Development trends in Substation Design

on behalf of SC B3

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Convenor Activity Area 1 (AA1)
« Substation concepts and development »

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Agenda

- Evolution of primary equipment and design
- Trends for substations in urban areas
- UHV see a renaissance
- IEC 61850 for secondary systems
- Future developments “around the corner”

Primary design principles

- Historically AIS S/S were designed for CB maintenance, since circuit breakers needed maintenance very frequently
- Single line configuration where accordingly built up with CB´s “surrounded” by DS

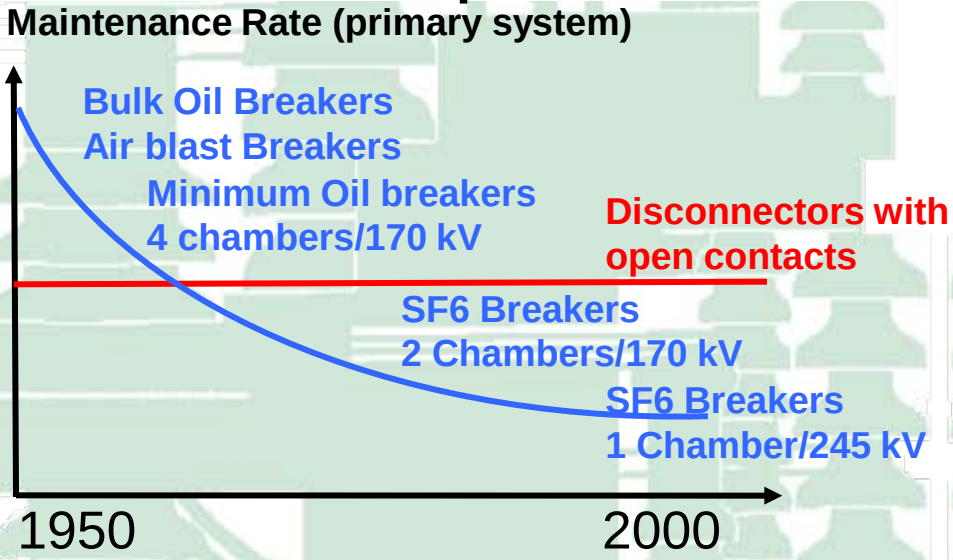
Evolution of CB´s and DS´s

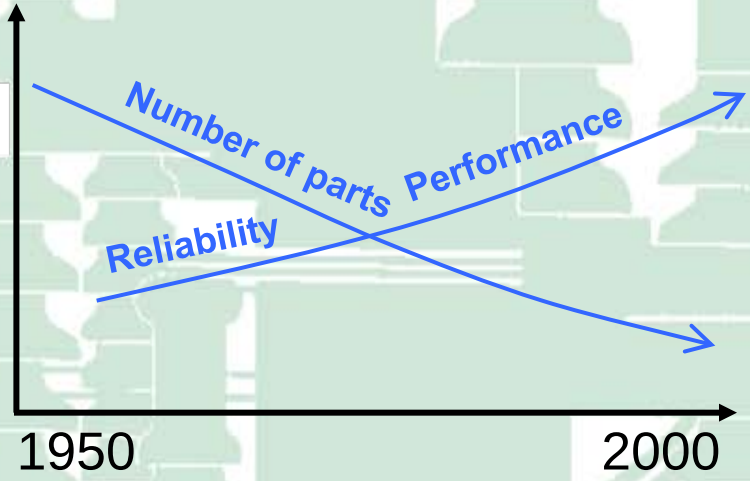
420 kV Air blast CB

420 kV Oil minimum CB

420 kV SF6 CB

- Modern CB´s require maintenance 15 years+, however open air DS´s unchanged





Primary design principles cont.

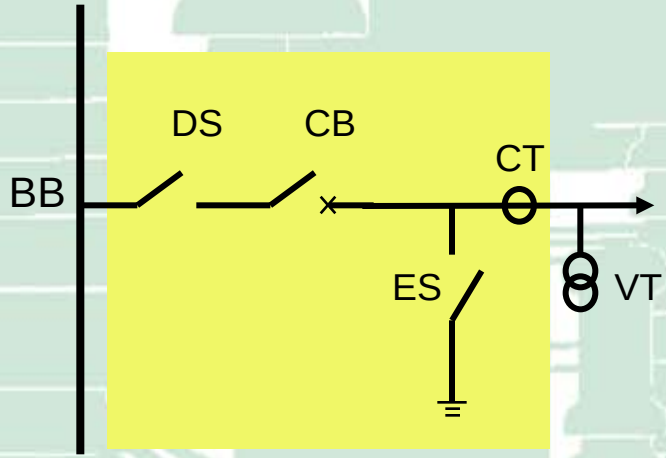
- Disconnecting function today more needed for maintenance of OH-lines, Power Transformers, Reactors etc.
- New designs with disconnecting function “together” with CB, instead of separate, has evolved
  - Hybrid
  - Disconnecting CB

  } Main Stream (SF6 encl. contacts)

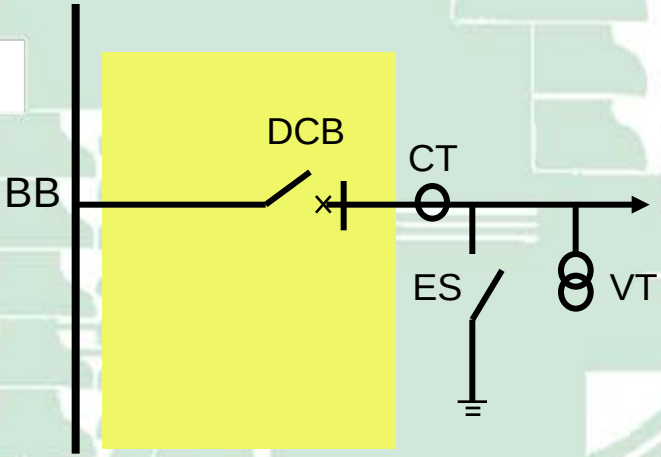
  - Rotating CB
  - Withdrawable CB

  } Niche products

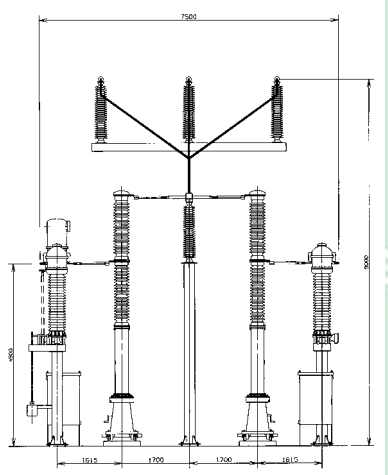
Hybrid



Disconnecting CB



Rotating CB



Withdrawable CB

Primary design principles

- Installing the disconnecting function together with CB
  - Reduce footprint
  - Extends maintenance intervals, for the solutions having all primary contacts in SF6
  - Resulting in an overall higher availability

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Utility challenges

Environment

- Reduce outlet of (CO2,…)
- Sound, visual impact, ….
- Interior (Personell safety)
- Exterior (Third party safety)

Electrical dependence

- Increased customer services
- Reliability
- Political pressure
- Investment decision

Utility

Profitability

- Reduce maintenance costs
- Reduce outages
- Minimize penalties
- Image

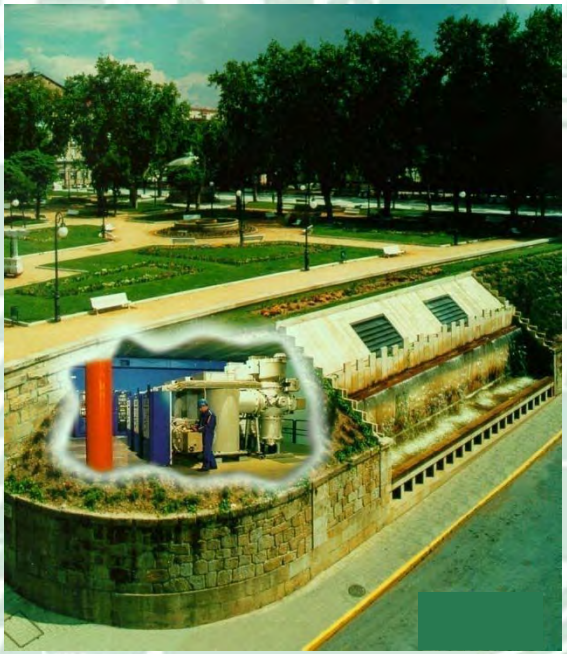
Legislation

- Report inventory of SF6
- SF6 leakage limited by law (California)

Problem with Urban substations

- Originally outskirt of city, now surrounded by residential buildings, offices, shopping centers, hotels etc.
- Usually open air substation, with not so nice aesthetic, society want power without seeing it
- Third party safety has become an issue
- Evolution driven by permitting and siting issues that have become the “long lead time” item, external (visual) view very important
- Making substation ”invisible” makes it easier to get acceptance by the society

Urban substations visual view



Pros with “invisible” solutions

- No substation fence and yard, building itself give the “shell” protection and third party safety
- Station modularized and as much as possible pre-manufactured
- Can be located close to the consumers, virtually ”invisible” in building or truly invisible underground
- Site work as little and short as possible, saves cost, shorten overall delivery time and minimize disturbance to neighbors during site activities

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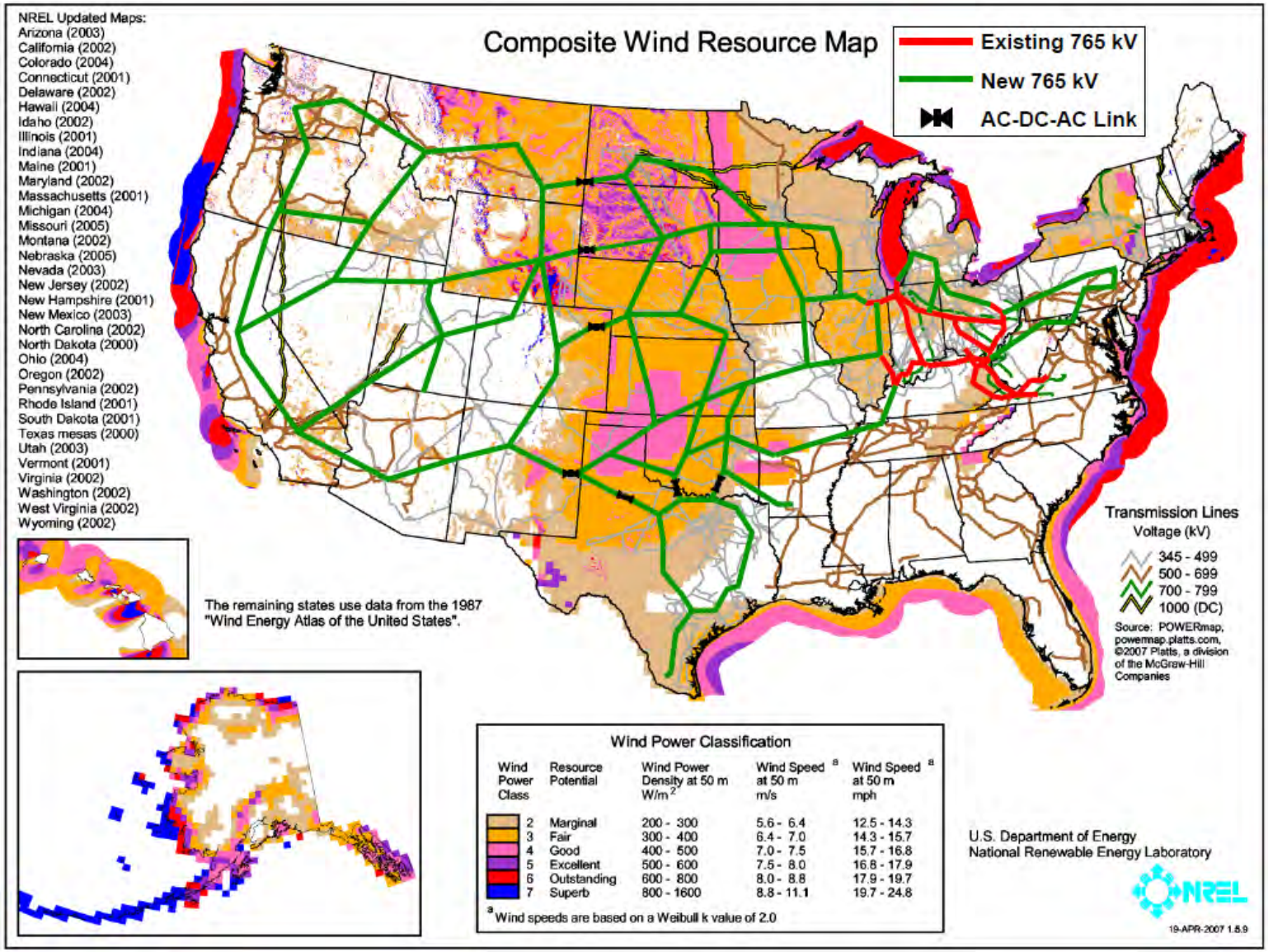
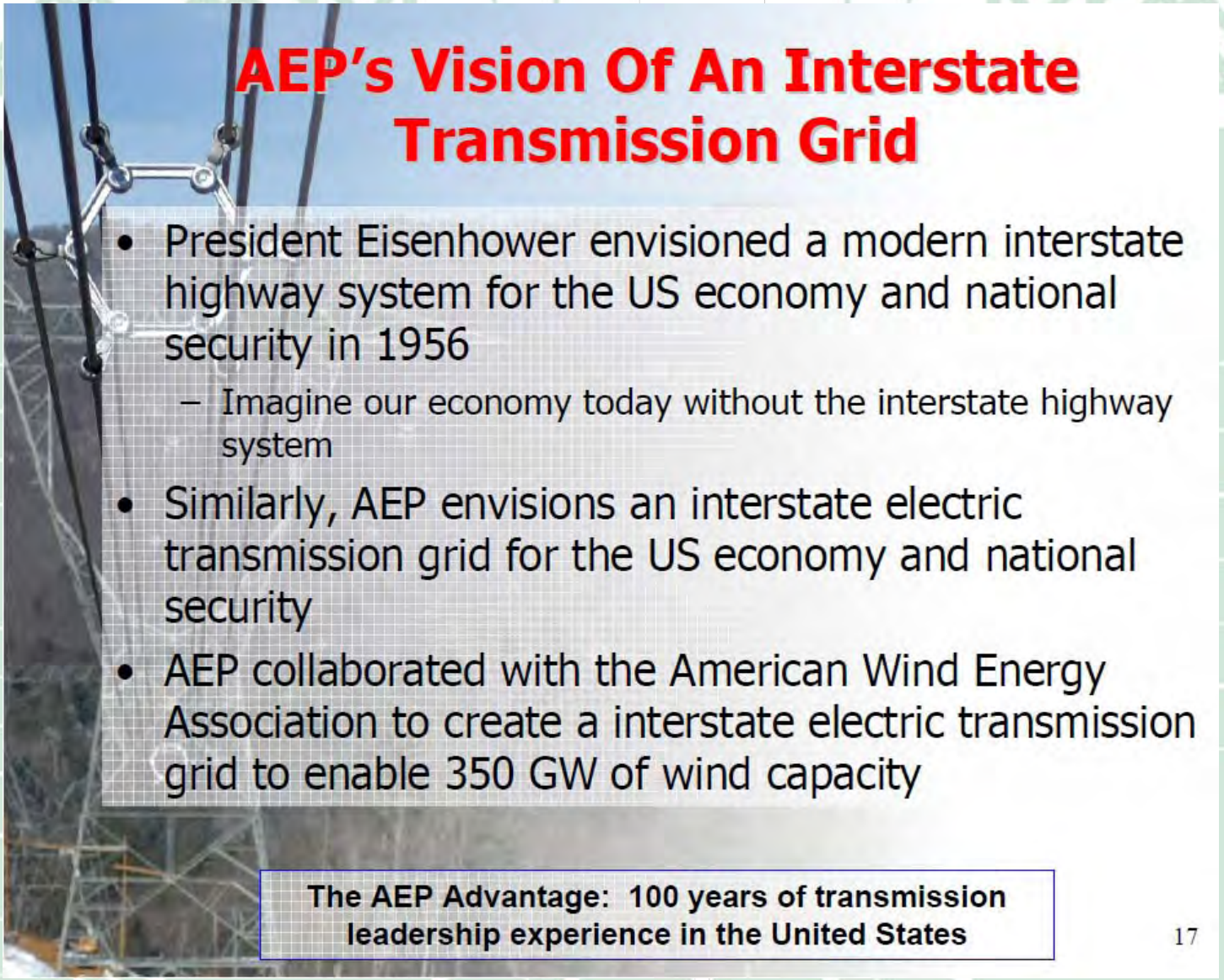
Existing and planned US 765 kV



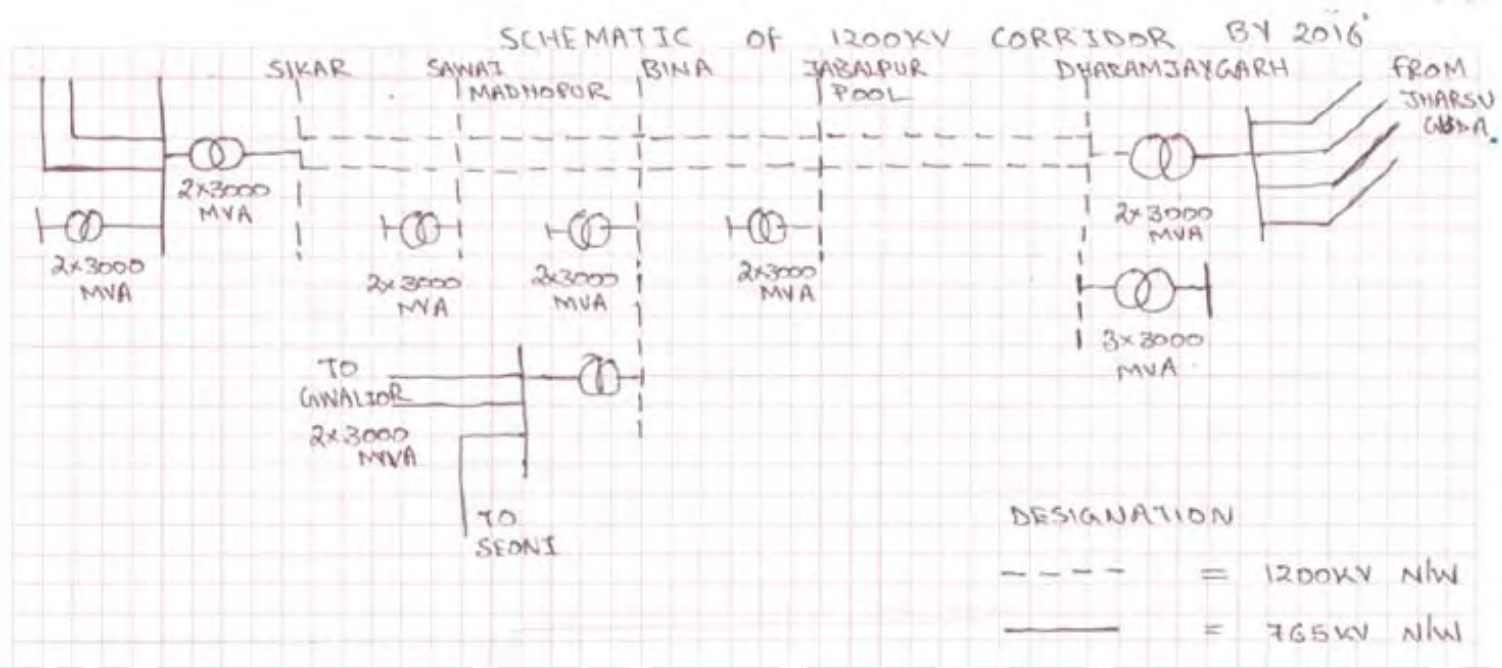
AEP INTERSTATE PROJECT: I-765



Source Mike Heyeck, AEP

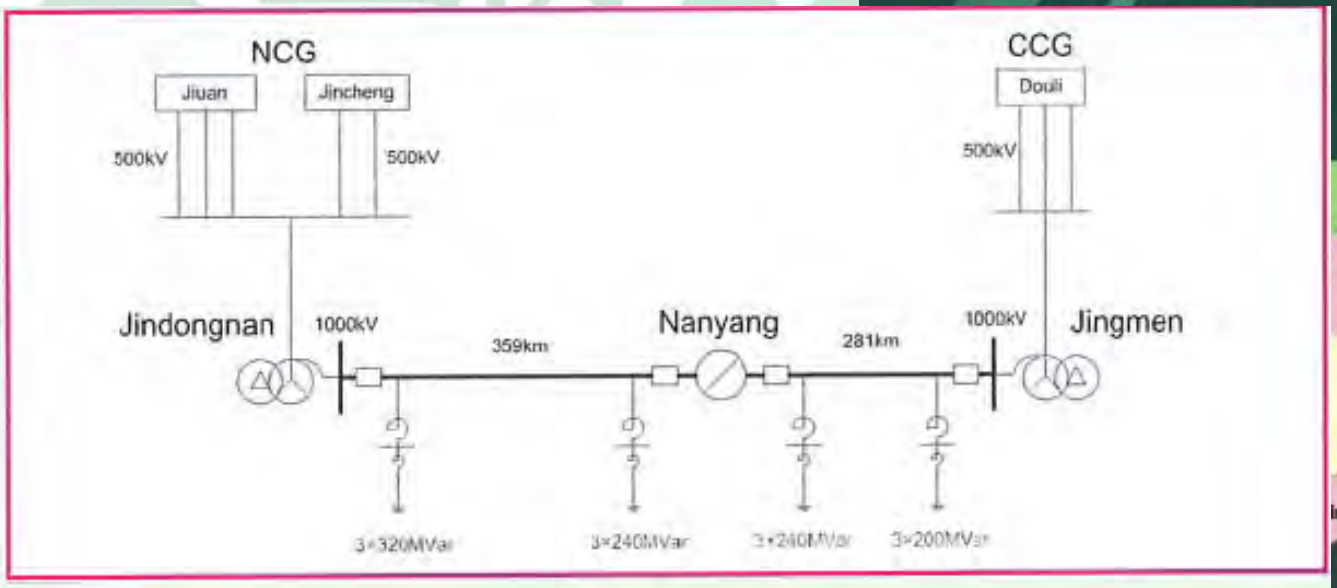
India 800/1200 kV AC-system

- Started to build a 800 kV network, first S/S in 2004, as a backbone for their system
- Planning for a 1200 kV system as a backbone to the backbone. (2016)



China 1100 kV AC-system

- South-North connection, in service January 2009
  Transmission capacity 2800 MW
- Number of large DC-connections West-East
  up to +/- 800 kV, 6400 MW



Project scheme

China 1100 kV AC-system

- Hybrid or GIS solutions

Japan 1100 kV AC-system

- Has been discussed since the 90-ies
- Upgrading existing 500 kV to 1100 kV
- Some lines already prepared for 1100 kV
- First stations about to be energized

CIGRE UHV-activities

- WG A3.22 Technical requirements for substation equipment exceeding 800 kV, TB 362 Dec. 2008
- WG B3.22 Technical requirements for sub-stations exceeding 800 kV, TB 362 Dec. 2009
- WG A3.28 Switching phenomena and testing req. for UHV & EHV equipment, May 2010
- WGB3.29 Field tests technology on UHV sub-station during constr. and operation, May 2010
- Common CIGRE/IEC Colloquia
  - Beijing, July 2007
  - New Delhi, Jan 2009
  - …

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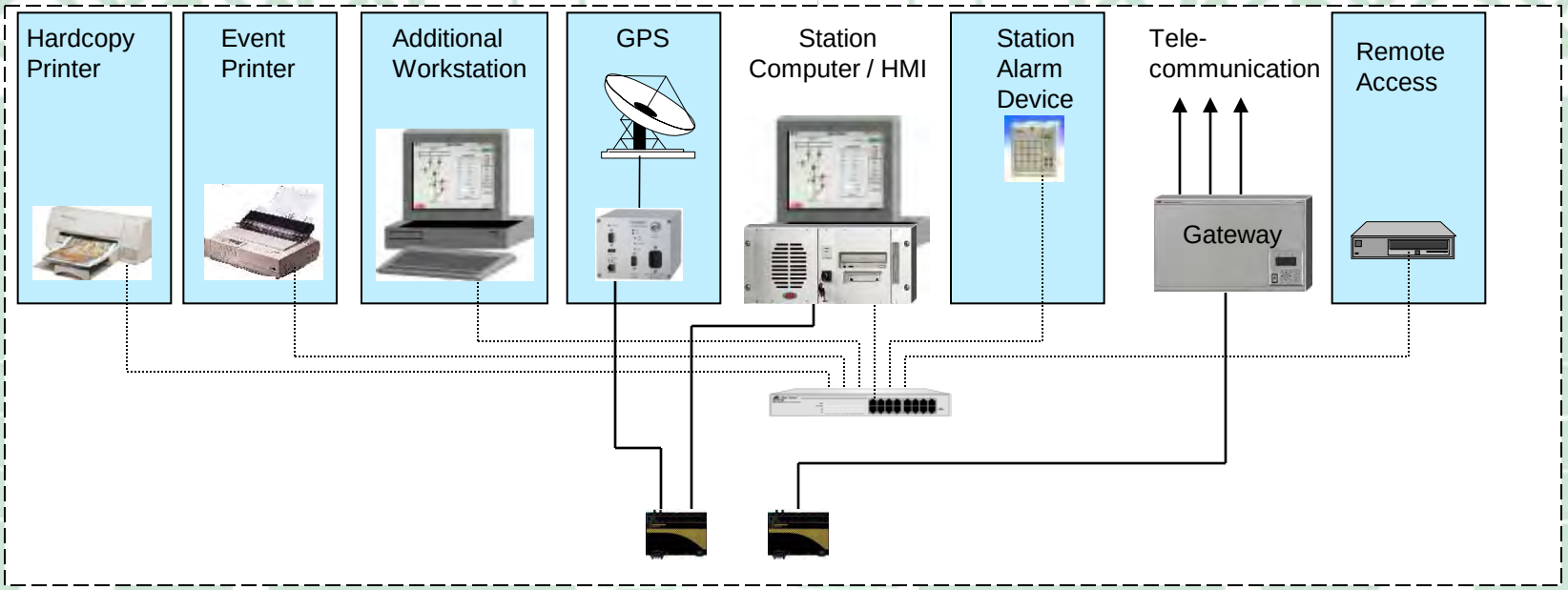
Station bus IEC 61850-8-1

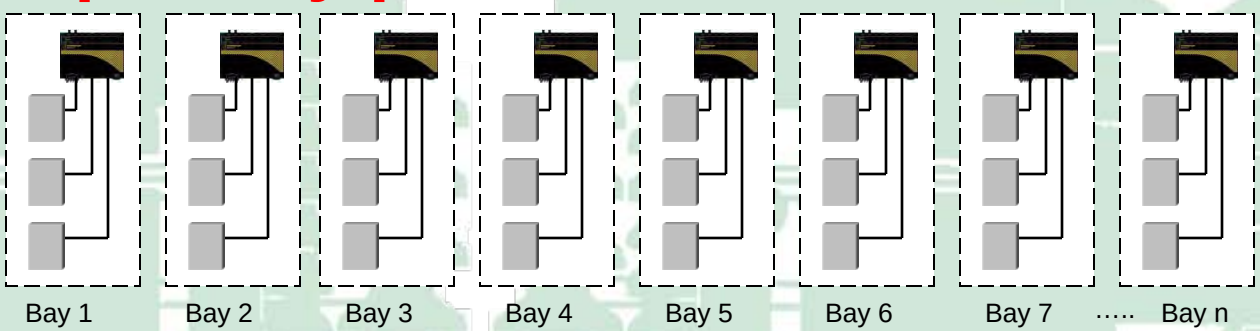
- Almost all customers use IEC 61850-8-1 protocol today, very fast transition from proprietary protocols
- Make it possible to use Intelligent Electronic devices (IEDs) from different manufacturers connected to the same station bus
- IEC 61850-8-1 also enable splitting between function and physical location

Station bus changes



Fibre **Proprietary protocols -> IEC61850-8-1**

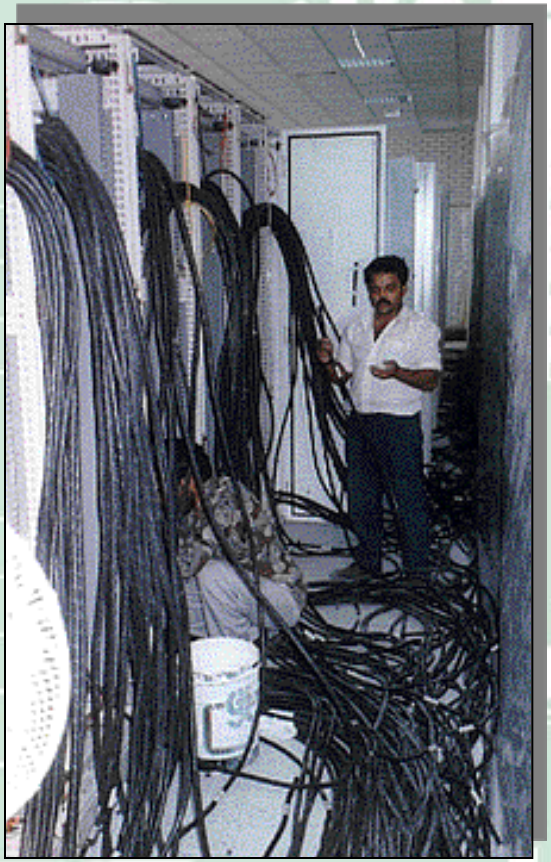
Copper

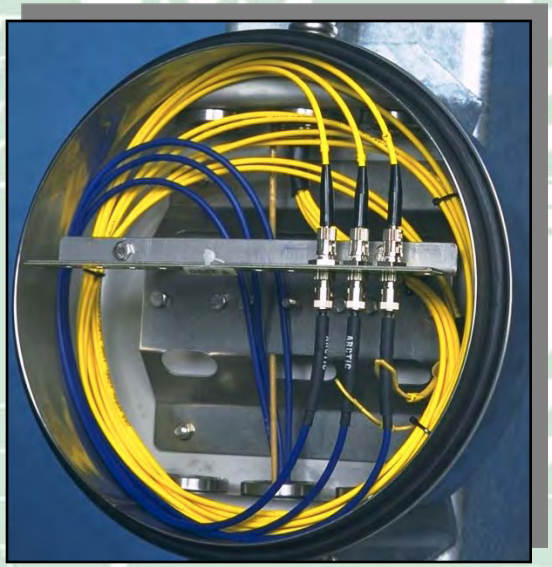


Process bus IEC 61850-9-2

- This is next step and a more revolutionary change, going from 1A/110 V -> fiber optic
- Will make it possible to exchange all copper cable, except for power feeding, to fiber optics
- Many pilots installed around the world
- First commercial delivery under way (Australia)
- Enabler for introduction of Non Conventional Instrument Transformers (NCIT)

Process bus introduction





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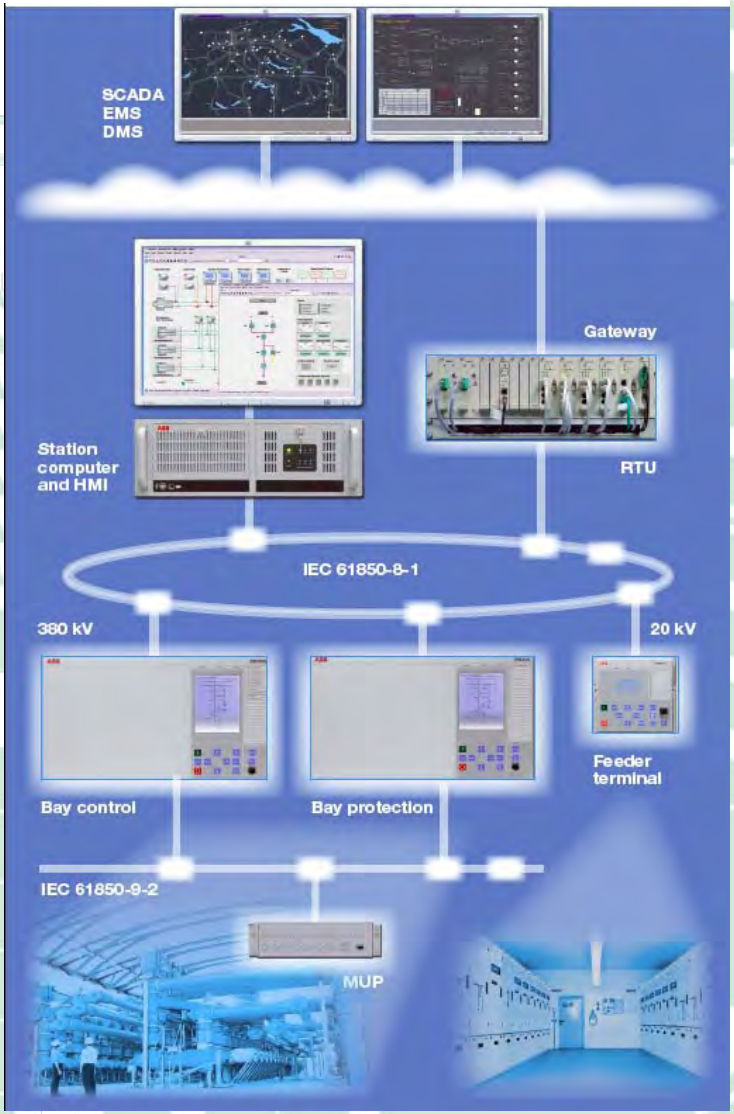
Non conventional instr. Transf.

- Process bus, IEC 61850-9-2
  - Will enable introduction of NCIT using fiber optics sensors
  - Environmental friendly no copper, steel, iron, concrete, insulation material, etc.
  - NCIT will be possible to integrate in other high voltage apparatus and further reduce the footprint of substation
  - Merging units on NCIT transfer sensor signals to 9-2 protocol

Future Substation

- IEC 61850-9-2 implemented
- Non conventional sensors for current and voltage
- Fiber optic cables throughout, except power feeding



Summary

- "Switching machines" with reduced maintenance (all primary contacts in SF6)
  - maintenance focus ->fault tolerant focus, 1 ½-CB, 2-CB
- Invisible substations for urban areas
  - Virtual invisible in buildings similar to surrounding
  - Truly invisible underground for city centers.
- UHV solutions renaissance in many countries
- IEC 61850 moving very fast
  - 8-1 station bus is already the preferred standard
  - 9-2 process bus in the doorstep
- NCITs around the corner, linked to 9-2 introduction

Thank you for your attention!