: Shore-side electrical system for docked ships (Transmission System Solutions Track)	Melvin Brown
4/21/2011- Thursday	**Time**	**Code**	**Location**	**Title**	**Presenter**
Session 14	11:00 AM	EPS-124-1B	Technology & Solution Center (Theater #1)	Logistics planning for large substation projects	Scott Andries
Session 14	12:00 PM	WPS-131-1	Grand Ballroom 12	Reliability-based transmission system planning (Transmission System Solutions Track)	Bob Reymers
Session 14	1:00 PM	WRE-102-1B	Grand Ballroom 13	Electrical balance of plant for renewable energy (Renewable Energy Product Applications Track)	Melvin Brown

Substations Sales & Marketing Team

Urban Strandberg
Vice President
Marketing & Sales
Phone: +1 919 856 3083
Cell: +1 925 330 7066
urban.strandberg@us.abb.com

Scott Andries
Business Development Manager
Large Transmission, Utilities
Phone: +1 919 856 2511
Cell: +1 919 522 6957
scott.andries@us.abb.com

Tracey Evers
Business Development Manager
Public Power, Caribbean
Phone: +1 919 856 3081
Cell: +1 919 961 1220
tracey.evers@us.abb.com

Robert Reymers
Business Development Manager
Key Accounts
Phone: +1 919 807 8260
Cell: +1 919 622 3967
robert.m.reymers@us.abb.com

Melvin Brown
Business Development Manager
Industrials & Renewables
Phone: +1 919 807 8253
Cell: +1 919 274 0346
melvin.brown@us.abb.com

Debbie Harvell
Marketing Specialist
Phone: +1 919 807 8280
Fax: +1 919 856 2400
debbie.b.harvell@us.abb.com

ABB

Meeting Rooms at the Marriott World Center
Reserved for Power Systems Substations

Monday, April 18th 4:30 pm – 5:30 pm
(Marco Island Meeting Room)

Tuesday, April 19th 4:30 pm – 5:30 pm
(Marco Island Meeting Room)

Wednesday, April 20th 5:30 pm – 6:30 pm
(Marco Island Meeting Room)

Reminders
Automation & Power World 2011

- Please be sure to complete the workshop evaluation
- Professional Development Hours (PDHs) and Continuing Education Credits (CEUs):
  - You will receive a link via e-mail to print certificates for all the workshops you have attended during Automation & Power World 2011.
  - BE SURE YOU HAVE YOUR BADGE SCANNED for each workshop you attend. If you do not have your badge scanned you will not be able to obtain PDHs or CEUs.

Power and productivity
for a better world™