MULTI VENDOR IEC 61850 IMPLEMENTATION

A UTILITY'S PERSPECTIVE

ABHAY KUMAR & C.P.AWASTHI

POWER GRID CORPORATION OF INDIA LTD

27.09.17 AMSTERDAM

ABOUT POWER GRID CORPORATION OF INDIA LTD

* Owns & operates 1, 42,433 circuit kilometers of EHV & UHV Transmission Lines

* 224 Sub-Stations at 400 kV & 765 kV voltage level.

* 295,673 MVA Transformation Capacity

* Out of 224, 118 IEC 61850 based substations at 400 kV & 765 kV level.

A Glimpse of the Evolution of the Indian National Power Grid

One Nation - One Grid – One Frequency

August 2006
North synchronized
with Central Grid

One Nation
One Grid
One Frequency

March 2003
West synchronized
With East & North-East

Dec'2013
South
synchronized
with
NEW Grid

October 1991
East & North-East
synchronized

NEW Grid

South
Grid

Central Grid

NE

N

E

W

S

Raichur-Sholapur
Inter-Regional Link commissioned

Five Regional Grids
Five Frequencies

Present Transmission Network

POWER MAP OF INDIA
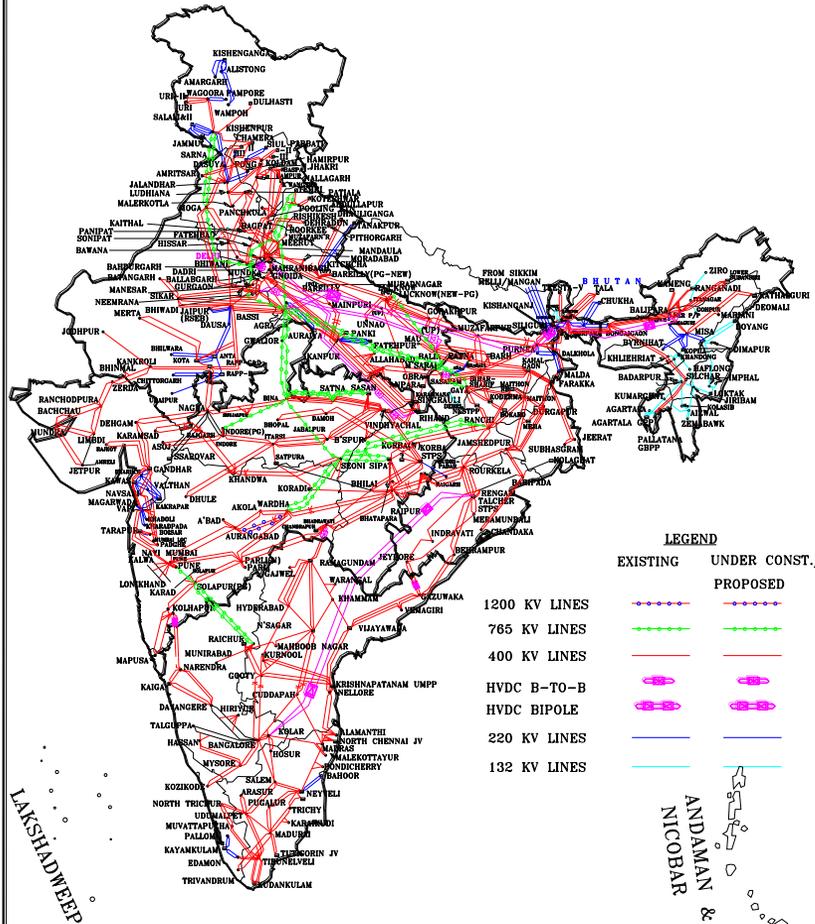
* **765kV/400kV lines: about 142,433 ckms**
* **HVDC Bipole (±800kV): 2600 ckm**
* **3 no.s HVDC Bipole (±500kV): 7,500 ckms**.
* **HVDC Back-to-back: 7 nos. (3000MW)**
* **FSC – 40 nos.; TCSC – 6 nos.**
* **SVC- 03 under operation & 1 under execution.**
* **STATCOM- 01 under operation & 13 under execution.**
* **Bipole VSC HVDC- 01 under execution**
* **Bipole LCC HVDC- 01 under execution**
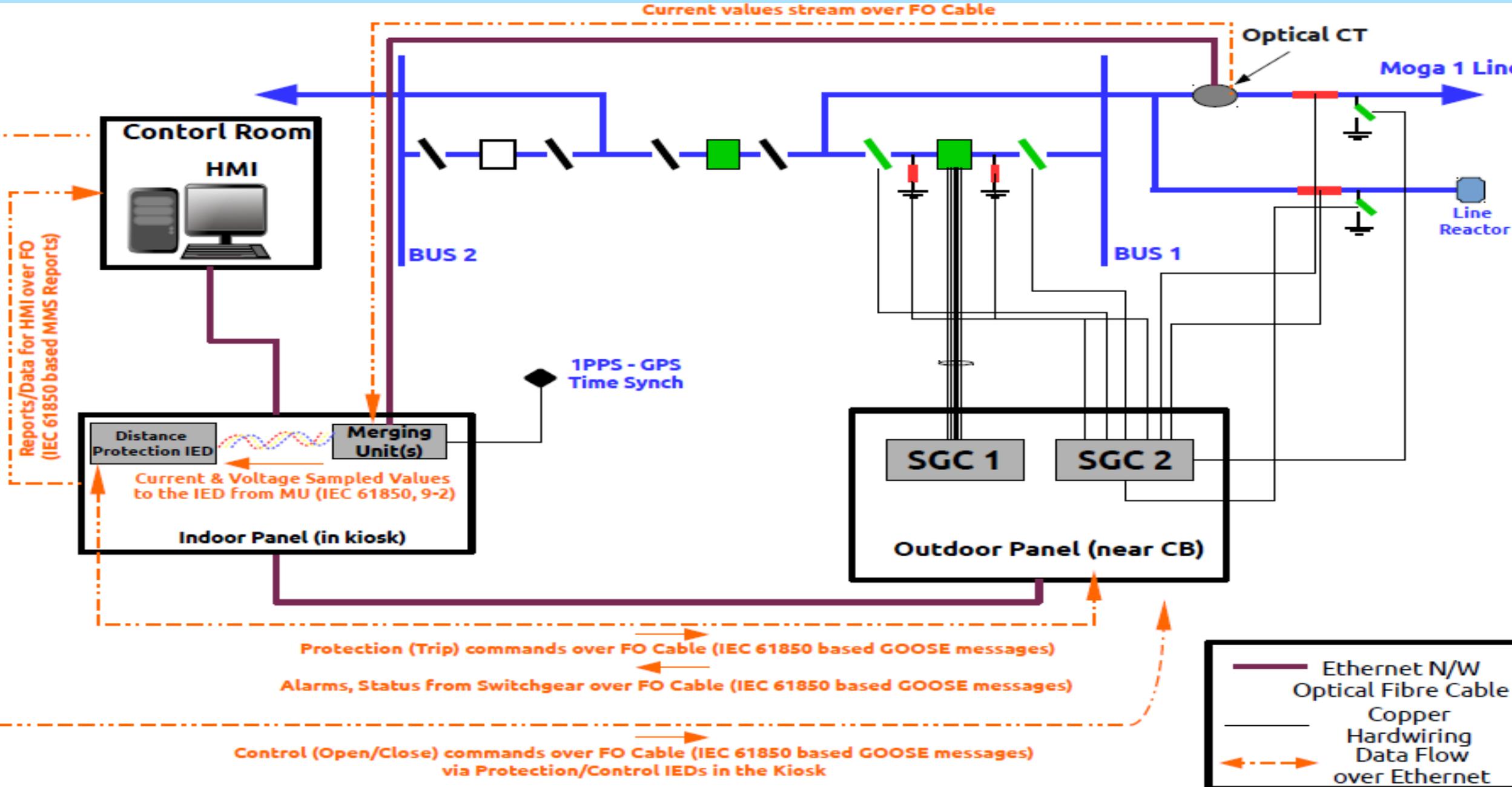
Interconnection with Neighboring Countries

- **Geographically wide spread Indian Grid facilitates interconnections with Neighboring countries.**
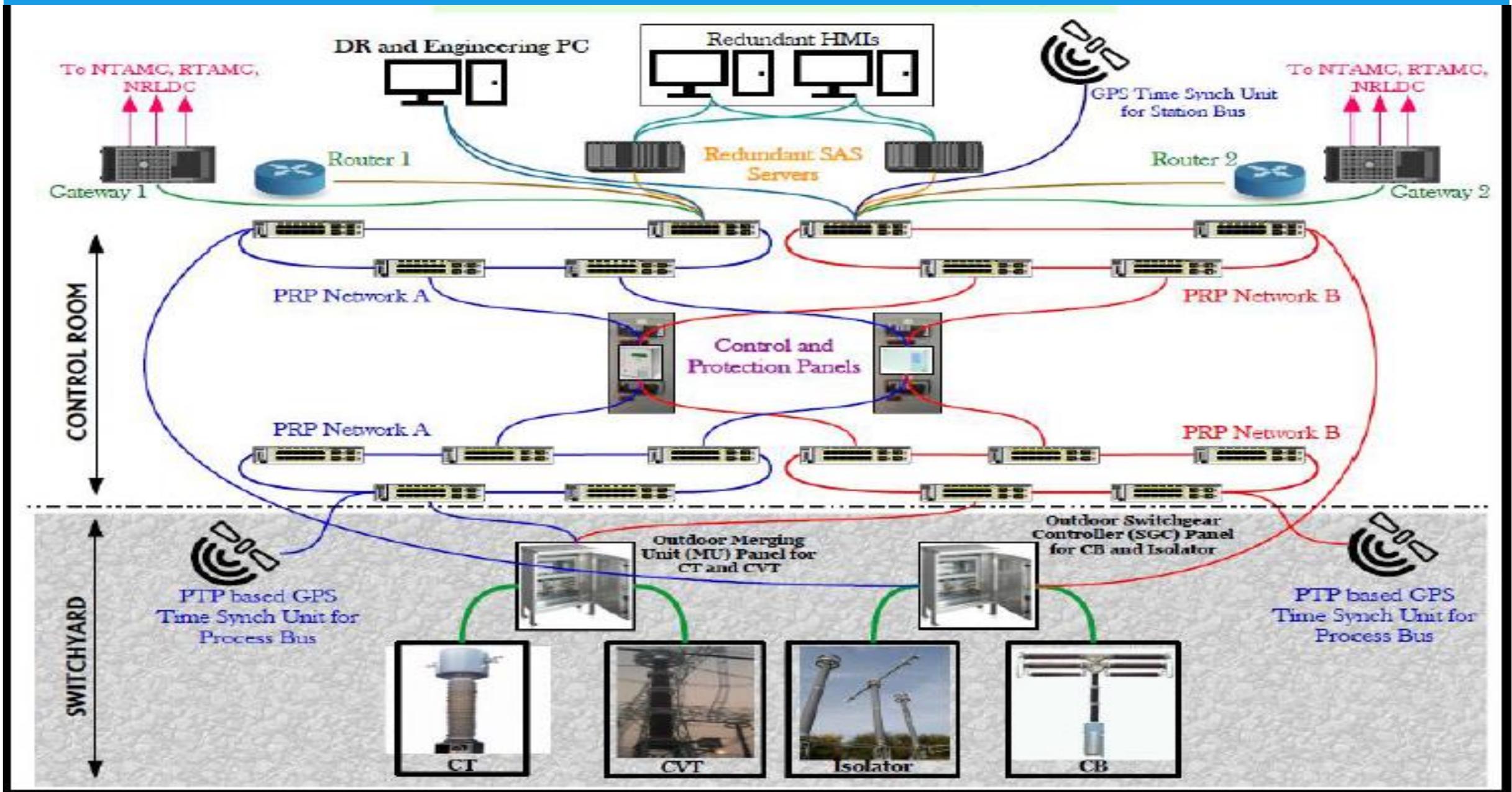- **India provides a good demand market to harness energy resources of other countries too.**

ADOPTION OF IEC 61850 IN POWERGRID INDIA

* The first substation based on IEC 61850 was commissioned in the year 2007.

* Over the last decade 118 substations having IEC 61850 based automation system were commissioned.

* Pilot project on IEC 61850 Process Bus commissioned in 2014.

* Implementation of first commercial Full Digital Substation commenced in 2017.

PROCESS BUS PILOT INSTALLATION AT 400/220 kV BHIWADI SUBSTATION

Current values stream over FO Cable

Optical CT

Moga 1 Line

Control Room

HMI

BUS 2

BUS 1

Line Reactor

Reports/Data for HMI over FO (IEC 61850 based MMS Reports)

1PPS - GPS Time Synch

Distance Protection IED

Merging Unit(s)

Current & Voltage Sampled Values to the IED from MU (IEC 61850, 9-2)

Indoor Panel (in kiosk)

SGC 1

SGC 2

Outdoor Panel (near CB)

Protection (Trip) commands over FO Cable (IEC 61850 based GOOSE messages)

Alarms, Status from Switchgear over FO Cable (IEC 61850 based GOOSE messages)

Control (Open/Close) commands over FO Cable (IEC 61850 based GOOSE messages) via Protection/Control IEDs in the Kiosk

Ethernet N/W Optical Fibre Cable

Copper Hardwiring

Data Flow over Ethernet

ARCHITECHTURE FOR DIGITAL SUBSTATION PROJECTS UNDER CONSTRUCTION

BENEFITS REAPED THROUGH IEC 61850 ADOPTION

* **Advanced diagnosis -** e.g Single screen , filter enabled, easily identifiable, multi IED, relevant event logs.

* **Superior Automation with Advance Safety** - we have Automatic Bus Shutdown/Back in Service schemes, Automatic Spare Phase ICT selection/deselection schemes, which enables enhanced safety while performing the operation automatically, in step check coordination with operator intelligence.

BENEFITS REAPED THROUGH IEC 61850 ADOPTION

* **Lower environmental footprint-** extremely less cables & cable trenches as compared to conventional substations.

* **Ease of implementing the complex schemes** - e.g spare phase selection/deselection for ICT/ Reactor Bank Protection in single phase ICT/ Reactor schemes, especially at 765 and 1200 kV.

* **Integration of different monitoring & control devices to a common system-** e.g Transformer diagnostic devices such as online DGA system , Remote Tap Change Controller, Controlled Switching Devices,etc.

DISCLAIMER

The journey of hitting a CENTURY in commissioning of IEC 61850 based substations has not been easy. It has been bumpy but enriching and exciting. The upcoming slides will show some of the issues encountered by us, most of which were resolved and for some we need the industry to ponder upon our concern as a Utility.
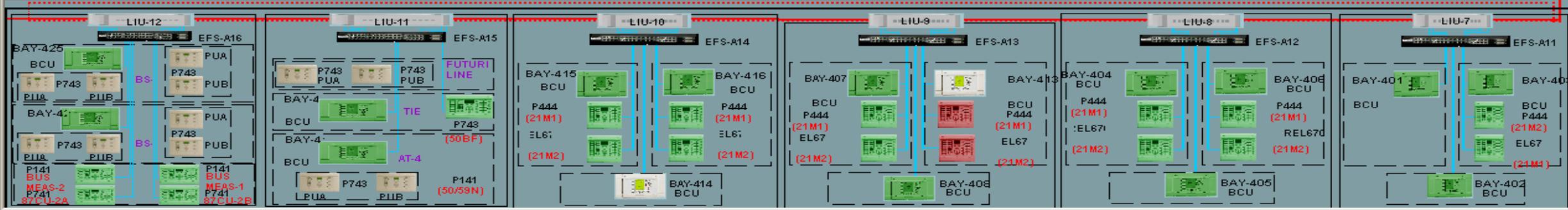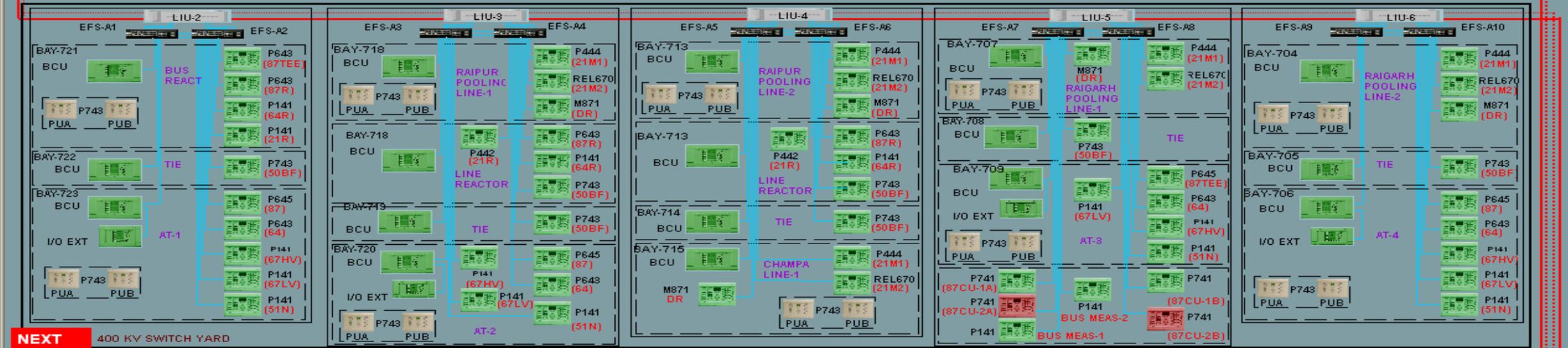
Nevertheless

POWERGRID India would always be a front runner in adopting this **thriving futuristic technology** to its fullest.

Issues faced during initial Installations-
GENERAL ISSUES

* Augmentation of substations has been a major challenge. At some of the substations, we have IEDs from more than four different vendors and integrating them to interoperate & to the existing HMI, on a turnkey basis with a proprietary configuration tool is both an economical and technical challenge.

* The number of IEDs that can be accommodated in a project is also a key issue. At some of our substations, the number of IEDs has crossed 150 and the servers are not able to handle the large number of IEDs.

* Windows version compatibility with new version of IEDs also has become an issue for augmentation projects.

AUX ROOM
AUX BCU

765/400 KV RAIGHAR SUB STATION
CONTROL ROOM

DISPLAY UNIT
88:88:88

SERVER - 1 MAIN   P2

OWS1   DR WORK STATION   OWS2

COMMUNICATION LINK/ CHANNEL ON
IEC-60870-5-101

TO RSSC ON
IEC-60870-5-101

RCC   P2

ANTENNA   AUX PANEL

SERVER - 2 (STANDBY)   P1   P2

GPS

GATEWAY-1   GATEWAY - 2

REMPTE HMI   DR WORK STATION

765 KV SWITCH YARD

EFS(B1)   LIU-1   EFS(B2)

LIU-2   LIU-3   LIU-4   LIU-5   LIU-6

EFS-A1   EFS-A2   EFS-A3   EFS-A4   EFS-A5   EFS-A6   EFS-A7   EFS-A8   EFS-A9   EFS-A10

BAY-721 BCU
BUS REACT
P643 (87TEE)
P643 (87R)
P141 (64R)
P141 (21R)
PUA P743 PUB

BAY-722 BCU
TIE
P743 (50BF)

BAY-723 BCU
P645 (87)
P643 (64)

I/O EXT
AT-1
P141 (67HV)
P141 (67LV)
P141 (51N)
PUA P743 PUB

BAY-718 BCU
RAIPUR POOLING LINE-1
P444 (21M1)
REL670 (21M2)
M871 (DR)

BAY-718 BCU
P442 (21R)
LINE REACTOR
P643 (87R)
P141 (64R)
P743 (50BF)

BAY-743 BCU
TIE
P743 (50BF)

BAY-720 BCU
P141 (67HV)
P645 (87)
P643 (64)
P141 (67LV)

I/O EXT
PUA P743 PUB
AT-2
P141 (51N)

BAY-713 BCU
RAIPUR POOLING LINE-2
P444 (21M1)
REL670 (21M2)
M871 (DR)

BAY-713 BCU
P442 (21R)
LINE REACTOR
P643 (87R)
P141 (64R)
P743 (50BF)

BAY-714 BCU
TIE
P743 (50BF)

BAY-715 BCU
CHAMPA LINE-1
M871 DR
PUA P743 PUB
P444 (21M1)
REL670 (21M2)

BAY-707 BCU
RAIGARH POOLING LINE-1
P444 (21M1)
REL670 (21M2)
M871 (DR)

BAY-708 BCU
P743 (50BF)

BAY-709 BCU
TIE
P141 (67LV)

I/O EXT
PUA P743 PUB
AT-3
P645 (87TEE)
P643 (64)
P141 (67HV)
P141 (51N)

P741 (87CU-1A)
P741 (87CU-2A)
P141 BUS MEAS-1
BUS MEAS-2
P741 (87CU-1B)
P741 (87CU-2B)

BAY-704 BCU
RAIGARH POOLING LINE-2
P444 (21M1)
REL670 (21M2)
M871 (DR)
PUA P743 PUB

BAY-705 BCU
TIE
P743 (50BF)

BAY-706 BCU
AT-4
P645 (87)
P643 (64)
P141 (67HV)
P141 (67LV)
P141 (51N)
I/O EXT
PUA P743 PUB

NEXT   400 KV SWITCH YARD

LIU-12   LIU-11   LIU-10   LIU-9   LIU-8   LIU-7

EFS-A16   EFS-A15   EFS-A14   EFS-A13   EFS-A12   EFS-A11

BAY-425 BCU
PUA P743 PUB
BS-
P743
PUA PUB

BAY-4.. BCU
BS-
PUA P743 PUB

P141 BUS MEAS-2 P741 87CU-2A
P141 BUS MEAS-1 P741 87CU-2B

P743 PUA   P743 PUB
FUTURI LINE
BAY-4.. BCU
TIE
P743 (50BF)
BAY-4.. BCU
AT-4
PUA P743
P141 (50/59N)

BAY-415 BCU
P444 (21M1)
EL67 (21M2)

BAY-416 BCU
P444 (21M1)
EL67 (21M2)
BAY-414 BCU

BAY-407 BCU
P444 (21M1)
EL67 (21M2)
BAY-408 BCU

BAY-413 BCU
P444 (21M1)
EL67 (21M2)

BAY-404 BCU
P444 (21M1)
EL67 (21M2)

BAY-40.. BCU
P444 (21M2)
EL67 (21M4)
BAY-405 BCU

BAY-401 BCU
BAY-40..
P444 (21M2)
EL67
BAY-402 BCU

Time of activity	Origin	Name	Status	Al...
08/09/2017 13:14:18:044	KOTRA/400 kV/441_RAIGARH-1/CB 441-52	CB DC-1	HEALTHY	1
08/09/2017 13:14:18:011	KOTRA/400 kV/441_REL670_21M2/INPUTS	CB TC-1	HEALTHY	1
08/09/2017 13:14:16:980	KOTRA/400 kV/441_RAIGARH-1/PROTECTION PANEL	CB TC-2	NORMAL	1

SYS ARCH. | MAIN SLD | ALARM | 765kV SLD | 704 | 705 | 706 | 707 | 708 | 709 | 713 | 714 | 715 | 718 | 719 | 720 | 721 | 722 | 723 | RAC SCHEME | TRF SW

400kV SLD | 416 | 417 | 418 | 419 | 420 | 421 | 429 | 428 | 427 | 430 | 431 | 432 | 433 | 434 | 435 | 436 | 437 | 438 | 439 | 440 | 441 | NEXT

Issues faced during initial Installations - EDITION SPECIFIC ISSUES

In the Edition 1 IEDs, the non reception of GOOSE messages did not generate an alarm in some vendor's IEDs, which was critical for detecting non receipt of GOOSE message by a subscriber IED in GOOSE based schemes. Alternate methods, such as taking the quality bits in an AND function to create an alarm were used to resolve the issue. This issue has been addressed in Edition 2 by providing the LGOS logical Node.

Issues faced during initial Installations - INTEROPERABILITY ISSUES

* Because of the hexadecimal App ID of the datasets of IEDs of some vendors, other vendor's IEDs had subscription issues. This lead to problem in some cases where the subscriber IEDs understood only the decimal form.

* The sequence of selecting status value and quality in SCD configuration tools was fixed in some vendor IEDs which impacted the communication.

* In some cases, the control command from the HMI to the bay controllers of different vendors did not work. This was resolved after some modifications in the visible string of the control command .

Issues faced during initial Installations - APPROPRIATE SPECIFICATION REQUIREMENT

Using the incorrect Logical Node, e.g GGIO for Distance Protection Operated can introduce delay in appearance of the event on HMI for analysis of the event and defies the basic concept of Logical Node classification for exact identification in an SCD file.

Issues faced during initial Installations - APPROPRIATE SPECIFICATION REQUIREMENT

Specifying the nomenclature of IEDs in an SCD file helped in removing the identification ambiguity during testing and diagnosis.

EDITION 2 CHALLENGES- Interoperability between Edition 1 & 2 Devices

* For station wide switchgear reservation function and for transfer of special protection signals from one bay to other, GOOSE interoperability between Existing Edition 1 & Edition 2 devices is required in our augmentation projects. Most of the vendors have not demonstrated/confirmed this interoperability.

* For our augmentation projects where in we have the HMI Client and IEDs of Edition 1 and the substation bay augmentation project has IEDs of Edition 2, due to interoperability limitation, vendors are demanding up gradation of the existing HMI software to integrate Edition 2 IEDs which is expensive.

EDITION 2 CHALLENGES- Processing the GOOSE messages with lower StNum

* Edition 1 IEDs did not have the simulation bit provision, as such testing of the GOOSE based protection schemes often lead to mal operation during testing on account of simulation mistakes.

* Though the provision of simulation bit has been provided in Edition 2, the processing of GOOSE message with a lower StNum, by a subscriber IED is still important from the security point of view.

* Mere detection of such GOOSE messages is of no importance to us. We need the subscriber IEDs to discard them and trigger an alert in such a case from cyber security point of view.

EDITION 2 CHALLENGES- Availability of Devices

* Limited availability of PTP Compliant Merging Units.

* Non availability of proper logical nodes, e.g XCBR in some vendors Circuit Breaker IEDs.

* Non availability of sufficient ports in some vendors IEDs for flexible network configuration.

* Non availability of IEC 61850 systems for HVDC & FACTS. Integration of such systems requires protocol conversion.

Availability of Tools and Our Expectations

* Limited availability of Tools which **generate SSD files.**

* Similarly there are limited tools that have the compatibility to SSD files & can **configure** the system as per our SSD file.

* If a **Publisher and Subscriber Matrix** can be generated out of an SCD file, it would be of immense help in commissioning of Digital Substations and later in Maintenance.

THANK YOU

Abhay Kumar- **abhaykumar @ powergridindia.com**

Chandra Prakash Awasthi-chandraprakash@powergridindia.com

POWER GRID CORPORATION OF INDIA LIMITED

World Class, Integrated, Global Transmission Company

(A Government of India Enterprise)