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ELECTRIFICATION SYSTEM
FOR
DEDICATED FREIGHT CORRIDOR

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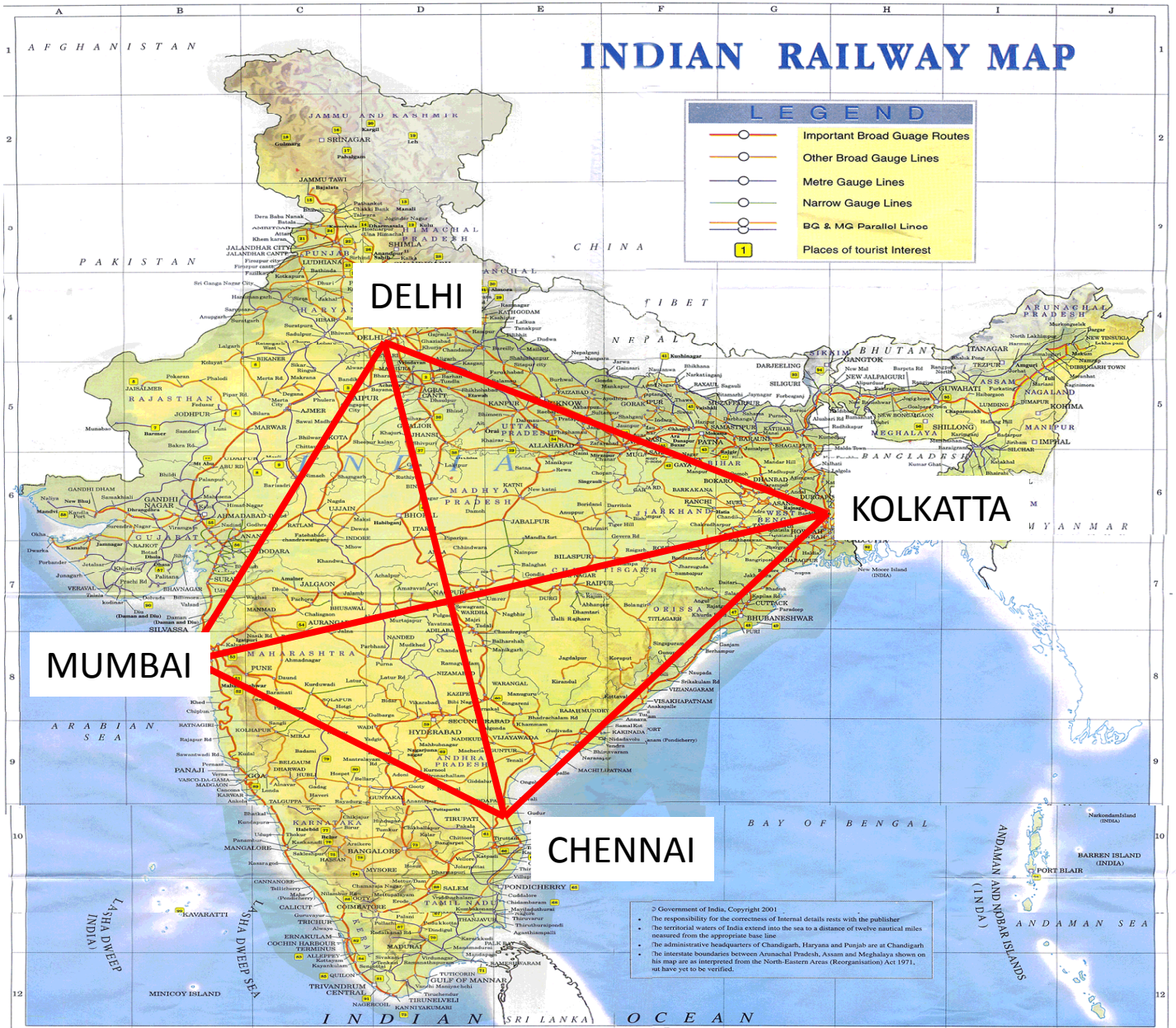
Indian Railways- An Overview



High Density Corridor (Golden Quadrilateral + Diagonals)

16% of route Km carries 52% of passenger & 58 % of freight

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Indian Railways- Concerns For Freight Traffic

- Falling market share (90% to 30%)
- Capacity constraints on high density network
- Differential speeds of trains
- Inability to carry longer/heavier trains

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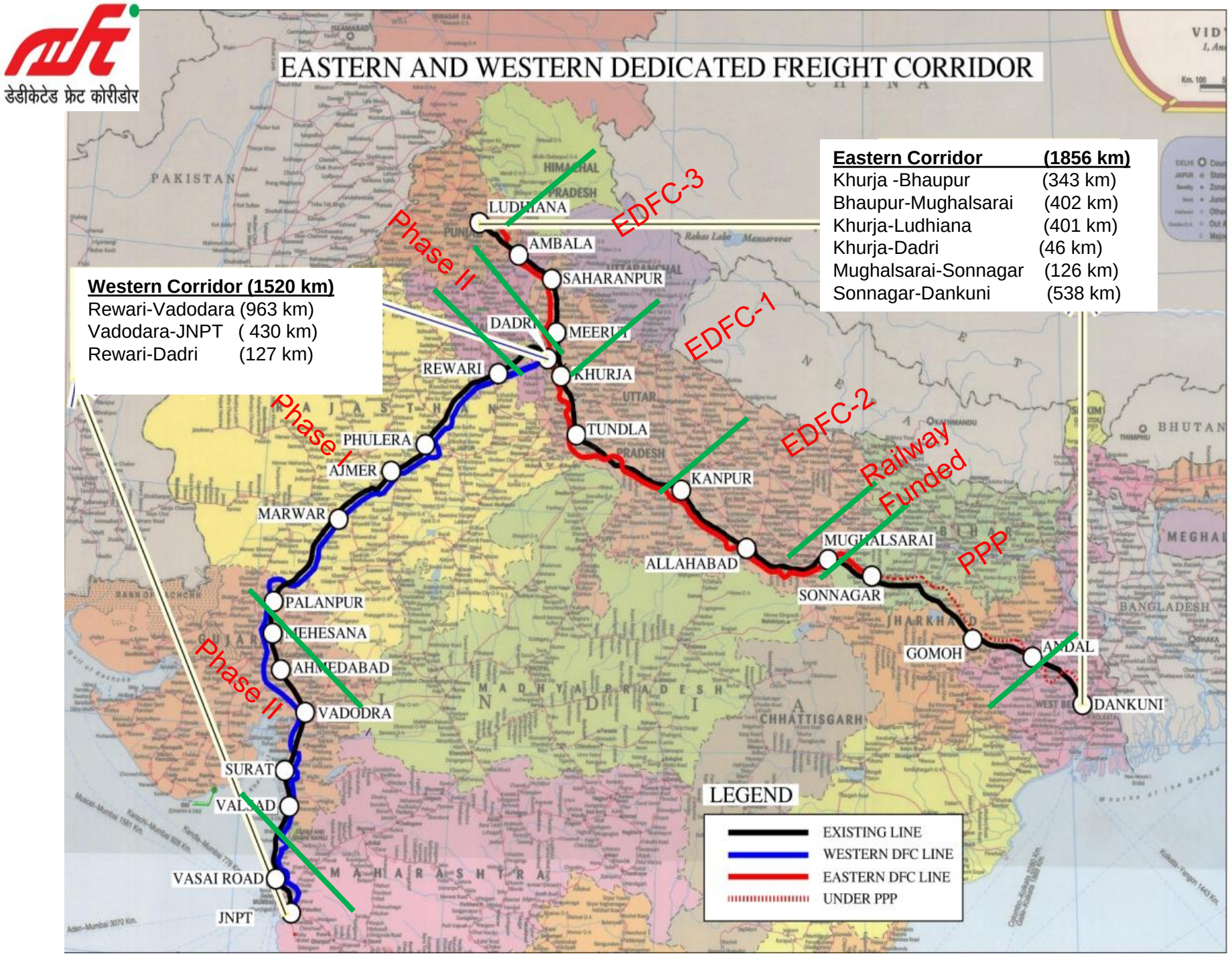
Mandate & Objectives of DFCCIL

- Special Purpose Vehicle to undertake planning & development, mobilization of financial resources and construction, maintenance and operation of the Dedicated Freight Corridors.

- **Objectives**
  - Reduce unit cost of transportation:
  - Create rail infrastructure to carry higher throughput per train;
  - Offer IR's customers guaranteed, faster transit at economic tariff;
  - Increase IR's share in freight market;
  - Improved overall transport efficiency of national rail network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EASTERN AND WESTERN DEDICATED FREIGHT CORRIDOR
Eastern Corridor (1856 km)
Khurja -Bhaupur (343 km)
Bhaupur-Mughalsarai (402 km)
Khurja-Ludhiana (401 km)
Khurja-Dadri (46 km)
Mughalsarai-Sonnagar (126 km)
Sonnagar-Dankuni (538 km)
Western Corridor (1520 km)
Rewari-Vadodara (963 km)
Vadodara-JNPT (430 km)
Rewari-Dadri (127 km)
EDFC-3
EDFC-1
EDFC-2
Phase II
Phase I
Phase II
Railway Funded
PPP
LUDHIANA
AMBALA
SAHARANPUR
DADRI
MEERUT
KHURJA
REWARI
TUNDLA
PHULERA
AJMER
MARWAR
KANPUR
ALLAHABAD
MUGHALSARAI
SONNAGAR
GOMOH
ANDAL
DANKUNI
PALANPUR
MEHESANA
AHMEDABAD
VADODRA
SURAT
VALSAD
VASAI ROAD
JNPT
PAKISTAN
CHINA
NEPAL
BHUTAN
BANGLADESH
MADHYA PRADESH
CHHATTISGARH
MAHARASHTRA
LEGEND
EXISTING LINE
WESTERN DFC LINE
EASTERN DFC LINE
UNDER PPP

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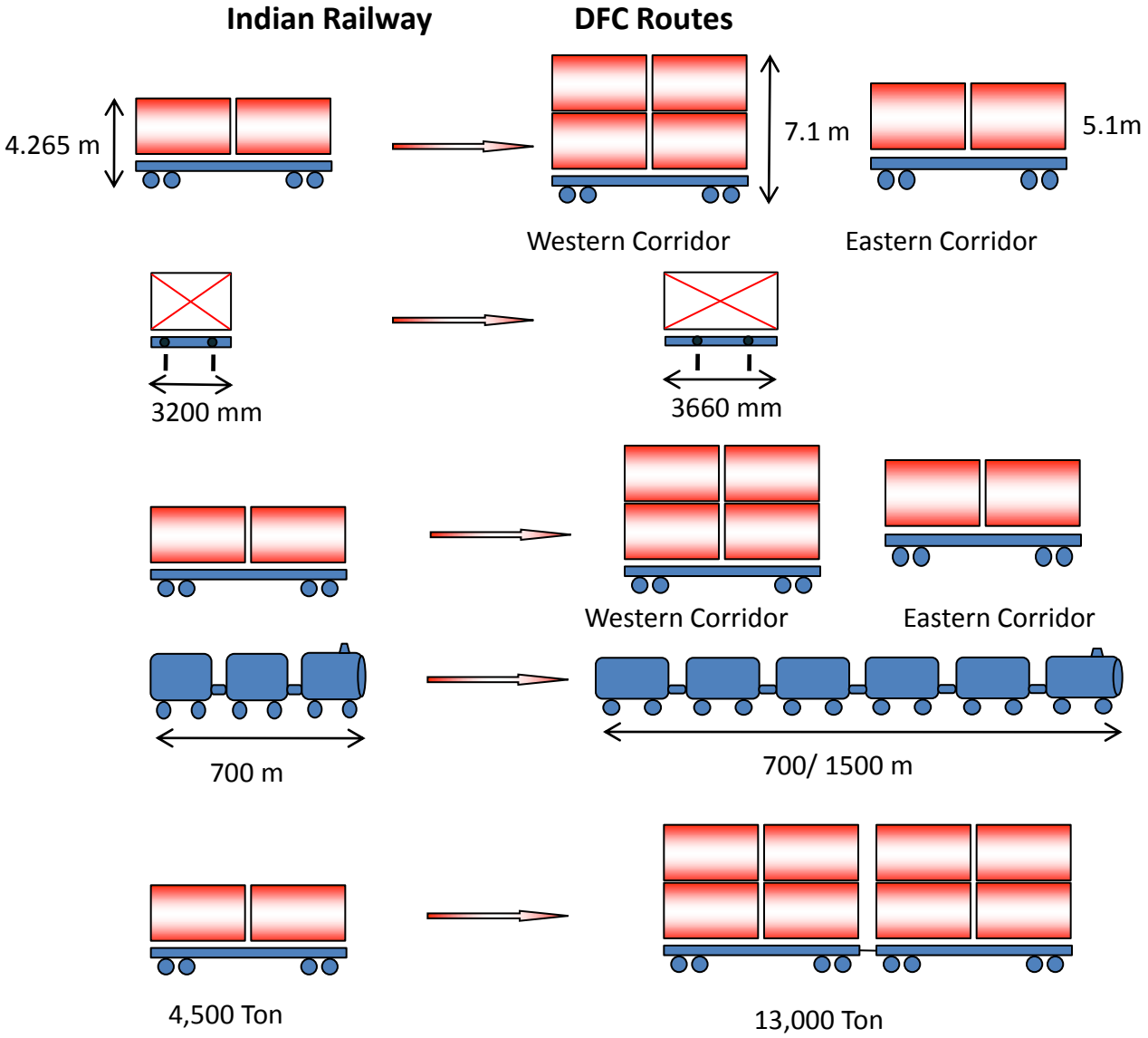
Operating Aspects of DFCC

- DFCC to manage train operation on DFC.
- DFCC to have own stations and control centers.
- Rolling stock ownership & its maintenance by IR.
- Feeder Routes /Sidings to be upgraded by IR .
- All LCs to be replaced by ROBs / RUBs.

Basic Design Features



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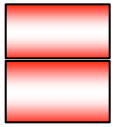
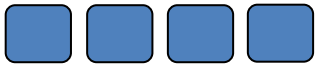
Basic Design Features (Contd.)

- Heavier Axle Loads

	Indian Railway	DFC Routes
Axle Load	22.9 t / 25 t 	 25 t Bridges & formation designed for 32.5 t
Maximum Speed	 75 Kmph	 100 Kmph
Average speed	25 kmph	70 kmph
Grade	Upto 1 in 100	1 in 200

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Basic Design Features (Contd.)

	Indian Railway	DFC Routes
Traction	Electrical (25 KV)	Electrical (25 KV AT Feeder System)
Station Spacing	7-10 Km	40 Km (Approx.)
Signalling	Absolute /Automatic with 1 Km spacing	Automatic with 2 Km spacing
Communication	Emergency Sockets	Mobile Train Radio

Operational Requirements

- Heavy haul train operation with electric traction
- Train load 4500/6500 tonne & 9000/13000 tonne trains in the ratio of 2:1
- Maximum Speed- 100kmph
- Deployment of high horse power locomotive (9000/12000 HP) i.e 7000/10000 MVA.
- Long Haul Operation with train length of 1500 m or more.
- Western Corridor suitable for Double Stack Container operation

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DFC Cost Estimates

Project Cost (in Rs. Crores)	WDFC (1503 km)	EDFC (1318 km)	Total
Civil works	25312	16009	41321
Electrical works	4278	2980	7258
S&T	3110	1993	5103
Mechanical	160	160	320
Total Hard Cost	**32860**	**21142**	**54002**
Soft cost*	**13858**	**5531**	**19389**
Total cost	**46718**	**26673**	**73391**
Land cost	4383	3684	8067
Grand Total	**51101**	**30357**	**81459**

** Soft Cost – Escalation (11,141), Insurance/Taxes (651), Contingency (1,954), IDC (5,641)*

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Funding Plan

(All figs. in INR Crores)

Particulars	Eastern Corridor	Western Corridor	Total
Equity from MoR	10,352	7,996	18,348
Loan from JICA	-	38,722	38,722
Loan from World Bank	16,322	-	16,322
Total Funding (without Land)	**26,674**	**46,718**	**73,392**
MoR (Land)	3,684	4,383	8,067
Total Funding with Land	**30,358**	**51,101**	**81,459**

Ratio of External funding: MoR funds is 3:1

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EDFC- Timelines

Section	Phased commissioning sections	Compressed timelines
Bhaupur-Khurja: 343 km	**Bhaupur – Khurja** (343 km)	**Mar ’18**
Bhaupur-Mughalsarai: 402 km.	**Jeonathpur - New Karchana** (139 km)	**June-18**
	New Karchana - New Bhaupur (241 km)	**Dec-18**
	Mughalsarai – Jeonathpur (22 km)	**Jun-18**
Mughalsarai-Sonnagar: 126 km	**Sasaram – Durgawati** (56 km)	**Mar 16**
	Durgawati – Mughalsarai (61 km)	**Mar-18**
Dadri-Khurja: 46 km.	**DADRI-KHURJA:** 46 km.	**Dec’18**
Khurja-Ludhiana: 401 km	**Pilkhani – Ludhiana** (179 km)	**Mar-19**
	Khurja – Pilkhani (222 km)	**Dec,19**

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WDFC –Timelines

Original Timelines	Revised phased commissioning sections	Compressed timelines
Rewari-Iqbalgarh (639 km)	**Rewari-Phulera** (217 km)	**Mar'18**
	Phulera-Bangurgram (117km)	**Mar'18**
	Marwar-Palanpur (207 km)	**Mar' 18**
	Bangurgram – Marwar (98 km)	**June'18**
Iqbalgarh-Vadodara (308 km)	**Makarpur-Udhana** (119 km)	**Mar'19**
	Palanpur-Makarpura (294 km)	**Mar'19**
Vadodara-JNPT (430 km)	**Udhana-Kharbao** (241 km)	**Mar'19**
	Kharbao-JNPT (84 km)	**Oct'19**
Rewari-Dadri (127 km).	**Rewari-Dadri** (127 km)	**Sept '19**

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Phased Commissioning..

Year-wise commissioning	Eastern DFC (Kilometres to be commissioned)	Western DFC (Kilometres to be commissioned)	Total Kilometres
During 2015-2016	56 (Durgawati-Sasaram)	-	56
2017-2018	413 Bhaupur-Khurja (343 km), Durgawati-Mughalsarai & Karwandiya-Sasaram(70 km)	541 Rewari-Phulera (217 km), Phulera-Bangurgram (117 km) Marwar-Palanpur (207 km)	954
2018-2019	627 Jeonathpur-New Karchana (139) New Karchana-New Bhaupur (241 km) Mughalsarai-Jeonathpur(22km) Dadri-Khurja (46 km), Pilkhani-Ludhiana (179 km)	752 Bangurgram-Marwar (98 km) Makarpur-Udhana(119 km) Palanpur-Makarpur (294 km) Udhana-Kharbao (241 km)	1379
2019-2020 (upto Dec 19)	222 Khurja-Pilkhani (222 km)	211 Kharbao-JNPT (84 km), Rewari-Dadri (127 km)	433

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Contracting Strategy

- Construction through lump-sum Design & Build contracts
- Document preparation for contracting being done through internationally reputed General Consultants(GC)
- Contract management through Project Management Consultants(PMC)
- Quality and Safety Management through QSAC

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Contracting Strategy

- Packaging and Slicing based on Road shows
- ICB based on WB/JICA Procurement Guidelines
- Design and Build LUMP SUM
- Completion Period: 3 to 4 yrs
- Defect Notification Period: 2 yrs

Contracting Strategy

- FIDIC Yellow Book customized for Design-Build railway infrastructure works.
- Slice & Package System - enhanced competition.
- PQ followed by one/two stage bidding-
  - Pre-Qualification followed by two stage bidding – EDFC
  - Pre-Qualification followed by single stage bidding – WDFC
  - Engagement of consultant through Quality-Cum-Cost-Based-System (QCBS)
- New technology encouraged.
  - New technologies as per Acceptance Criteria

Approach For New Technology

- Performance Specification Based on EN, IEC and other International standard.
- Acceptance Criteria of PROVEN New Technology
- Transfer of Technology for local sourcing (upto 50%) and encouragement for Make in India

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Acceptance Criteria for Materials

- Three years of satisfactory performance
- Should have supplied equipment of 70% (min.) rating of the equipment offered
- Should have supplied 50% quantity to be used in the contract in last seven years
- Can supply two times(max.) the quantity supplied in last seven years

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Make In India Initiative

- 50% quantity can be sourced locally through Technology Transfer to any Indian Company
- Extended Guarantee for 3 years beyond DNP for such items

The Incremental Approach

- 25 KV AC Traction has served IR very well in terms of meeting the capacity and throughput requirements

- Increased demand has been met by upgrading the transformers (12.5/13.5 to 21.6/30 MVA). Also by introduction of additional Traction Sub Stations (TSSs).

- Incremental approach not feasible for High Speed and Heavy Haul

Need For Quantum Upgradation Of AC Traction System

- **To meet additional power requirements due to**
  - Increase in Axle load from 20.0 -----22.5 ---- 25.0
    27.5 ---- 30.0 ---- 32.5 T.
  - Increase in train haulage capacity (Long haul).
  - Increase in train frequency

What NEXT?

For High speed

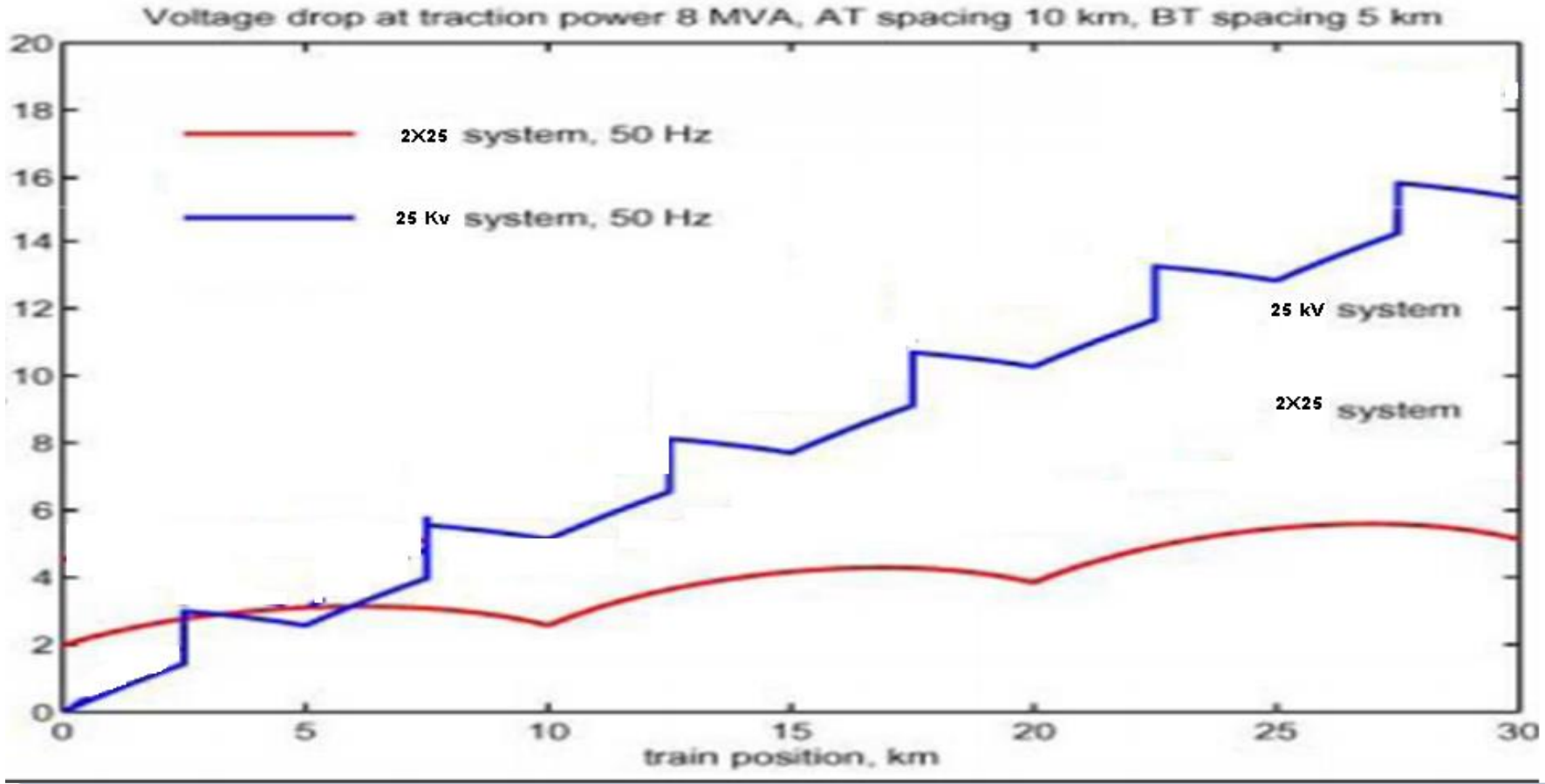
&

heavy haul railway network.

25 kV AT feed system?

AC Supply Systems-Why Choose AT Feed System

VOLTAGE DROP COMPARISON

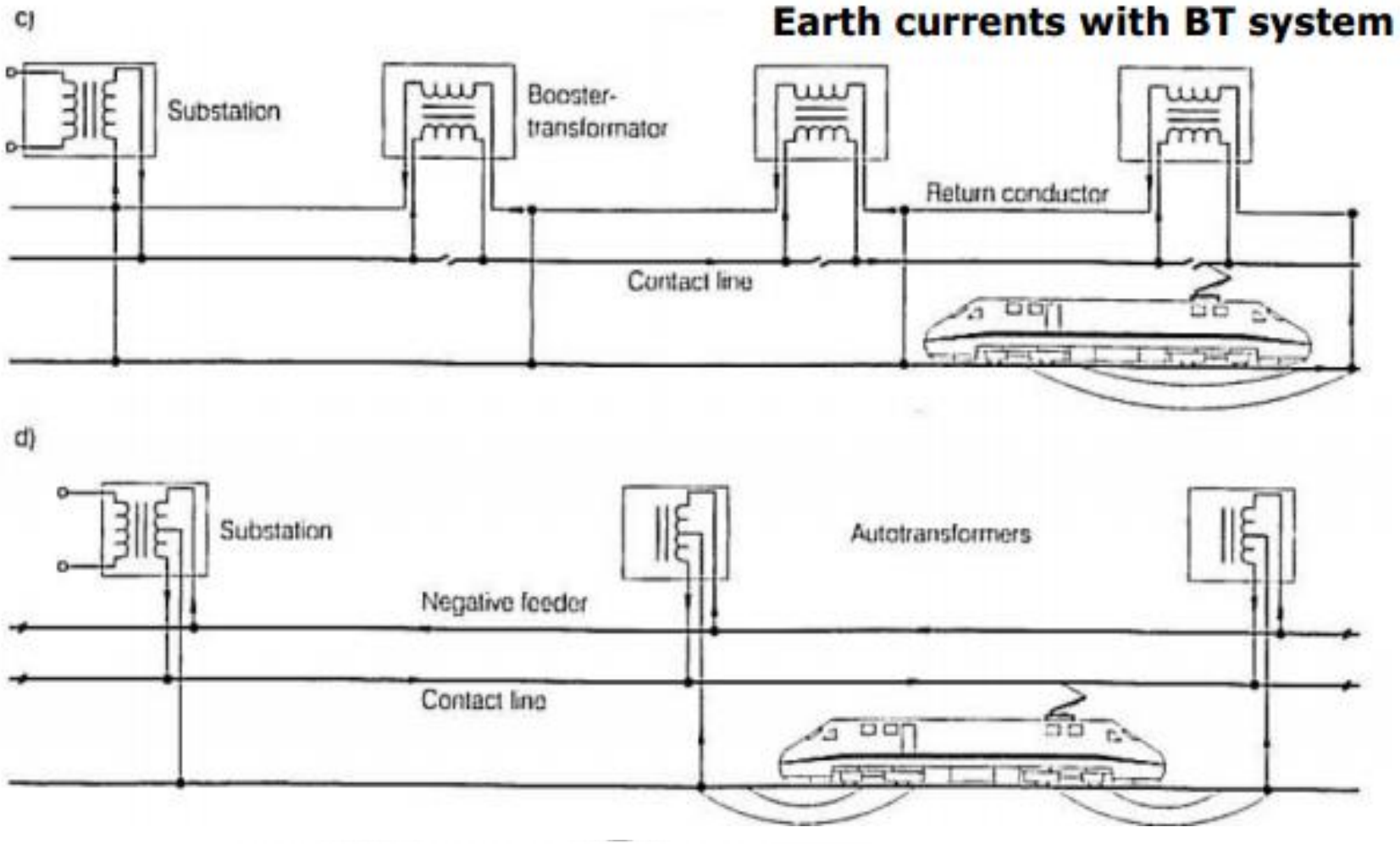


Reason: Supply condition would improve drastically

Major Operational Advantages Of 25kv AT Feeding System

- The insulation level will remain at 25 kV
- Feed voltage doubles up to 50 kV reducing OHE current by 50%
- Permits traction supply points to be at 60-80 km apart.
- Improved voltage regulation and power density >1MVA/RKM
- Same EMUs & locomotives can be used
- Provides quantum jump of 100% in haulage capacity

What is 2x25 kV AT Feeding System



Earth currents with AT system

DFCCIL APPROACH FOR ELECTRIFICATION

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DFCCIL Project Mandate

- Heavy haul train operation with electric traction with 13 minute head way ; 4500/6500 tonne & 9000/13000 tonne trains in the ratio of 2:1, speed- 100kmph, deployment of high horse power locomotive (9000/12000 HP) i.e 7000/9000 MW.

- Traction system matching with line capacity to meet traffic projection of 2031-32.

EDFC: Traffic volume /capacity increase 64 Billion NTKM to 250 Billion (4 times).

WDFC: Traffic volume /capacity increase 44 billion NTKM to 260 billion NTKM (6 times).

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Power Supply Arrangement

Corridor	Total TSS	TSS Spacing	Planned with DISCOM's Connectivity	Planned with CTU connectivity
EDFC	19	60 kM (DL) & 90 kM(SL)	7	12
WDFC	25	60 kM	*25	NIL

In WDFC, 11 TSS are having integrated supply arrangement with IR & common connection with DISCOM.

In EDFC transmission line is being constructed through POWERGRID with CTU connectivity to provide supply to 12 TSS. The network is also interconnected with existing IR network.

Power Supply Arrangement(Contd…)

- Spacing of traction sub-station (55 ~ 65 km)
- Spacing of switching posts (15 ~ 17 km) Auto transformer (8 MVA)
- Ratings of traction power transformer (60/84 MVA)

Power Supply Arrangement(Contd…)

- Higher Current carrying capacity for switch gears and isolators
- SF-6 CB for HV side & VCB for 25 kV side
- Protection: Fast acting Intelligent Numerical Protection
- Dynamic Reactive Power Compensation

OHE Design

- OHE deign as per EN 50119
- Feeder wire all along the section.
- Overhead Aerial Earth Conductor (AEC) for traction earth return current, all along the section
- Buried Earth Conductor (BEC) for limiting the step and touch potential with in limits specified in EN 50122-1.
- Dropper; current carrying, flexible
- Modular cantilever in representative section (WDFC)

OHE Design

- Cylindrical Foundations based on UIC ORE method
- Steel structures –Higher length in WDFC (MMD 7.1 m)
- Suitable steel structure to support thicker conductor

OHE Design(Contd…)

- Contact wire : (Copper Alloy)*
- Catenary wire : (Copper Alloy)*
- Feeder wire : AAAC
- Aerial Earth Conductor (AEC): As per earthing and bonding requirement
- Buried Earth Conductor (BEC): As per outcome of traction power simulation study.
- The critical values of all these parameters can be found out by simulation study.

* Material to withstand temperature up to 100°C (EN 50119/IEC-60913-2013)

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OHE Design(Contd…)

- High rise OHE with 7.47 m height suitable for double stack operation on flat wagons on Western DFC.

- First in the world at such MMD.

Need For Simulation

- Traction Power Simulation to finalize ratings of major equipment & sizing of OHE conductors
- OHE Pantograph Simulation –to ensure current collection quality
- Earthing & Bonding Simulation- To keep the system safe under fault & normal condition for the users

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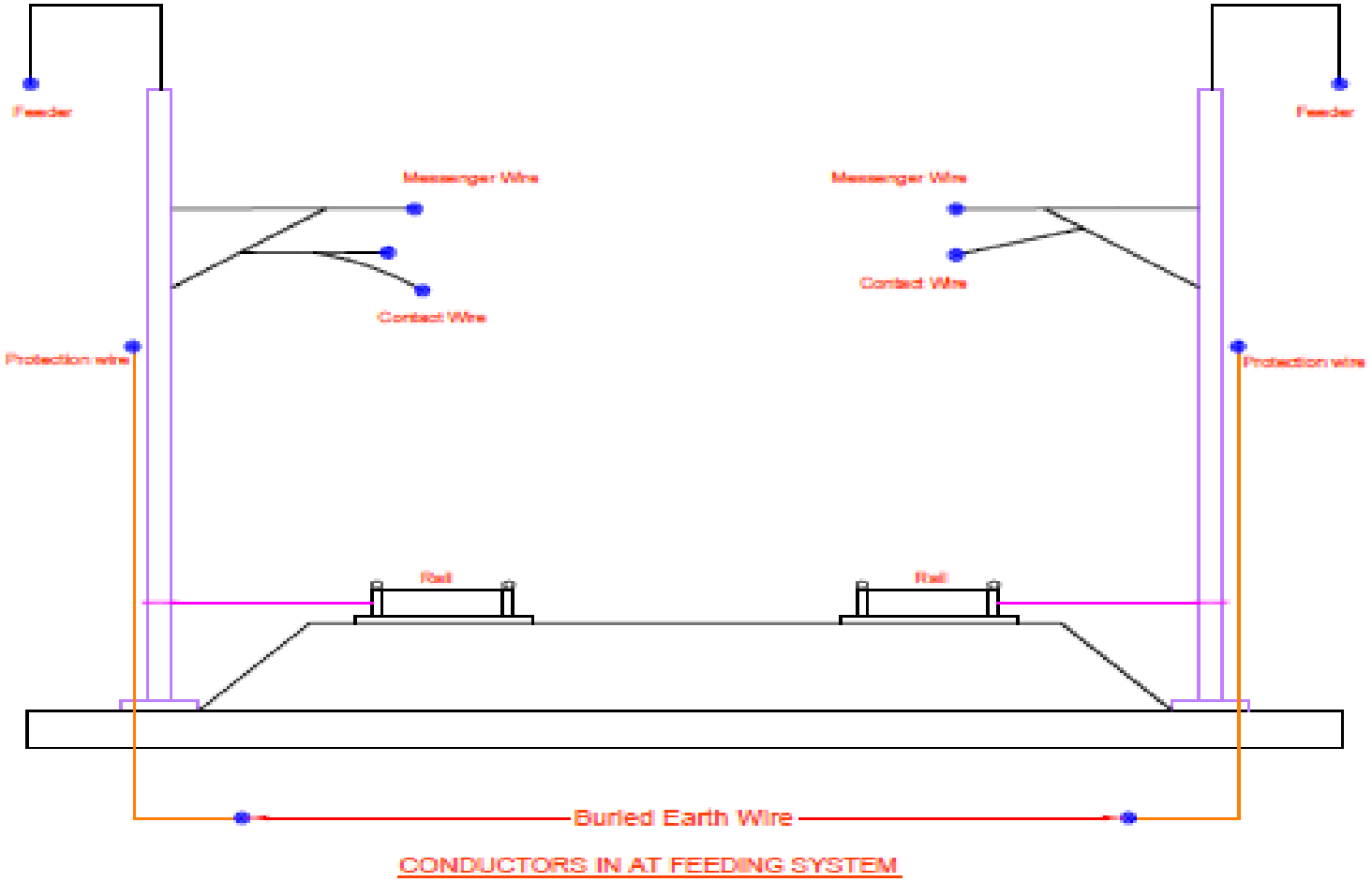
Traction Power Supply Simulation Outcome

ITEM DESCRIPTION	EDFC Bhaupur-Khurja	WDFC (Rewari-makarpura)
Traction Power Scheme	Single Phase with centre point earthed	Scott Connected 55kV secondary
Transformer rating	38/63 MVA ONAN/OFAF single phase	60/84/100 MVA ONAN/ONAF/OFAF
Auto transformer rating	16.5 MVA	10/8 MVA
Contact Wire	150 sqmm	150 sqmm
Contact material	Cu-Ag	Cu-Tin
Catenary Wire	120 sqmm	120 sqmm
Catenary material	Cu-Mg	Cu-Tin
Feeder Wire	288 mm^2	288 mm^2
Feeder material	AAAC	AAAC

Traction Power Supply Simulation Outcome

Item Description	EDFC	WDFC
Cantilever Assembly	Design Awaited	Design Awaited
Auto Tensioning Device	Design Awaited	Possibly 5 Pulley type
Tension	3000 kgf	2400 kgf
Mast	B-175, B-200,B-225 ,B-250	B-225 and above
Temperature rise in OHE	<100 deg cent	<100 deg cent
Temperature rise in Feeder Wire	< 80 deg cent	<80 deg cent.
Arial earth wire	91.97 mm^2	Design Awaited
AEW material	ACSR	ACSR
Droppers	10 mm^2 Cu-Mg	Design awaited
Maximum span	58.5 m	54 m

OHE Layout



CONDUCTORS IN AT FEEDING SYSTEM

Mechanized Construction

Mechanized Construction

- Foundations through auger
- Mast erection by machine and grouting by concrete mixing plant mounted on rail/road vehicle.
- Conductor (contact and catenary wire) stringing by rail mounted twin conductor stringing machine.
- Droppering and clipping by rail/road mounted trolleys

Mechanised Construction(Contd)

- Mechanized construction of cylindrical foundation
- Achieve reliability & consistency in the design
- Improved pace of work (saving in construction time)

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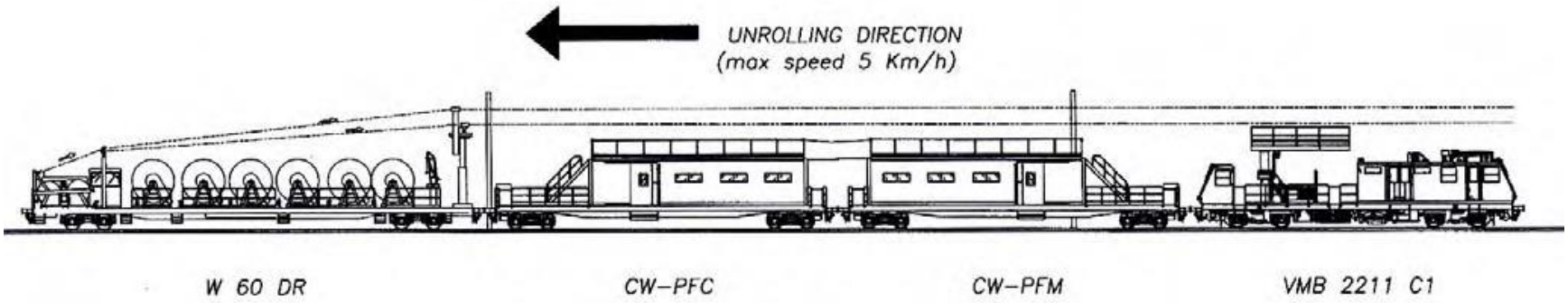
Mechanised Construction(Contd…)

- Mechanized unwinding and anchoring of catenary and contact wires.



SCADA Design

- TCP/IP based open protocol SCADA system (IEC- 60870-5-104)
- Video Wall display
- Fault Locator: Current measurement neutral CT base accuracy 100 m.
- Infrastructure to create Railway smart grid.

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OCC Building at Allahabad

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OCC Building at Allahabad

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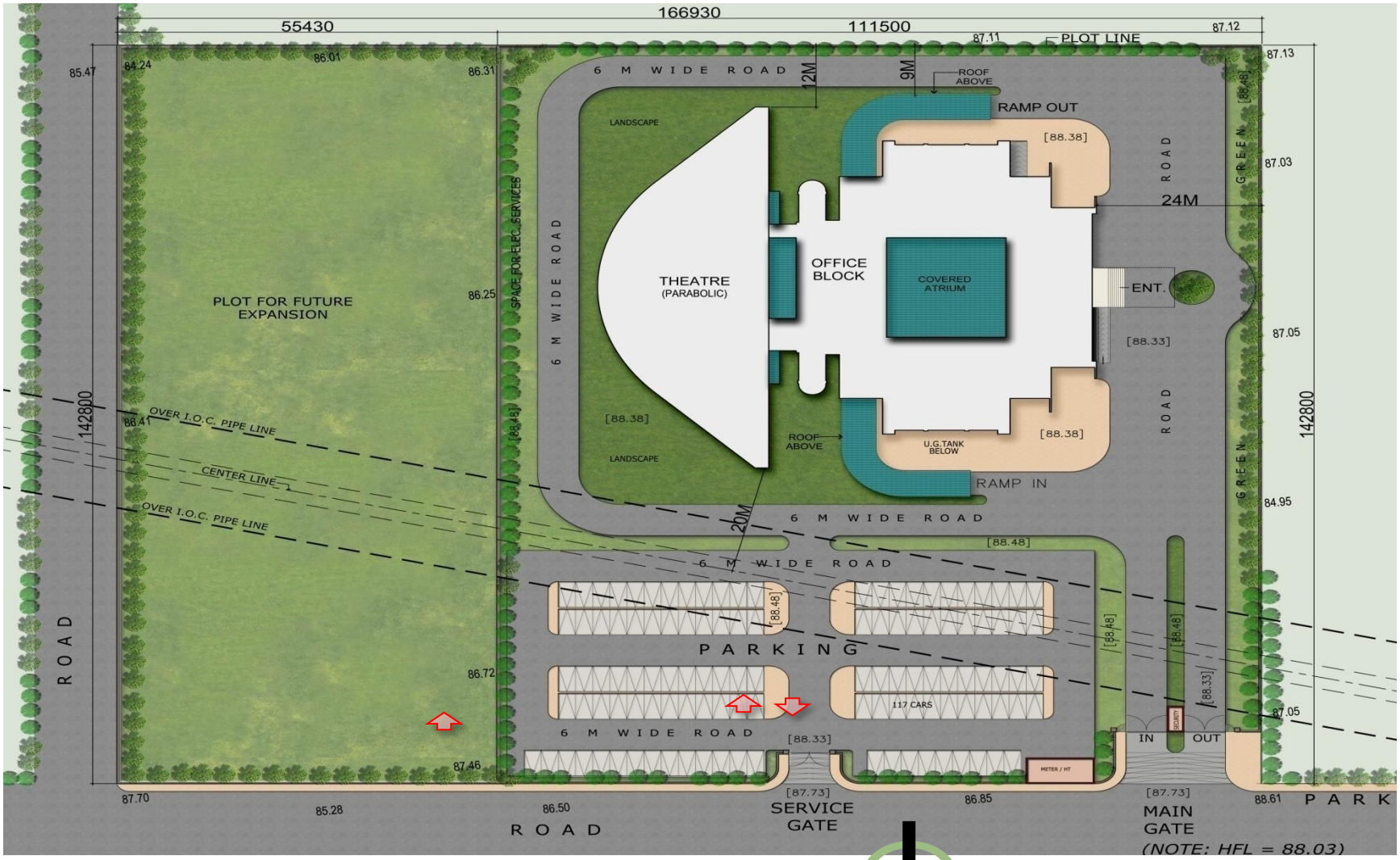
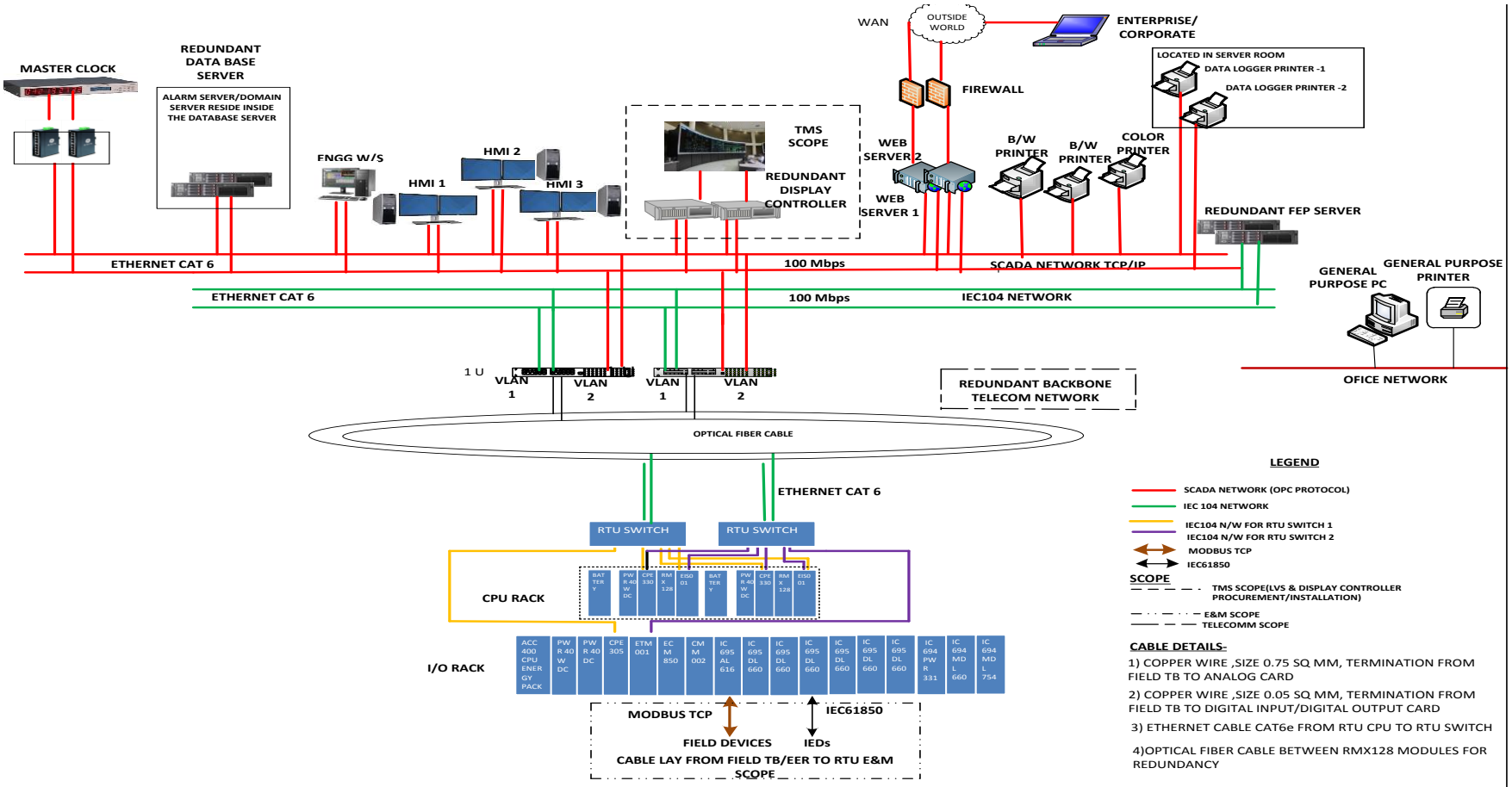
OCC Building at Allahabad



SCADA Architecture



CABLE DETAILS-

1) COPPER WIRE ,SIZE 0.75 SQ MM, TERMINATION FROM FIELD TB TO ANALOG CARD

2) COPPER WIRE ,SIZE 0.05 SQ MM, TERMINATION FROM FIELD TB TO DIGITAL INPUT/DIGITAL OUTPUT CARD

3) ETHERNET CABLE CAT6e FROM RTU CPU TO RTU SWITCH

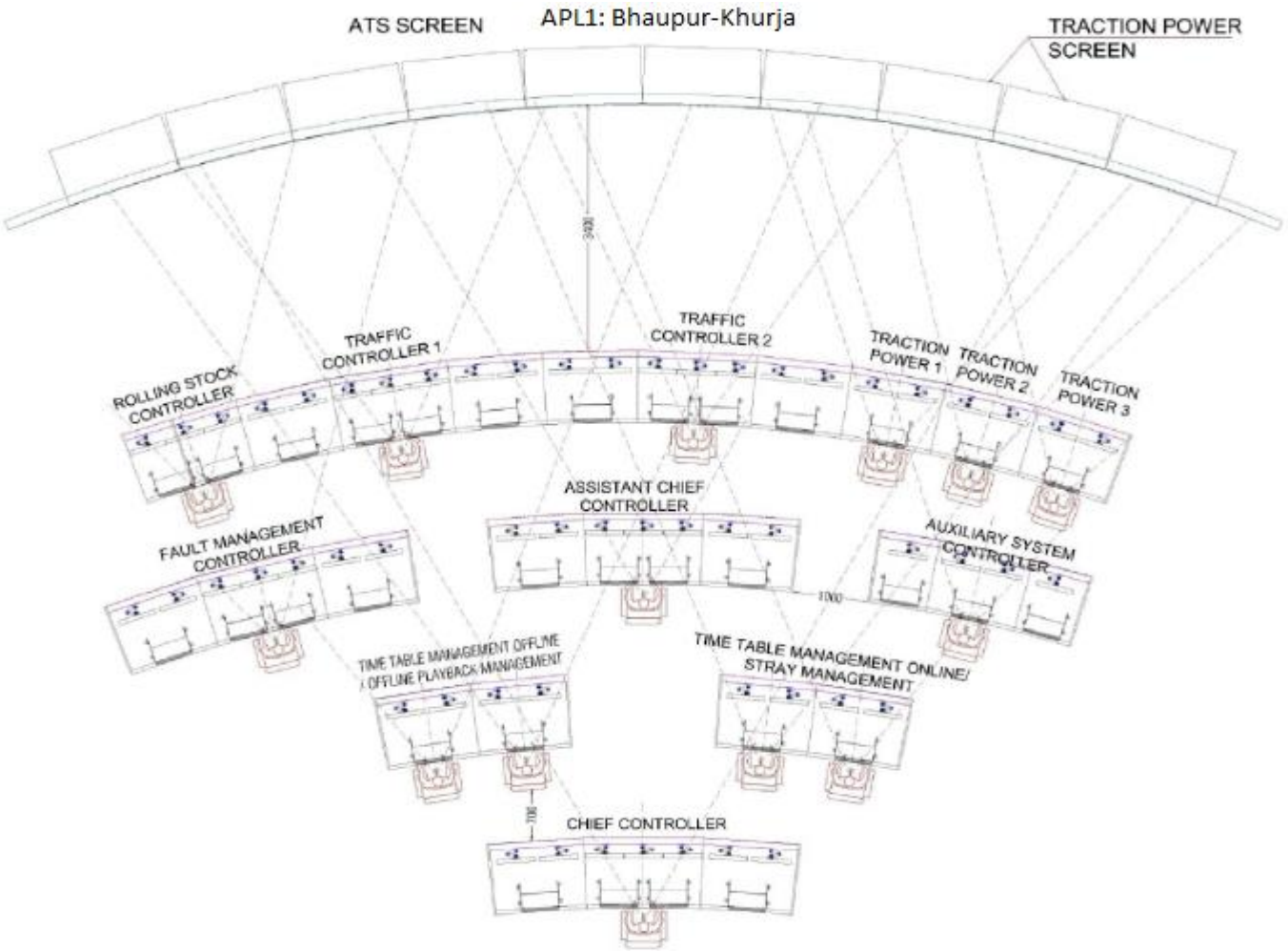
4)OPTICAL FIBER CABLE BETWEEN RMX128 MODULES FOR REDUNDANCY

NOTE-

1) AS INDICATED IN ARCHITECTURE , ALARM SERVER/ DOMAIN SERVER RESIDE INSIDE THE DATABASE SERVER

2) TENTATIVE DISTANCE B/W DEVICES – TO BE DECIDED

Ergonomically Designed OCC Layout



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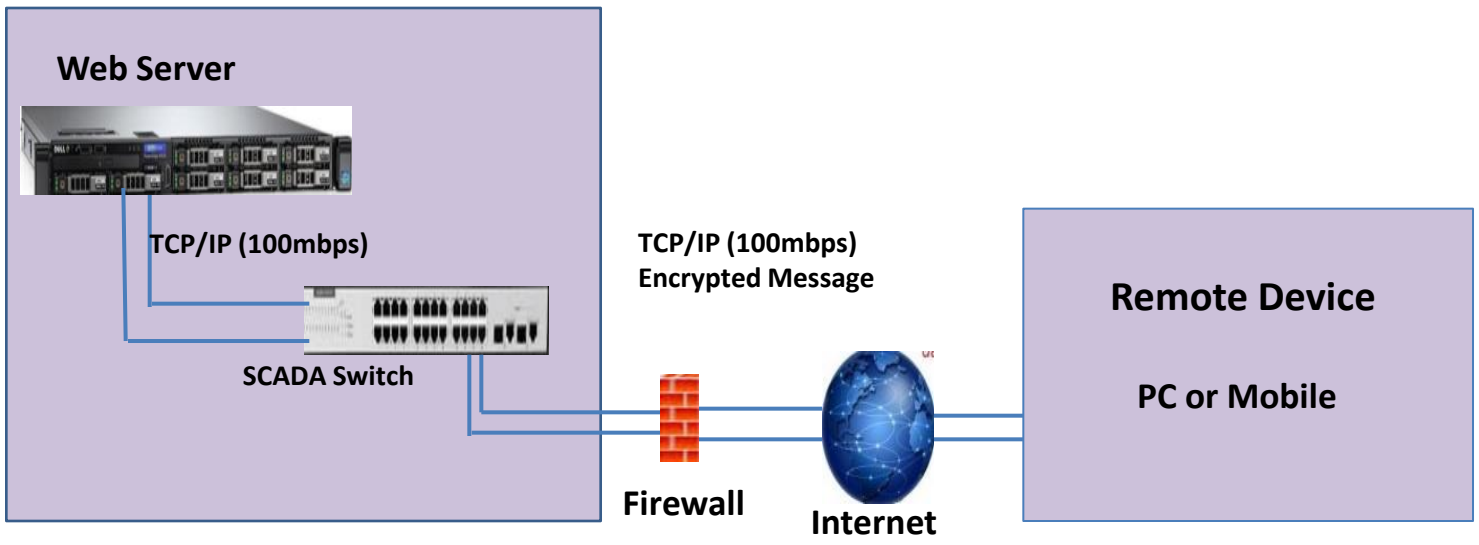
Video Wall Display

Web Access For Monitoring of SCADA

- Web Access functionality allows user to access SCADA HMI from remote location over internet through Firewall
- Only Monitoring facility will be provided to remote users



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Green Initiatives

- Green Building construction for OCC.
- Deployment of Green Energy for emergency lighting load.
- Use of BEE endorsed Star labeled products.
- Buildings to comply ECBC code.

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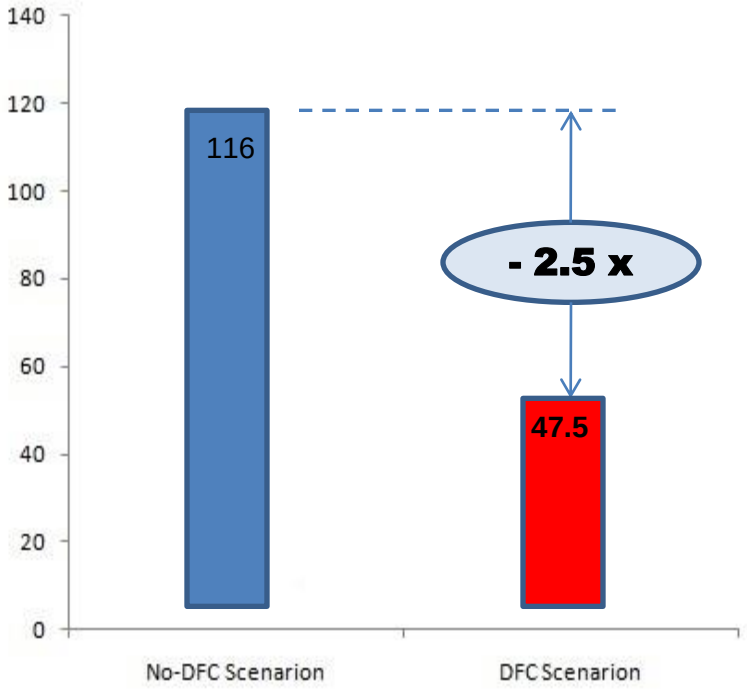
Green Initiatives

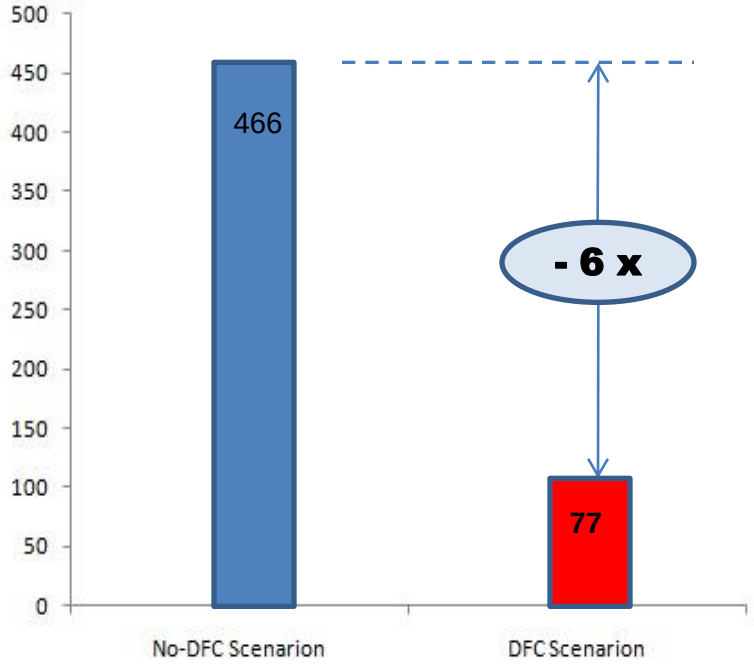
Carbon Footprint of Dedicated Freight Corridor

Cumulative GHG emissions over 30 years

Eastern Corridor
(1975 Billion Tonne-Km)



Western Corridor
(3241 Billion Tonne-Km)



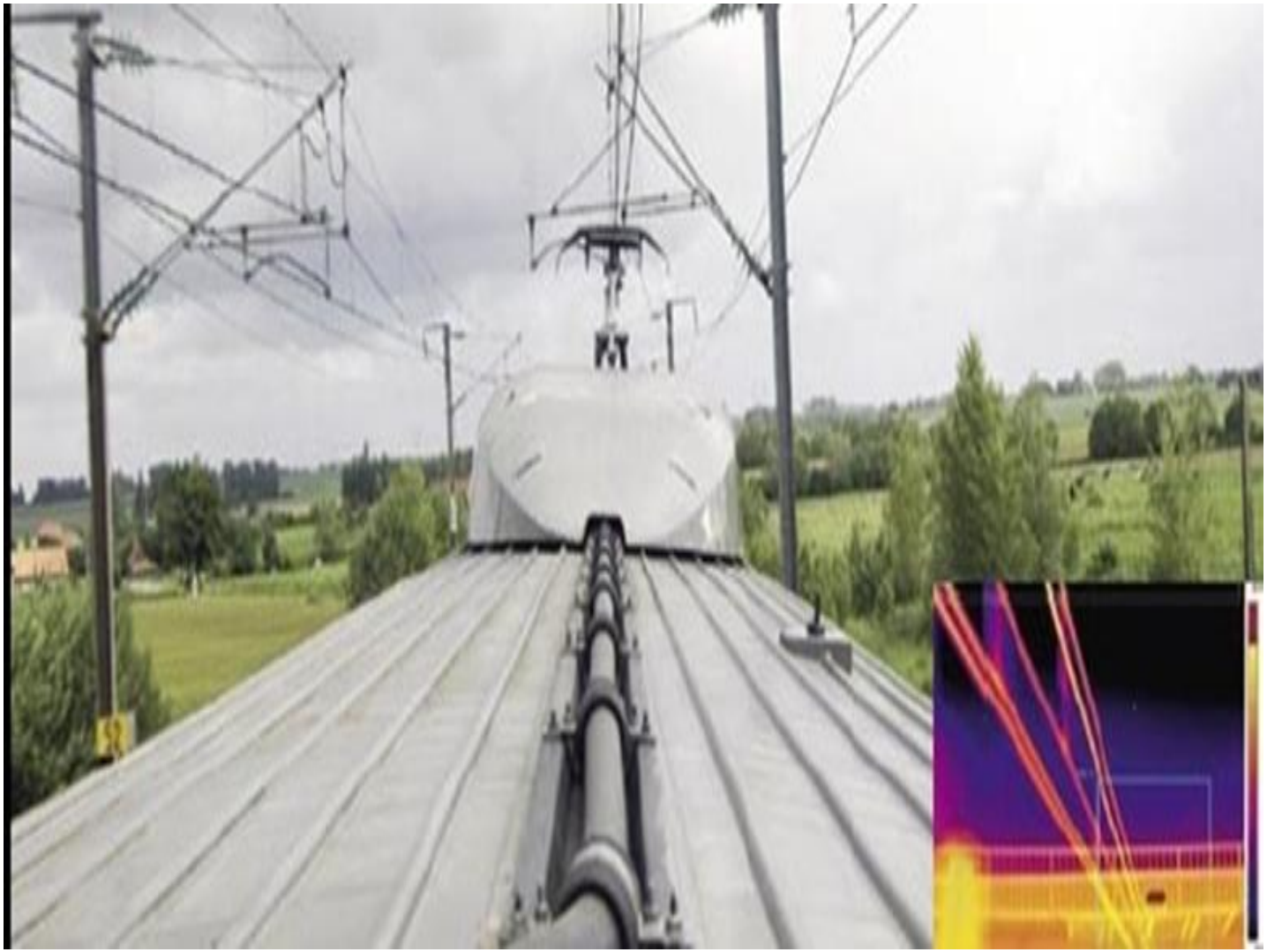
Green DFC - to save 457 million-tonne CO_2 over 30 years period.

Source: Report on 'Green House Gas Emission Reduction Analysis for DFC' by Ernst & Young

Mechanized Maintenance

- Fixed Traffic Block of 4 hrs.
- Deploying 0.2 man per TKM.
- OHE monitoring car for directed maintenance.
- Asset Management software

OHE MONITORING CAR



Mechanised Maintenance (Contd...)

Mechanized Maintenance

- Self-propelled & off-track maintenance machinery

OHE MONITORING & INSPECTION CAR

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Mechanised Maintenance(Contd...)

- **Mechanised unwinding and anchoring of catenary and contact wires.**

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What Railway Can Learn From DFCCIL Experience

- Design build lump sum based procurement contracts(turnkey contracts)
- QCBS based consultancy & project management contracts
- Adopting 2x25kV system for High Density Routes
- Use of simulation tools to optimize equipment sizing
- Use of superior conductors to meet future demand

What Railway Can Learn From DFCCIL Experience (contd….)

- Mechanized Cylindrical Foundation
- Simultaneous catenary/contact wiring
- Modern SCADA based on TCP/IP protocol

THANKS