インド国
マディヤ・プラデシュ州送電公社(MPPTCL)

# インド国
# マディヤ・プラデシュ州
# 送電網整備事業フェーズ２に係る
# 技術支援

# 業務完了報告書
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独立行政法人
国際協力機構（JICA)

東京電力株式会社

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# 略語表

| 略語 | 正式名称 |
|---|---|
| ACE | Additional Chief Engineer |
| ACSR | Aluminum Conductor Steel Reinforced |
| AS | Aluminum-Clad Steel Wire |
| ATS | Atomic Power Station |
| BHEL | Bharath Heavy Electrical Limited |
| CE | Chief Engineer |
| CEA | Central Electricity Authority of India |
| CRA | Commercial & Regulatory Affairs |
| CoD | Collect on Delivery |
| DCDS | Double Circuit Double String |
| DCSS | Double Circuit Single String |
| DMIC | Delhi-Mumbai Industrial Corridor |
| DPR | Detailed Project Report |
| DS | Disconnecting Switch |
| DVC | Damodar Valley Corporation |
| EC | Environmental Clearance |
| ED | Executive Director |
| EHT | Extra High Tension |
| EIA | Environmental Impact Assessment |
| EIS | Environmental Impact Statement |
| EPC | Engineering, Procurement and Construction |
| ES | Earthing Switch |
| GCB | Gas Circuit Breaker |
| GIS | Gas Insulated Switchgear |
| GoI | Government of India |
| GSW | Galvanized Steel Wire |
| HSES | High Speed Earthing Switch |
| HTLS | High Temperature Low Sag (conductor) |
| HPS | Hydro Power Station |
| HRD | Human Resource Development |
| ICB | International Competitive Bidding |
| IEE | Initial Environmental Examination |
| IEEE | Institute of Electrical and Electronics Engineers |
| IKL | Isokeraunic Level |
| INR | Indian Rupee |
| IPP | Independent Power Producer |
| IPP | Indigenous Peoples Plan |
| IUCN | International Union for Conservation of Nature |
| JICA | Japan International Cooperation Agency |
| JV | Joint Venture |
| LAA | Land Acquisition Act |

| | |
|---|---|
| LL-ACSR | Low Loss type ACSR (conductor) |
| M&I | Maintenance and Inspection |
| MPERC | Madhya Pradesh Electricity Regulatory Commission |
| MPPGCL | Madhya Pradesh Power Generating Company Limited |
| MPPTCL | Madhya Pradesh Power Transmission Company Limited |
| MPSEB | Madhya Pradesh State Electricity Board |
| MW | Megawatt |
| NGO | Non-Governmental Organizations |
| NPC | Nuclear Power Corporation of India Limited |
| NRRP-2007 | National Rehabilitation and Resettlement Policy, 2007 |
| NTPC | NTPC Limited (National Thermal Power Corporation Limited) |
| ODA | Official Development Assistance |
| O&M | Operation and Maintenance |
| OPTCL | Odisha Power Transmission Company Limited |
| OPGW | Optical Ground Wire |
| PGCIL | Power Grid Corporation of India Limited |
| PQ | Prequalification |
| PSAF | Power Systems Analysis Framework |
| PSS/E | Power System Simulator for Engineering |
| PC | Procurement and Construction |
| RAP | Resettlement Action Plan |
| RE | Renewable Energy |
| ROW | Right-of-Way |
| SAIDI | System Average Interruption Duration Index |
| SAIFI | System Average Interruption Frequency Index |
| STPS | Super Thermal Power Station |
| SCADA | Supervisory Control and Data Acquisition |
| SE | Superintending Engineer |
| SLDC | State Load Dispatching Center |
| S/S | Substation |
| TANTRANSCO | Tamil Nadu Transmission Corporation Ltd. |
| T&C | Testing and Communication |
| T&D | Transmission and Distribution |
| TEPCO | Tokyo Electric Power Company, Inc. |
| T/L | Transmission Line |
| TPS | Thermal Power Station |
| UGS | Ultra-High Strength Galvanized Steel Wire |

# 第1章 事業の背景と必要性

## 1.1. 本技術支援の背景等

インドでは、近年の急速な経済成長に伴いエネルギー消費が増加を続けており、世界第4位の電力消費国となっている（2012年）。他方、深刻な電力の需給逼迫が続いており、2014-15年度（2014年4月～2015年3月）は、1,067,085 GWhの需要に対して供給量は1,028,955GWhと3.6%の不足、供給能力もピーク時148,166 MWの需要に対して141,160 MWと4.7%の不足となった。関連して第12次5ヶ年計画（2012年4月～2017年3月）では、第11次5ヶ年計画に引き続き、新電力法に基づく電力セクター改革、特に超臨界圧にフォーカスした電源開発（第13次5ヶ年計画以降の新規石炭火力発電所開発は全て超臨界圧としている）、送配電設備増強及び地方電化を国内の重要課題として掲げている。

マディヤ・プラデシュ州は、インド中央部に位置し、インド全体で2番目の土地面積308,144km$^2$と、6番目の人口約7,300万人を擁する州である。日印政府イニシアティブにより進められているデリー・ムンバイ間産業大動脈構想（Delhi-Mumbai Industrial Corridor: DMIC）を構成する州でもあり、インドール空港近辺の経済特区開発、デワス市付近の物流拠点の開発及びピタムプール工業地域開発等が計画されている。このため、同州では、今後の堅調な経済発展が見込まれ、電力需要が増加することが予想されている。同州における電力の需給状況は、2014-15年度は、53,737 GWhの需要に対して供給量は53,445 GWhと0.5%の不足であり、インド全体の状況を上回っているが、不足がある状況である。将来的な電力需要に対応するため、同州政府は、複数の独立系電力発電事業者（Independent Power Producers: IPPs）との間で、発電所開発にかかる覚書を署名しており、今後さらなる電力供給量の増加も見込まれている。新規発電量は、需要増加が見込まれる都市部のみならず、地方部にも供給されるため、同州において広域にわたる送電網の増強が必要である。右状況に対応すべく、2011年に国際協力機構（Japan International Cooperation Agency: JICA）はマディヤ・プラデシュ州送電公社（Madhya Pradesh Power Transmission Company Limited: MPPTCL）との間で、「マディヤ・プラデシュ州送電網整備事業」に係る円借款契約（総事業費22,213百万円、うち円借款額18,475百万円）を締結し、同州における電力系統の安定化の達成を目的として、送変電網の整備が実施してきた。他方、今後の電力供給の増加に鑑みると、継続的なインドにおける最大の電力需要地である西部電力系統の安定化及び効率的な送配電網を実現することが必要であるとの判断から、今般、MPPTCLは、改めて我が国の有償資金協力を想定した「マディヤ・プラデシュ州送電網整備事業フェーズ2（以下、本事業）」の計画書（Detailed Project Repot: DPR）を作成した。しかしながら、同州にはより効率的な送電系統の確立に有効な最新技術（低ロス電線、高温低弛度電線、ガス絶縁開閉装置（Gas Insulated Switchgear: GIS）変電所等）の導入実績が無いためDPRはこれらの技術を活用した内容にはなっておらず、より適切な事業計画の策定が必要な状況であった。

表 1-1　18th Electricity Power Survey における各州の電力需要予測

単位: MW

| State/Uts | FY2011-12 | FY2016-17 | FY2021-22 | FY2026-27 | FY2031-32 |
|---|---|---|---|---|---|
| Delhi | 4,770 | 6,398 | 9,024 | 12,681 | 17,246 |
| Haryana | 6,376 | 10,273 | 14,244 | 20,103 | 27,202 |
| Himachal Pradesh | 1,335 | 1,900 | 2,589 | 3,424 | 4,476 |
| Jammu & Kashmir | 1,802 | 2,687 | 4,217 | 5,996 | 8,302 |
| Punjab | 8,363 | 12,342 | 14,552 | 18,352 | 23,144 |
| Rajasthan | 8,097 | 13,886 | 19,692 | 28,828 | 40,284 |
| Uttar Pradesh | 12,021 | 23,081 | 36,061 | 53,690 | 73,708 |
| Uttarakhand | 1,656 | 2,189 | 2,901 | 3,911 | 5,222 |
| Chandigarh | 336 | 426 | 559 | 732 | 948 |
| **Northern Region** | **37,265** | **60,934** | **86,461** | **121,979** | **164,236** |
| Goa | 530 | 815 | 1,192 | 1,658 | 2,216 |
| Gujarat | 11,556 | 19,091 | 26,973 | 38,691 | 53,301 |
| Chhattisgarh | 3,155 | 4,687 | 6,599 | 9,090 | 12,116 |
| **Madhya Pradesh** | **8,897** | **13,904** | **18,802** | **27,519** | **38,088** |
| Maharashtra | 18,398 | 28,645 | 39,622 | 54,982 | 74,528 |
| D. & N. Haveli | 640 | 944 | 1,297 | 1,733 | 2,294 |
| Daman & Diu | 308 | 441 | 605 | 818 | 1,082 |
| **Western Region** | **39,351** | **62,015** | **86,054** | **120,620** | **163,222** |
| Andhra Pradesh | 14,122 | 22,445 | 33,194 | 51,601 | 74,818 |
| Karnataka | 8,545 | 13,010 | 18,403 | 25,396 | 34,720 |
| Kerala | 3,489 | 4,669 | 6,093 | 8,150 | 10,903 |
| Tamil Nadu | 12,271 | 20,816 | 29,975 | 43,044 | 59,127 |
| Pudducherry | 497 | 630 | 782 | 787 | 940 |
| **Southern Region** | **36,175** | **57,221** | **82,199** | **118,764** | **165,336** |
| Bihar | 2,226 | 5,018 | 9,306 | 16,239 | 23,411 |
| Jharkhand | 3,201 | 4,616 | 6,341 | 8,780 | 11,930 |
| Odisha | 3,964 | 5,672 | 6,749 | 8,712 | 11,280 |
| West Bengal | 7,454 | 11,793 | 17,703 | 26,027 | 36,187 |
| Sikkim | 106 | 144 | 176 | 245 | 341 |
| **Eastern Region** | **15,122** | **24,303** | **35,928** | **53,053** | **72,874** |
| Assam | 1,257 | 1,817 | 2,534 | 3,613 | 5,033 |
| Manipur | 171 | 346 | 497 | 869 | 1,212 |
| Meghalaya | 361 | 445 | 596 | 828 | 1,112 |
| Nagaland | 130 | 185 | 271 | 403 | 554 |
| Tripura | 239 | 340 | 472 | 674 | 913 |
| Arunachal | 88 | 135 | 177 | 266 | 365 |
| Mizoram | 160 | 285 | 352 | 521 | 723 |
| **North Eastern** | **2,021** | **2,966** | **4,056** | **6,169** | **8,450** |
| Andaman | 51 | 67 | 89 | 125 | 172 |
| Lakshadweep | 7 | 11 | 18 | 23 | 30 |
| **India** | **124,995** | **199,540** | **283,470** | **400,705** | **541,823** |

(Source: 18th Electricity Power Survey by CEA)

## 1.2. 本事業の目的

本事業の目的は、マディヤ・プラデシュ州の今後の電力需要の増加に対応すべく、MPPTCLが所有する同州の送変電設備を増強することにより、同州の電力供給能力の増強及び電力系統の安定化を図ることである。

## 1.3. 本調査の概要

本調査の概要を下表に示す。

**表 1-2 本調査の概要**

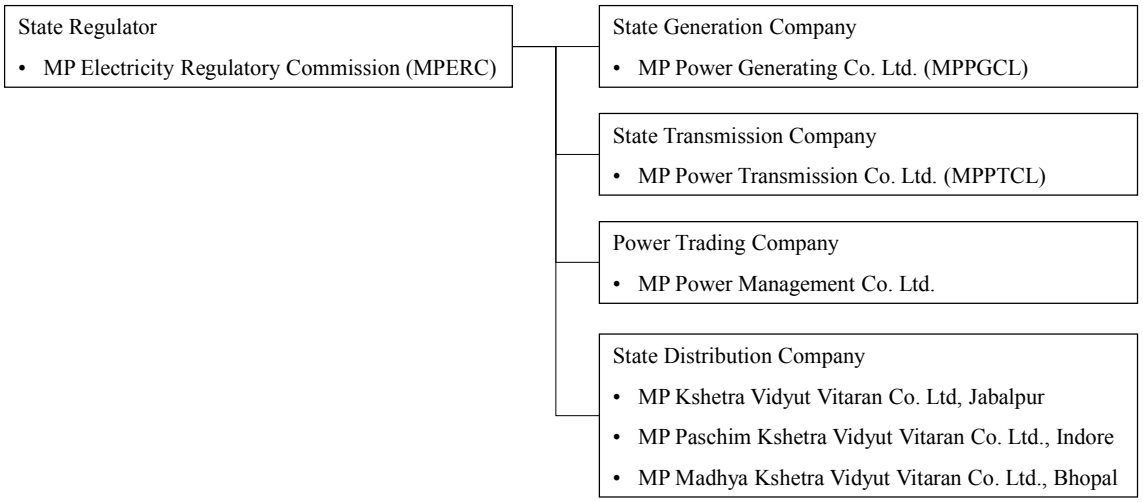
| | |
|---|---|
| 目的 | マディヤ・プラデシュ州における効率的な送電系統の整備に有効な最新技術の導入を前提に、本事業の計画・設備設計等を見直すとともに、MPPTCL へ環境社会配慮面での支援を行うことで、事業の効果増大・促進を図る。 |
| 検討概要 | 1. 系統計画の確認・更新<br>2. DPR の確認・更新<br>3. 新技術・本邦技術導入可能性調査<br>4. 環境社会配慮支援<br>5. 本事業実施体制調査 |
| 対象期間 | 2015 年 7 月～2015 年 10 月（現地調査 2 回） |
| 対象地域 | マディヤ・プラデシュ州全域 |
| 相手国機関 | マディヤ・プラデシュ州送電公社 |

## 1.4. マディヤ・プラデシュ州の電力セクター概要

マディヤ・プラデシュ州の電気事業は、インド国内他州と同様に、従来、垂直統合型のマディヤ・プラデシュ州電力局（Madhya Pradesh State Electricity Board: MPSEB）が担ってきた。その後、MPSEB の経営効率を改善し、経済発展に伴う電力需要の増加に対応するため、電力セクターに市場原理を導入することを主目的として、2000 年にマディヤ・プラデシュ州電力改革法（The Madhya Pradesh Vidyut Sudhar Adhiniyam, 2000）が制定され、翌 2001 年に施行された。同法令に基づき、マディヤ・プラデシュ州の電気事業全体の規制機関であるマディヤ・プラデシュ州電力規制委員会（Madhya Pradesh Electricity Regulatory Commission: MPERC）が 2001 年に、発電事業、送変電事業、配電事業の運営を行うマディヤ・プラデシュ州発電公社（Madhya Pradesh Power Generating Company Limited: MPPGCL）、MPPTCL、地域分けされた 3 つの配電公社が 2002 年にそれぞれ設立された（図 1-1 参照）。同州の送変電設備のうち、132kV 以上の送変電設備[1]を MPPTCL が、それ以下の 33kV 以下の配電設備

[1] MPPTCL の所管設備は、設備の使用電圧の高い方から、132kV/33kV 変電所における 33kV 配電線引出し口までである。また少数の 66kV 設備を含む。

を地域分けされた配電公社がそれぞれ運用している。その後 2006 年に、マディヤ・プラデシュ州内外の電力を購入し、州内の 3 つの配電公社に電力を卸す機能を担うマディヤ・プラデシュ州電力マネジメント公社（Madhya Pradesh Power Management Company Limited（旧名、マディヤ・プラデシュ州電力取引公社））も併せて設立されている。




（Source: JICA Study Team）

**図 1-1 マディヤ・プラデシュ州の電力セクター**

### 1.4.1. MPPTCL の役割と今後の戦略

MPPTCL はマディヤ・プラデシュ州の送電事業を担う送電公社として、グリッドコード（電力供給規定）を順守し、安定した電力を顧客に供給することが第一の役割である。MPPTCL は今後、州内で急速に増加する発電および電力需要に対して安定した電力を供給するため、MPERC の諸規制の下で、計画的に送変電設備の増強を進めるとともに、効率的な送変電設備の運用に係る新技術を導入していく計画である。具体的には、変電所運用効率化のため、SCADA システムの新規導入を現在進めている状況である[2]。また、州給電所（State Load Dispatching Center: SLDC）と上記 SCADA システムとを連携させ、事故時の負荷調整を自動で行うための、自動負荷調整システムの導入を並行して進めている[3]。

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[2] Jabalpur、Bhopal、Indore の 3 か所に、MPPTCL が運用する全ての変電所を遠隔監視制御するための Control Center を新設する事業。中国メーカーの Dongfang Electronics Company Ltd.が 2013 年 9 月に落札し、ターンキー契約で業務が進められ、一部運転開始している。

[3] 需給逼迫時の負荷遮断を自動で行うためのシステム。SCADA システム同様に、中国メーカーの Dongfang Electronics Company Ltd.が 2015 年 3 月に落札し、ターンキー契約で業務が進められている。

1.4.2.　マディヤ・プラデシュ州の電力需給状況

表 1-3 にマディヤ・プラデシュ州の発電容量を、表 1-4 に最大電力需要をそれぞれ示す。年度ごとの発電設備容量に関しては、両表を比較すると、各年度供給力が最大需要を上回っており、発電設備容量は十分確保できる見通しになっている。年度ごとの発電容量・最大電力需要の推移に着目すると、両指標とも対前年度比の伸び率が平均して 7%程度と非常に高いことが分かる。但し、実際の発電電力についてみると、必ずしも十分な発電容量は確保できていない。例えば、CEA の Monthly Power Supply Report[4]によると、2014 年 4 月から 2015 年 3 月の期間で、最大需要 9,755MW に対し、供給力 9,717MW と、38MW（0.4%）の不足が発生している。これは、火力発電所の燃料調達不調、老朽化発電所の発電能力低下が原因と推測される。

発電容量のうち、2014-15 年度の発電容量 15,190MW の発電所別内訳を表 1-5 に、また今後の発電所開発計画を表 1-6 に示す。表 1-6 によると、短期的には 2015-16 年度に 3 ヶ所の IPP 630MW が運転開始予定であり、長期的には 2021-22 年度までに、マディヤ・プラデシュ州発電公社（Madhya Pradesh Power Generation Company Limited: MPPGCL）、国営火力発電公社（National Thermal Power Company: NTPC）および国営原子力発電公社（Nuclear Power Company of India: NPC）による総計 8,000MW 規模の発電所建設が計画されている。同州においては、今後増加する発電設備・電力需要に対応して、送変電設備の拡充が急務である。

**表 1-3　マディヤ・プラデシュ州の発電容量**

| 発電事業者 | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2021-22 |
|---|---|---|---|---|---|---|---|---|
| The State of MP [MW] | 5,237 | 5,237 | 5,237 | 5,831 | 7,085 | 7,085 | 7,085 | 7,085 |
| Central Sector [MW] | 3,231 | 3,231 | 3,565 | 4,684 | 4,684 | 5,344 | 6,763 | 8,108 |
| Others (IPPs, JVs, DVC, RE)　[MW] | 6,722 | 7,655 | 7,655 | 7,655 | 7,886 | 7,886 | 7,886 | 7,886 |
| 合計 [MW] | 15,190 | 16,123 | 16,457 | 18,170 | 19,655 | 20,315 | 21,734 | 23,079 |
| 対前年増加率[%] | - | 6.1 | 2.1 | 10.4 | 8.2 | 3.4 | 7.0 | 6.2 |

注、2015-16 以降は計画値

(Source: MP Power Management Co. Ltd.)

[4] http://cea.nic.in/monthlypowersupply.html

表 1-4　マディヤ・プラデシュ州内の配電会社の最大電力予測値

| 配電会社 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2021-22 |
|---|---|---|---|---|---|---|---|
| East Discom [MW] | 3,140 | 3,418 | 3,672 | 3,980 | 4,270 | 4,592 | 4,891 |
| Central Discom [MW] | 3,344 | 3,641 | 3,910 | 4,239 | 4,548 | 4,890 | 5,209 |
| West Discom [MW] | 4,029 | 4,386 | 4,710 | 5,106 | 5,478 | 5,890 | 6,275 |
| 州内合計[MW] | 10,513 | 11,445 | 12,293 | 13,326 | 14,297 | 15,372 | 16,375 |
| 対前年増加率[%] | - | 8.9 | 7.4 | 8.4 | 7.3 | 7.5 | 6.5 |

(Source: MPPTCL)

**表 1-5　マディヤ・プラデシュ州の発電容量**

単位: MW

| 種別 | No. | プロジェクト名 | 設備容量 | ﾏﾃﾞｨﾔ・ﾌﾟﾗﾃﾞｼｭ州 持分 (2015年3月時点) |
|---|---|---|---|---|
| マディヤ・プラデシュ州発電公社 | | | | |
| MPPGCL 火力発電 | 1 | Amarkantak TPS Ph-I | 2x30 (50) | 0 |
| | 2 | Amarkantak TPS Ph-II | 2x120 | 240 |
| | 3 | Amarkantak TPS Ph-III | 1x210 | 210 |
| | 4 | Satpura TPS Ph-I | 5x62.5 | 0 |
| | 5 | Satpura TPS Ph-II | 1x200+1x210 | 410 |
| | 6 | Satpura TPS Ph-III | 2x210 | 420 |
| | 7 | Satpura TPS Ph-IV | 2x250 | 500 |
| | 8 | Sanjay Gandhi TPS Birsinghpur Ph-I | 2x210 | 420 |
| | 9 | Sanjay Gandhi TPS Birsinghpur Ph-II | 2x210 | 420 |
| | 10 | Sanjay Gandhi TPS Birsinghpur Ph-III | 1x500 | 500 |
| | 11 | Shri Singaji TPS Ph-I | 2x600 | 1,200 |
| | | 小計（MPPGCL 火力発電） | | 4,320 |
| MPPGCL 水力発電 | 12 | Rani Awanti Bai Sagar, Bargi HPS | 2x45 | 90 |
| | 13 | Bansagar HPS Ph - I (Tons) | 3x105 | 315 |
| | 14 | Bansagar HPS Ph - II (Silpara) | 2x15 | 30 |
| | 15 | Bansagar HPS Ph - III (Deolond) | 3x20 | 60 |
| | 16 | Bansagar HPS Ph - IV (Jhinna) | 2x10 | 20 |
| | 17 | Birsinghpur HPS | 1x20 | 20 |
| | 18 | Madikheda HPS | 3x20 | 60 |
| | 19 | Rajghat HPS (MP Share 50%, rest UP) (Situated in MP) | 3x15 | 23 |
| | 20 | Gandhi sagar HPS (MP share 50%, rest Rajasthan) (Situated in MP) | 5x23 | 58 |
| | 21 | Ranapratap Sagar HPS (MP Share 50%, rest Rajasthan) (Situated in Rajasthan) | 4x43 | 86 |
| | 22 | Jawahar Sagar HPS (MP Share 50%, rest Rajasthan) (Situated in Rajasthan) | 3x33 | 50 |
| | 23 | Pench HPS (MP Share 66.6%, rest Maharashtra) (Situated in Maharashtra) | 2x80 | 107 |
| | | 小計（MPPGCL 水力発電） | | 917 |
| 小計（マディヤ・プラデシュ州） | | | | 5,237 |
| 中央政府発電公社 | | | | |
| | 24 | NTPC Korba STPS | 3x200+4x500 | 557 |
| | 25 | NTPC Vindhyanchal STPS - I | 6x210 | 443 |
| | 26 | NTPC Vindhyanchal STPS - II | 2x500 | 318 |
| | 27 | NTPC Vindhyanchal STPS - III | 2x500 | 245 |
| | 28 | NTPC Vindhyanchal STPS - IV | 2x500 | 284 |
| | 29 | NTPC Sipat STPS Stage-I | 3x660 | 337 |
| | 30 | NTPC Sipat STPS Stage-II | 2x500 | 187 |
| | 31 | NTPC Mouda STPS Stage-I | 2x500 | 184 |
| | 32 | NTPC Kawas GPP (Gas) | 4x106+2x116.1 | 140 |
| | 33 | NTPC Gandhar GPP (Gas) | 3x144.3+1x224.49 | 117 |
| | 34 | NTPC Kahalgaon STPS Stage - II (ER) | 3x500 | 74 |
| | 35 | NPC Kakrapar APS (Atomic) | 2x220 | 114 |
| | 36 | NPC Tarapore APS (Atomic) | 2x540 | 231 |
| 小計（中央政府発電公社） | | | | 3,231 |
| その他 | | | | |
| IPPs | 37 | Torrent Power GPP, Gujrat (Gas) | 3x382.5 | 100 |
| | 38 | BLA Power TPS, Gadarwara | 1x45 | 16 |
| | 39 | Jaypee Bina Power TPS | 2x250 | 350 |
| | 40 | Lanco Amarkantak TPS, Raigarh | 1x300 | 300 |
| | 41 | Reliance UMPP, Sasan | 6x660 | 1,485 |
| | 42 | Essar Power STPS, Mahan, Singrauli | 1x600 | 30 |
| | 43 | Jaiprakash Power STPS, Nigri | 2x660 | 495 |
| | | 小計（IPPs） | | 2,776 |
| JV Hydro | 44 | NHDC Indira Sagar HPS | 8x125 | 1,000 |
| | 45 | NHDC Omkareshwar HPS | 8x65 | 520 |
| | 46 | Sardar Sarovar HPS (Share 57%) (Situated in Gujrat) | 5x50 + 6x200 | 827 |
| | 47 | NVDA Indira Sagar LBC HPS | 3x5 | 15 |
| | 48 | NVDA Bargi LBC HPS | 2x5 | 10 |
| | 49 | Rihand and Matatila HPS (Situated in UP) | 6x50+3x10.2 | 55 |
| | | 小計（JV Hydro） | | 2,427 |
| DVC | 50 | DVC Mejia TPS | 4x210 + 2x250 | 200 |
| | 51 | DVC Chandrapur TPS Unit 7 & 8 | 2x250 | 200 |
| | 52 | DVC Durgapur TPS | 2x500 | 100 |
| | | 小計（DVC） | | 500 |
| 再生可能エネルギー発電 | 53 | Solar Plants | | 305 |
| | 54 | Wind Plants | | 685 |
| | 55 | Biogas/Biomass Plants | | 24 |
| | 56 | Micro Hydel Plants | | 5 |
| | | 小計（再生可能エネルギー発電） | | 1,020 |
| 小計（その他） | | | | 6,722 |
| 合計 | | | | 15,190 |

(Source: MPPTCL)

## 表 1-6　マディヤ・プラデシュ州の今後の発電所開発計画

| 種別 | プロジェクト名 | CoD | 発電容量 (MW) | 州持分 (MW) | 年度別発電容量増加量 (MW) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2021-22 |
| マディヤ・プラデシュ州発電公社 | | | | | | | | | | | |
| | MPPGCL - Shri Singaji Phase-2, Unit-1 | Mar-2018 | 1x660 | 594 | | | 594 | | | | |
| | MPPGCL - Shri Singaji Phase-2, Unit-2 | Sep-2018 | 1x660 | 594 | | | | 594 | | | |
| | MPPGCL - Replacement Unit of Satpura | Mar-2019 | 1x660 | 660 | | | | 660 | | | |
| | 小計（MPPGCL） | | | 1,848 | 0 | 0 | 594 | 1,254 | 0 | 0 | 0 |
| 中央政府発電公社 | | | | | | | | | | | |
| | NTPC Vindhyanchal STPS, Stage - 5, Unit-1 | Apr-2016 | 1x500 | 128 | | 128 | | | | | |
| | NTPC Mouda STPS, Stage-2, Unit-1&2 | Dec-2016 | 2x660 | 206 | | 206 | | | | | |
| | NTPC Lara STPS, Rajgarh (Unit 1 to 6) | Sep-2017 | 6x660 | 319 | | | 319 | | | | |
| | NTPC Gadarwara STPS, Unit-1 | Sep-2017 | 1x800 | 400 | | | 400 | | | | |
| | NTPC Gadarwara STPS, Unit-2 | Mar-2018 | 1x800 | 400 | | | 400 | | | | |
| | NTPC Barethi STPS, Chhatarpur, Unit-1&2 | Dec-2019 | 2x660 | 660 | | | | | 660 | | |
| | NTPC Barethi STPS, Chhatarpur, Unit-3&4 | Sep-2020 | 2x660 | 660 | | | | | | 660 | |
| | NTPC Barethi STPS, Chhatarpur, Unit-5&6 | Dec-2021 | 2x660 | 660 | | | | | | | 660 |
| | NTPC Solapur STPS, Unit-1&2 | Mar-2021 | 2x660 | 304 | | | | | | 304 | |
| | NTPC Khargone STPS, Unit-1 | Mar-2021 | 1x660 | 330 | | | | | | 330 | |
| | NTPC Khargone STPS, Unit-2 | Sep-2021 | 1x660 | 330 | | | | | | | 330 |
| | NTPC Dhruvan STPS, Gujrat, Unit-1,2&3 | Sep-2021 | 3x660 | 230 | | | | | | | 230 |
| | NTPC North Karanpura STPS, Unit-1 | Dec-2018 | 1x660 | 66 | | | | 66 | | | |
| | NTPC North Karanpura STPS, Unit-2 | Jun-2019 | 1x660 | 66 | | | | | 66 | | |
| | NTPC North Karanpura STPS, Unit-3 | Dec-2019 | 1x660 | 67 | | | | | 67 | | |
| | NPC Kakrapar APS, Unit-3 | Sep-2020 | 1x700 | 125 | | | | | | 125 | |
| | NPC Kakrapar APS, Unit-4 | Sep-2021 | 1x700 | 125 | | | | | | | 125 |
| | 小計（中央政府発電公社） | | | 5,076 | 0 | 334 | 1,119 | 66 | 793 | 1,419 | 1,345 |
| その他 | | | | | | | | | | | |
| | MB Power STPS, Unit-1 | May-2015 | 1x600 | 210 | 210 | | | | | | |
| | MB Power STPS, Unit-2 | Dec-2015 | 1x600 | 210 | 210 | | | | | | |
| | Essar Power STPS, Unit 1 & 2 | | 2x600 | 150 | | | | | | | |
| | Jhabua Power STPS, Unit-1 | Sep-2015 | 1x600 | 210 | 210 | | | | | | |
| | BLA Power TPS Unit-2 | | 1x45 | 16 | | | | | | | |
| | DB Power TPS, Unit-1 | | 1x660 | 231 | | | | | | | |
| | 小計（IPPs） | | | 1,027 | 630 | 0 | 0 | 0 | 0 | 0 | 0 |
| 再生可能エネルギー発電 | | | | | | | | | | | |
| | Solar Plants | Jan-2016 | | 130 | 130 | | | | | | |
| | Wind Plants | Jan-2016 | | 236 | 236 | | | | | | |
| | Bio Mass/Bio gas Plants | Jan-2016 | | 8 | 8 | | | | | | |
| | 小計（再生可能エネルギー発電） | | | 374 | 374 | 0 | 0 | 0 | 0 | 0 | 0 |
| 合計 | | | | 8,324 | 1,004 | 334 | 1,713 | 1,320 | 793 | 1,419 | 1,345 |

(Source: MPPTCL)

下表に MPPTCL が保有する送変電設備の概要を示す。近年の設備増加率を示すため、利用可能な 2002 年 3 月時点の設備数との比較を合わせて示す。MPPTCL では、2015 年 6 月現在、送電線 30,686km（回線長）および 294 か所の変電所を有している。近年の電力需要増加に伴い、設備数・設備容量を急激に増加させており、2002 年 3 月～2015 年 6 月の間に、送電線回線長 75%増加、変電所箇所数 109%増加、変電所出力 178%増加を示している。なお、MPPTCL の所有する変電所はすべて気中絶縁変電所（Air Indulated Substation: AIS）であり、現在までガス絶縁開閉装置（Gas Insulated Switchgear: GIS）は保有していない。

**表 1-7　MPPTCL が保有する設備の概要**

| 設備 | 単位 | 2002 年 3 月時点設備数 | 2015 年 6 月時点設備数 | 2002 年 3 月～2015 年 6 月の増加率 |
|---|---|---|---|---|
| 400kV 送電線 | Circuit-km | 1,706 | 3,074 | 80% |
| 220kV 送電線 | Circuit-km | 6,496 | 12,001 | 85% |
| 132kV 送電線 | Circuit-km | 9,229 | 15,549 | 68% |
| 66kV 送電線 | Circuit-km | 61 | 61 | - |
| 送電線合計（回線長） | Circuit-km | 17,493 | 30,686 | 75% |
| 400kV 変電所 | No. | 4 | 9 | 125% |
| | MVA | 2,940 | 6,720 | 129% |
| 220kV 変電所 | No. | 26 | 64 | 146% |
| | MVA | 6,610 | 18,630 | 182% |
| 132kV 変電所 | No. | 110 | 220 | 100% |
| | MVA | 6,910 | 20,517 | 197% |
| 66kV 変電所 | No. | 1 | 1 | - |
| | MVA | 20 | 20 | - |
| 変電所合計 | No. | 141 | 294 | 109% |
| | MVA | 16,480 | 45,887 | 178% |
| 変電所の変圧器総数 | No. | 356 | 718 | 102% |

(Source: MPPTCL Overview)

### 1.4.3. マディヤ・プラデシュ州の送配電ロス率

マディヤ・プラデシュ州内の送配電ロス率の推移を以下に示す。2014-15 年度実績値において、送電ロス率は 3.0%と非常に低い値を示しており、現状すでに効率的な送電系統の運用が図られている状況が分かる。他方で、配電ロス率は、2014-15 年度実績値で 24.1%と非常に高く、一般に需要家に近い低電圧の配電系統のロスが高くなる傾向を考慮しても、今後の改善の余地が大きいと言わざるを得ない。マディヤ・プラデシュ州では、増加する需要に対応した送電系統の強化に加えて、配電系統のロス低減にも適切な投資を行うべきである。

**表 1-8 マディヤ・プラデシュ州内の送配電ロス率**

単位: %

| FY | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2021-22 |
|---|---|---|---|---|---|---|---|---|
| 送電ロス | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| 配電ロス | 24.1 | 22.2 | 20.9 | 19.9 | 18.8 | 17.8 | 16.8 | 15.7 |
| 平均送配電ロス | 27.1 | 25.2 | 24.0 | 23.0 | 22.0 | 21.0 | 20.0 | 19.0 |

注、2015-16 以降は計画値

(Source: MP Power Management Co. Ltd.)

### 1.4.4. 電力品質、変電所運転電圧

マディヤ・プラデシュ州の電力品質に関しては、グリッドコード（電力供給規定）の中で下表の運用電圧、また電力周波数の運用幅[5]が規定され運用されている。MPPTCL に聞き取りを行った範囲では、事故等を除く平常運用時においては、これらの運用基準はおおむね守られている状況である。ただし、配電系統に近い 132kV 系統においては、今後の需要増加に伴い、需要側に近い末端の変電所の電圧低下が 10%に近づくことが予想されている。MPPTCL では、132kV の電圧変動許容幅の規制値以外に、社内の運用目標値として-9%を定め、これを逸脱しないよう、適宜 132kV 変電所を新設・増設を行っている。

**表 1-9 マディヤ・プラデシュ州内の運用電圧幅（規制値）**

| 定格電圧 [kV] | 電圧変動許容幅 [%] | 最大許容電圧 [kV] | 最低許容電圧 [kV] |
|---|---|---|---|
| 400kV | +5% / -10% | 420 | 360 |
| 220kV | +/- 10% | 245 | 200 |
| 132kV | +/- 10% | 145 | 120 |

(Source: Electricity Grid Code (Revision-I), 2005)

[5]表 1-10 において、運用目標値許容幅の上限に比べ下限の幅が大きいことについては、インドは電力供給不足により、かつては 48.5Hz から 50.0Hz の間で運用されていることが多く、系統運用の実情を考慮し設定したものと推測される。

表 1-10　マディヤ・プラデシュ州内の電力周波数

| 運用目標値 | | 規制値 | |
|---|---|---|---|
| 上限 | 下限 | 上限 | 下限 |
| 50.5 Hz<br>(+1%) | 49.0 Hz<br>(-2%) | 51.5 Hz<br>(+3%) | 48.5 Hz<br>(-3%) |

(Source: Electricity Grid Code (Revision-I), 2005)

1.4.5.　供給信頼度

CEA のレポートによると 2013-14 年度におけるマディヤ・プラデシュ州の各配電会社のシステム平均停電時間 (System Average Interruption Duration Index: SAIDI) とシステム平均停電回数 (System Average Interruption Frequency Index: SAIFI) は表 1-11 の通りである。

マディヤ・プラデシュ州の場合、SAIDI は 152.17 分から 60,800.52 分の間に、また SAIFI は 1.97 回から 885.26 回の間にと、いずれも幅広い分布となっており、地域格差が大きいことが伺える。また先進国における SIADI が数分から 1 時間程度、東京電力における SAIFI が 0.1 回から 0.2 回程度であること比べると、まだまだ供給信頼度が高いとは言えないレベルである。

表 1-11 マディヤ・プラデシュ州の供給信頼度

| Distribution Company | SAIDI<br>[Minutes] | SAIFI<br>[No. of Incidents] |
|---|---|---|
| **MP Paschim KVVCL, Indore** | | |
| Indore | 359.49 | 12.87 |
| Dhar | 481.31 | 3.10 |
| Khandwa | 281.29 | 9.57 |
| Burhanpur | 770.16 | 24.80 |
| Khargone | 401.19 | 36.21 |
| Badwani | 1503.26 | 2.85 |
| Jhabua | 609.36 | 46.67 |
| Ujjain | 2497.23 | 32.89 |
| Dewas | 582.00 | 22.92 |
| Shajapur | 152.17 | 1.97 |
| Ratlam | 470.59 | 14.38 |
| Mandsaur | 2425.00 | 38.30 |
| Neemuch | 440.00 | 5.97 |
| **MP Poorv KVVCL, Jabalpur** | | |
| Boregaon | 2072.00 | 110.00 |
| Chanatoriya | 3584.26 | 90.00 |
| Chhatarpur | 3048.21 | 198.30 |
| Chindwada | 3085.61 | 89.62 |

| Distribution Company | SAIDI [Minutes] | SAIFI [No. of Incidents] |
|---|---|---|
| Damoh | 7600.98 | 294.60 |
| Jabalpur | 23455.63 | 885.26 |
| Katni | 241.58 | 31.00 |
| Rewa | 1470.52 | 32.54 |
| Sagar | 2406.32 | 78.11 |
| Satna | 8143.38 | 234.61 |
| Anooppur | 9255.99 | 218.67 |
| Balaghat | 272.15 | 72.86 |
| Narsingpur | 6722.99 | 207.25 |
| Panna | 60800.52 | 777.50 |
| Shahdol | 5757.94 | 204.17 |
| Seoni | 4378.04 | 133.60 |
| Sidhi | 13143.08 | 244.25 |
| Tikamgarh | 10183.67 | 332.33 |
| Umariya | 4905.19 | 175.33 |
| Waidhan | 9818.15 | 285.08 |
| **MPMKVVCL, Bhopal** | | |
| Bhopal | 2046.89 | 63.48 |
| Sehore City | 4017.44 | 171.33 |
| Vidisha Town | 6338.89 | 124.24 |
| Betul City | 9546.88 | 250.67 |
| Rajgarh | 4615.51 | 49.50 |
| Hoshangabad | 7055.13 | 287.22 |
| Harda | 6966.78 | 254.50 |
| Raisen | 704.90 | 102.67 |
| Mandideep | - | - |
| Gwalior | 3267.66 | 263.69 |
| Datia | 1598.29 | 59.54 |
| Morena | 27251.27 | 177.17 |
| Bhind | 6630.72 | 93.06 |
| Guna | 7787.11 | 306.38 |
| Ashoknagar | 8985.74 | 604.75 |
| Shivpuri | 16335.52 | 153.42 |
| Sheopur | 3441.51 | 24.57 |

(Source: Reliability Index of the Cities/Towns/Villages - DISCOM wise by CEA)

1.4.6.　託送料金制度

MPPTCL は託送料金収入により送電事業を運営しており、主な収入は、発電会社で発電された電気を配電会社に送電することにより得られる託送収入である。MP ERC により認可された託送料金は表 1-12 の通りとなっており、契約期間の長短によって異なる託送料金が設定されている。

**表 1-12 託送料金表**

| No. | 項目 | 2013-14 年度 | 2014-15 年度 | 2015-16 年度 |
|---|---|---|---|---|
| 1 | 年間固定費［1000 万 INR］ | 1642.49 | 1724.99 | 1795.72 |
| 2 | 送電容量［MW］ | 10530 | 13015 | 14540 |
| 3 | 長期契約託送料金［10 万 INR/MW/年］ | 15.60 | 13.25 | 12.35 |
| 4 | 長期契約託送料金［INR/MW/日］ | 4273.48 | 3631.19 | 3374.37 |
| 5 | 短期契約託送料金（長期の 25%）［INR/MW/日］ | 1068.36 | 907.80 | 843.59 |
| 6 | 6 時間短期契約託送料金［INR/MW］ | 267.09 | 226.95 | 210.90 |
| 7 | 6～12 時間短期契約託送料金［INR/MW］ | 534.18 | 453.90 | 421.80 |
| 8 | 12～24 時間短期契約託送料金［INR/MW］ | 1068.37 | 907.80 | 843.59 |
| 9 | 想定年間送電容量［GWh］ | 56437 | 62543 | 69310 |
| 10 | 短期オープンアクセス料金（No.1/No.9*0.25）［INR/MWh］ | 72.76 | 68.95 | 64.77 |

（2015 年 7 月平均、1.94 円／INR）

（Source: Transmission Multi-Year Tariff Order for FY2013-14 to FY2015-16, MPERC）

# 第2章 事業概要

## 2.1. 事業概要

本事業は、マディヤ・プラデシュ州全域における 400kV、220kV、132kV 送電線敷設、新規変電所建設及び既設変電所の増強である。実施機関の MPPTCL では、公式には 5 年ごとに 5 カ年計画を作成し、MPERC の認可を受けて事業計画が決定される。最新版の 5 カ年計画は、第 12 次 5 か年計画（2012 年 4 月～2017 年 3 月）が認可され、実施中である。MPPTCL では、これに加え需要想定の変化などを適宜反映した、送変電設備増強箇所をまとめたロングリストを有しており、本事業は 2015-16 年度から 2021-22 年度までのリストの中から、33 のサブプロジェクトが選定された。

表 2-1 に本事業のサブプロジェクトを示す。ここで、MPPTCL が今回新規に導入する送変電新技術として、送電線に LL-ACSR が 220kV 送電線 190km（亘長）、220kV 変電所 1 ヶ所に GIS がそれぞれ採用された。

**表 2-1 本事業に含まれる 33 サブプロジェクト**

| No.[*4] | サブプロジェクト名称 | 送電線 [亘長 km][*1] | | | 新・増設変電所[*2] | | |
|---|---|---|---|---|---|---|---|
| | | 400kV | 220kV | 132kV | 変電所 | 変圧器電圧 | 変圧器容量 |
| 1 | LILO of Khandwa – Rajgarh | 5 | | | - | - | - |
| 2 | Super Corridor | | LL 50 | 13 | 新 Super Corridor (GIS) | 220/132kV<br>132/33kV | 160MVA×1<br>63MVA×1 |
| 4 | Charging/Upgrading Chichli - Udaipura | | | | 増 Udaipura | 220/132kV | 160MVA×1 |
| 5 | Chhatarpur – Tikamgarh | | LL 110 | | - | - | - |
| 6 | LILO of Bina - Ganibasoda | | 10 | | 増 Bina | 400/220kV | 315MVA×1 |
| 7 | Rewa - Rewa UMSP - Sidhi | | LL 30<br>60 | | - | - | - |
| 9 | Julwania - Pati(Silawad) | | | 40 | 新 Pati (Silawad) | 132/33kV | 50MVA×1 |
| 10 | LILO of Mangliya - Indore SZ | | | 3 | 新 Mahalaxmi | 132/33kV | 63MVA×1 |
| 11 | Julwania - Shahpura | | | 65 | 新 Shahpura | 132/33kV | 50MVA×1 |
| 12 | Datia - Bhitarwr | | | 40 | 新 Bhitarwr | 132/33kV | 50MVA×1 |
| 13 | MugaliaChhap - Mahwadia | | | 10 | 新 Mahwadia | 132/33kV | 50MVA×1 |
| 15 | Sidhi - Madwas | | | 50 | 新 Madwas | 132/33kV | 50MVA×1 |
| 16 | Panagar - Dheemarkheda | | | 65 | 新 Dheemarkheda | 132/33kV | 50MVA×1 |
| 17 | Prithivipur – Orchha | | | 30 | 新 Orchha | 132/33kV | 50MVA×1 |
| 18 | Sirmour - Atraila | | | 30 | 新 Atraila | 132/33kV | 50MVA×1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 19 | Udaipura - Tendukheda | | | 45 | 新 Tendukheda | 132/33kV | 50MVA×1 |
| 20 | Gohad - Gormi | | | 25 | 新 Gormi | 132/33kV | 50MVA×1 |
| 21 | Narsinghgarh - Suthaliya | | | 50 | 新 Suthaliya | 132/33kV | 50MVA×1 |
| 22 | LILO of Satna - Kymore | | | 5 | 新 Unchhera | 132/33kV | 50MVA×1 |
| 23 | Sidhi - Sinhawal | | | 50 | 新 Sinhawal | 132/33kV | 50MVA×1 |
| 24 | Rajgarh - Chachoda | | | 61 | 新 Chachoda | 132/33kV | 50MVA×1 |
| 25 | Maneri - Mandla | | | 80 | - | - | - |
| 26 | Sukha(Jabalpur) | | | | 増 Sukha(Jabalpur) | 220/33kV | 50MVA×2 |
| 27 | Hoshangabad | | | | 増 Hoshangabad | 220/132kV | 160MVA×1 |
| 28 | Barwaha | | | | 増 Barwaha | 220/132kV | 160MVA×1 |
| 29 | Betma | | | | 増 Betma | 132/33kV | 50MVA×1 |
| 30 | Khirkiya | | | | 増 Khirkiya | 132/33kV | 50MVA×1 |
| 31 | Amla | | | | 増 Amla | 132/33kV | 50MVA×1 |
| 32 | Tejgarh | | | | 増 Tejgarh | 132/33kV | 50MVA×1 |
| 33 | Satwas | | | | 増 Satwas | 132/33kV | 50MVA×1 |
| 34 | Sitamau | | | | 増 Sitamau | 132/33kV | 50MVA×1 |
| 35 | Baroda | | | | 増 Baroda | 132/33kV | 50MVA×1 |
| 36 | Amrawadkhurd | | | | 増 Amrawadkhurd | 132/33kV | 50MVA×1 |
| 合計 | | Conv. 5 | Conv. 70<br>**LL 190** | Conv. 662 | 新 AIS 15<br>**新 GIS 1**<br>増 AIS 14 | | 2,281MVA |

註*1： 低ロス電線適用箇所は LL と付記する。
*2： GIS/AIS、新設/増設の別を示す。但し、各サブプロジェクトの工事対象として、既設変電所からの送電線引出し口増設、分路リアクトル増設が行われるが上表には記載していない。
*3： 赤字は新技術を表す。
*4： 検討過程で削除されたサブプロジェクトがあるため、抜け番が存在する。

(Source: DPR)

## 2.2. 系統計画・解析

インド各州の送電会社は各社が選んだそれぞれの解析ツールを使用しており、MPPTCL は系統計画・解析ツールとして PSAF を使用している。標準化の観点から、PGCIL が各送電会社に別の解析ツールである PSS/E を配布している。

本検討では MPPTCL が通常使用している PSAF から PSS/E にデータを変換し、PSS/E を用いて解析を実施した。検討対象は本事業の工事期間を想定し、2018-19 年度（ピーク需要）とした。インドには CEA が策定した Manual on Transmission Line Criteria（最新版 January 2013）があり、各州の送電会社はこれを参考にそれぞれの系統計画基準を策定している。

MPPTCL は、2004 年 8 月付けの Madhya Pradesh Electricity Grid Code（その後、小さな改定が 4 回実施されている）に示された基準に基づき、系統計画を実施している。

以下に、本調査で評価した検討内容を示す。

- 潮流・電圧計算
- 事故電流計算

事故時において発電機が安定して同期運転可能かを検討する過渡安定度については、一般的には、新しい発電機を導入するための検討や超高圧送電系統等の基幹系統の事故時において、電力系統が安定的に運転可能かを検討するために実施される。本事業に含まれる多くのサブプロジェクトは、地方部の電力供給信頼度向上や電力品質向上のために建設されるプロジェクトであり、過渡安定度にはほとんど無関係であると考えられること、また MPPTCL が PSS/E において実行可能な過渡安定度解析のためのデータを所持していないことから、MPPTCL が過去に外部コンサルタントに委託して実施した系統解析レポートの過渡安定度解析結果を参照し、系統が安定であるかどうかを判断した。なお、外部コンサルタントは MPPTCL が保有する解析ツールとは異なるツールで検討を実施しているため、MPPTCL は解析データを受領していない。

### 2.2.1. 潮流・電圧計算

MPPTCL は Madhya Pradesh Electricity Grid Code に基づき、単一の送電線・変圧器の事故時にも負荷遮断や発電機の出力調整を必要とせず、供給支障を生じさせない N-1 計画基準を適用している。しかし、下記に示す通り、年間の需要ピーク時である冬期午前中において灌漑ポンプ使用による一時的な需要集中が発生し、N-1 事故時に送電過負荷が発生する可能があるため、定格容量に対して 10%の増加を許容する短時間容量を適用している。また、マディヤ・プラデシュ州のグリッドコードに基づき、表 2-2 に示す電圧範囲内で電力系統を運転できるように計画しなければならない。

**表 2-2 運転電圧範囲**

| Nominal Voltage | Maximum [kV] | Minimum [kV] |
|---|---|---|
| **400 kV** | 420 (+5.0%) | 360 (-10.0%) |
| **220 kV** | 245 (+11.0%) | 200 (-9.1%) |
| **132 kV** | 145 (+9.8%) | 120 (-9.1%) |

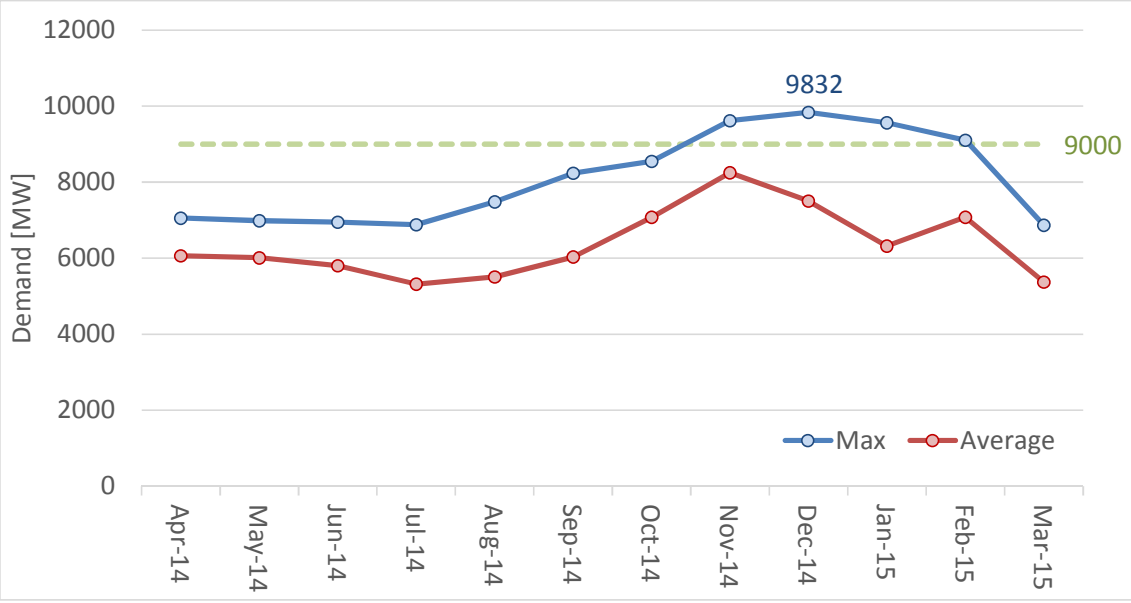
(Source: Madhya Pradesh Electricity Grid Code)

潮流電圧解析の結果、通常運転時（N-0）において過負荷する送電線・変圧器がないことが確認された。しかし、N-1 事故時において複数の送電線で過負荷が生じている図 2-1 と図

2-2 に示すとおり、電力ピークは年間のピーク需要期間である冬期の数ヶ月のうち、灌漑用ポンプが作動する午前中の数時間に発生しており、図 2-3 に示す通り、2014-15 年度の 1 年間 8,760 時間のうち 9,000 MW を超える高需要は 210 時間であった。MPPTCL によれば、これまでの経験から、これらの時間帯に発生する事故による過負荷の発生は非常に希であり、負荷切替や送電線接続変更の系統操作で過負荷解消が可能なため、これらの過負荷を計画上も許容している。なお、系統解析において、夏期・冬期とも統一された送電線の定格容量を適用しているが、マディヤ・プラデシュ州の冬期の最高気温は夏期と比較して 10°C から 15°C 程度気温が低下するため、ピーク時の送電線の熱容量は少なくとも 20%以上上昇すると推測される。

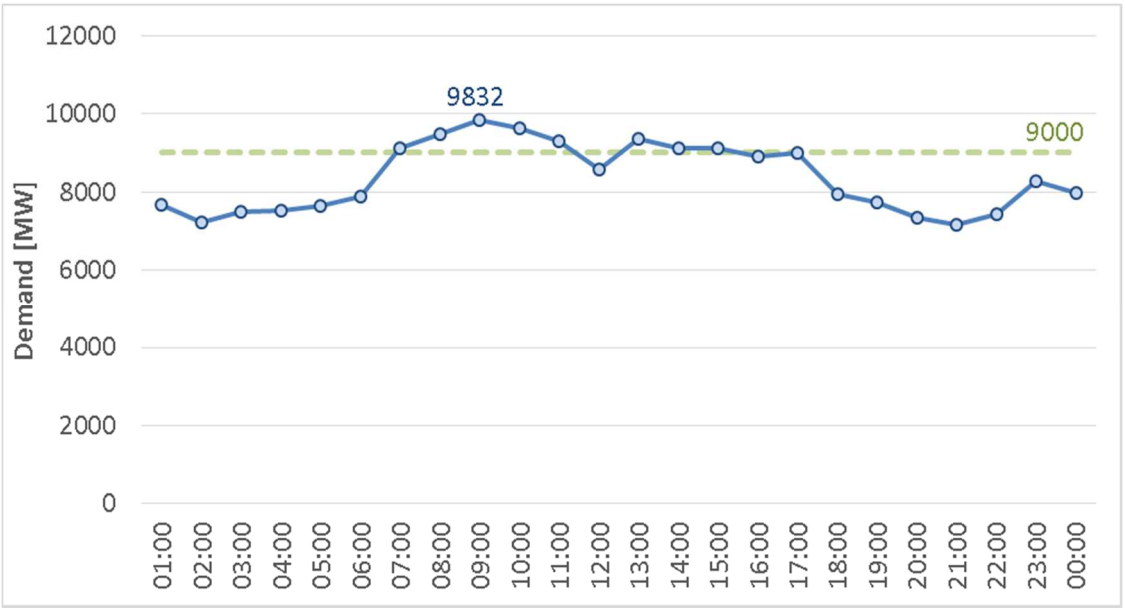
以上より、N-1 事故時に過負荷する送電線があるものの、MPPTCL が系統運用上対応可能と判断した。表 2-3 に示す変電所は地方部の電化率向上、電力品質（電圧）改善のための 132 kV 変電所であり、大きな電力需要が存在しないことから、MPPTCL は投資コストを削減し、より多くの地域への電力供給を優先するため、単一送電線での電力供給を計画している。従って、これらの送電線も N-1 系統計画基準を満足しない。

また、本事業に含まれる変電所の一部において、N-1 事故時に電圧基準を満たさない箇所があるが、MPPTCL は必要に応じて調相設備の設置で対応する予定である。



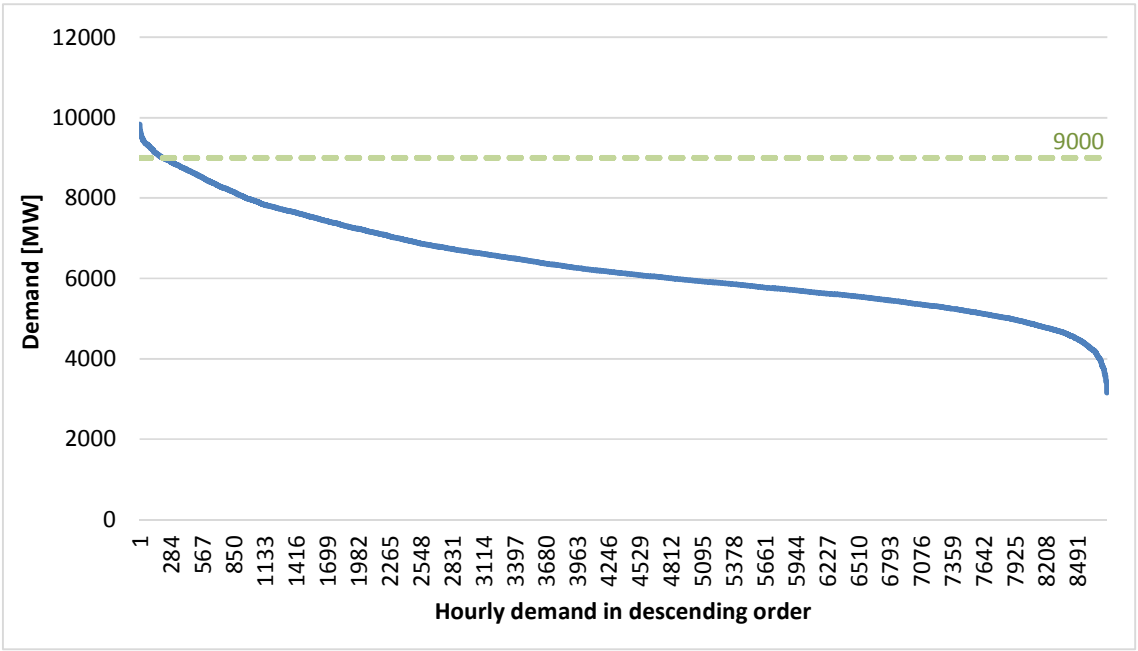

(Source: MPPTCL Datewise Hourly Demand in MW)

**図 2-1　2014-15 年度の各月の最大・平均電力**




(Source: MPPTCL Datewise Hourly Demand in MW)

**図 2-2　最大電力記録日 2014 年 12 月 9 日における電力需要カーブ**




(Source: MPPTCL Datewise Hourly Demand in MW)

**図 2-3　2014-15 年度の需要曲線**

表 2-3　N-1 系統計画基準を満足しない変電所

| No | Name | Source Substation |
|---|---|---|
| 9 | Pati (Silawad) | DCSS line from Julwaniya substation |
| 11 | Shahpura | DCSS line from Julwaniya substation |
| 12 | Bhitarwr | DCSS line from Datiya substation |
| 15 | Madwas | DCSS line from Sidhi substation |
| 16 | Dheemarkheda | DCSS line from Panagar substation |
| 17 | Orchha | DCSS line from Prithvipur substation |
| 18 | Atraila | DCSS line from Sirmour substation |
| 19 | Tendukheda | DCSS line from Udaipura substation |
| 20 | Gormi | DCSS line from Gohad substation |
| 21 | Suthaliya | DCSS line from Narsinghgarh substation |
| 24 | Chachoda | DCSS line from Rajgarh substation |

(Source: JICA Study Team)

MPPTCL が作成した DPR に基づき、400 kV 系統および 220 kV 系統における各プロジェクトの効果を表 2-4 に示す。

表 2-4　400 kV および 220 kV 系統における各プロジェクトの効果

| No | Project Name | Effect / Impact |
|---|---|---|
| 1 | Cheggaon | Shri Singaji 火力発電所に接続される 400kV 送電線の N-2 事故対策 |
| 2 | Indore | 都市開発が進むインドール地区における将来の負荷増加対策 |
| 4 | Udaipura | 近隣地域の需要増加対策 |
| 5 | Chhatarpur | N-1 時の放射系統運用対策 |
| 6 | Bina | N-1 時の過負荷対策 |
| 7 | Rewa UMSP | インド政府主導のメガソーラー接続のための系統増強 |

(Source: DPR)

132 kV 系統における各プロジェクトは、主に 33 kV 配電系統の電圧改善および配電線の短距離化および負荷分散によるロス低減のために実施されており、その効果を表 2-5 に示す。サブプロジェクト No. 23 において、最長 83 km（負荷 30.8 MVA）の 33 kV 配電線が 46 km となり（負荷 6.35 MVA）、これに伴い電圧降下が 44.5%から 9.0%に低減している。最大の電圧降下はサブプロジェクト No. 15 の 46.6%であるが、132 kV 変電所の新設により、配電線の距離が 58 km から最長 11.3 km に低減され、これに伴い電圧降下も 8.4%にまで改善している。また、本事業の実施により、大幅に電力ロスも改善されている。

表 2-5　132 kV 系統における各プロジェクトの効果

| No | Project Name | Voltage Improvement in distribution system [%] | | Distribution loss [kWh/year] | | | |
|---|---|---|---|---|---|---|---|
| | | W/o JICA | With JICA | Without JICA | With JICA | Reduction | |
| 9 | Pati | 20.0 | 4.3 | 5,367,312 | 873,271 | 4,494,041 | 84% |
| 10 | Maharaxmi | 11.9 | 4.9 | 6,887,618 | 3,285,847 | 3,601,771 | 52% |
| 11 | Shahpura | 32.2 | 6.1 | 11,738,610 | 2,208,160 | 9,530,450 | 81% |
| 12 | Bhirarwar | 33.1 | 5.5 | 12,749,950 | 1,271,630 | 11,478,320 | 90% |
| 13 | Mahwadiya | 12.9 | 3.7 | 5,856,434 | 1,431,103 | 4,425,331 | 76% |
| 15 | Madwas | 46.6 | 8.4 | 17,144,717 | 2,114,191 | 15,030,526 | 88% |
| 16 | Dheemarkheda | 19.8 | 4.9 | 10,510,734 | 2,065,154 | 8,445,580 | 80% |
| 17 | Orchha | 26.6 | 9.0 | 16,788,844 | 4,668,418 | 12,120,427 | 72% |
| 18 | Atraila | 15.4 | 5.4 | 5,377,443 | 1,904,763 | 3,472,680 | 65% |
| 19 | Tendukheda | 19.5 | 8.4 | 12,073,888 | 5,016,632 | 7,057,256 | 58% |
| 20 | Gormi | 16.7 | 2.9 | 6,647,273 | 777,134 | 5,870,139 | 88% |
| 21 | Suthaliya | 24.6 | 8.7 | 13,979,813 | 2,969,934 | 11,009,879 | 79% |
| 22 | Unchhera | 13.8 | 5.3 | 6,715,699 | 2,106,842 | 4,608,857 | 69% |
| 23 | Sinhawal | 44.5 | 9.0 | 19,353,488 | 3,802,150 | 15,551,338 | 80% |
| 24 | Chachoda | 17.8 | 5.9 | 7,231,058 | 2,639,012 | 4,592,046 | 64% |

(Source: DPR)

表 2-6 に本事業に含まれる新設送電線の最大潮流を示す。2018-19 年において、N-1 時においても本事業対象送電線は過負荷せず、余裕を持った計画となっていることが確認された。

表 2-6　2018-19 年度断面における本事業の送電線最大潮流

| Voltage | Conductor Type | Rated capacity | Max. power flow in JICA project | | |
|---|---|---|---|---|---|
| | | | Project No. | N-0 | N-1 |
| 400 kV | Twin Moose | 1010 MW | 1 | 411.7 | Below rating |
| 220 kV | Single Zebra | 245 MW | 6 | 143.8 | Below rating |
| 132 kV | Single Panther | 95 MW | 3 | 34.8 | Below rating |

(Source: JICA Study Team)

### 2.2.2. 短絡電流計算

送電線事故は変電所に設置される遮断器を開くことにより除去されるが、この際に流れる大きな電流は遮断器の定格遮断電流値以下でなければならない。各変電所至近端の送電線事故を考慮し、短絡電流を計算した。本事業において建設予定の変電所の最大短絡電流は表 2-7 の通りであり、定格遮断電流以内であることが確認された。

**表 2-7 2018-19 年度断面における最大短絡電流**

| Voltage | Rated current breaking capacity [kA] | Project No. | Substation / Bus | Max. short circuit current in JICA project [kA] |
|---|---|---|---|---|
| 400 kV | 40.0 | 1 | Khandwa | 29.9 |
| 220 kV | 40.0 | 6 | Bina | 33.3 |
| 132 kV | 31.0 | 2 | Indore (J) | 26.1 |

(Source: JICA Study Team)

しかしながら、表 2-8 に示す本事業対象外の複数の変電所において、短絡電流の超過があった。これらの変電所は電源付近に存在する変電所、または多数の送電線が接続される変電所であり、事故電流が大きくなりやすい状況にある。将来的には母線分割や系統変更等の運用対策が必要となる。

**表 2-8 定格遮断電流値を超過する変電所**

| Substation name | Voltage [kV] | Short circuit current [kA] | |
|---|---|---|---|
| | | Rating | Results |
| INDORE SZ | 132 | 31.0 | 32.0 |
| SATNA | 400 | 40.0 | 41.3 |
| VINDHYACHAL TPS | 400 | 40.0 | 58.0 |
| VINDHYACHAL PP | 400 | 40.0 | 54.7 |
| SASAN | 400 | 40.0 | 53.1 |
| VINDHYACHAL | 400 | 40.0 | 53.3 |

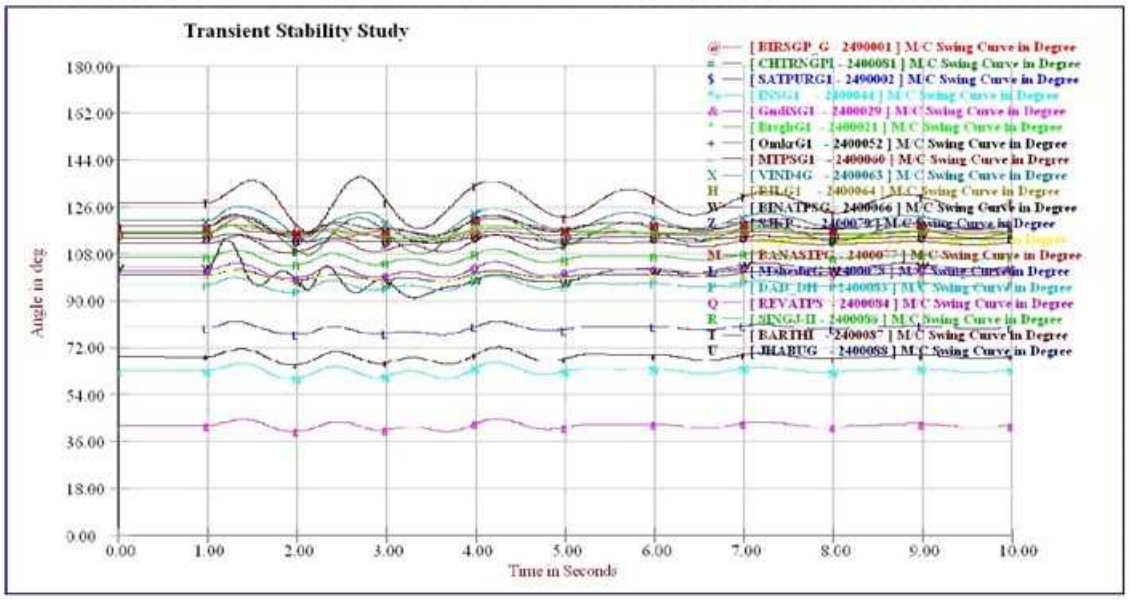
(Source: JICA Study Team)

### 2.2.3. 過渡安定度

送電線事故により、系統に接続された発電機の安定度が悪化し運転を継続できない場合がある。この場合、大きな発電力を失うこととなり、大規模停電につながる恐れがある。MPPTCL は PPS/E において過渡安定度を実行可能な解析データを保有しておらず、過渡安

定度解析は実施できなかった。しかし、本事業は発電所を新設するための検討ではなく、送電系統の増強プロジェクトであり基本的には安定度は向上すること、多くのサブプロジェクトは発電機から電気的に離れている 132 kV 系統の増強プロジェクトであることから、新設送電線事故が電力系統全体に与える影響は軽微であるため、過渡安定度の問題はないと判断した。

なお、MPPTCL が 2011 年に外部コンサルタントである Power Research and Development Consultants Pvt. Ltd.に委託して実施した系統解析レポートによると、当時の開発計画においてマディヤ・プラデシュ州の電力系統には過渡安定度の問題はないと報告されている。図 2-4 に解析結果の一例を示す。送電線事故除去後に発電機位相は元の位置に戻っており、結果は安定である。




(Source: MPPTCL / Report on Studies for formulation of proposal for evacuation of power from generating stations coming up in Madhya Pradesh and development of suitable interconnection with the transmission system being developed by PGCIL in Madhya Pradesh as well as to decide various electrical parameters of 2X660 MW Reva Thermal Power Project to be developed by M/s NHDC Ltd.)

**図 2-4　過渡安定度解析結果の例**

**(Unsuccessful re-closure at 400 kV line between Bina & Bhopal)**

## 2.3. 送電設備

### 2.3.1. 設計条件

マディヤ・プラデシュ州における送電線設計の主な基本条件は下記の通りである。また、送電設備の技術仕様は IS (Indian Standard) 及び IEC (International Electrotechnical Commission) や IEEE 等の国際標準に準拠している。

| | | |
|---|---|---|
| 最高温度： | 50 | ℃ |
| 最低温度： | 1 | ℃ |
| 最大湿度： | 95 | % |
| 平均温度： | 32 | ℃ |
| IKL： | 50 | 日 |
| 年平均降雨量： | 1,250 | mm |
| 風速域(Indian Standard)： | 4 | (47 m/s) |
| 耐震レベル： | 0.3 | G |

### 2.3.2. 鉄塔

MPPTCL の支持物はインド他州と同様に標準化されており、自立型鉄塔を使っている。鉄塔型には、直線、中角度、重角度、送電線横過ガントリーと河川横断がある。220kV 及び 132kV は多回線鉄塔も標準化されており、MPPTCL では 4 回線鉄塔まであるが、400kV は 2 回線鉄塔までである。

また、400 kV 送電線の等価設計径間長は 400m、最大及び最小径間長はそれぞれ 1,100m と 100m と規定されている。

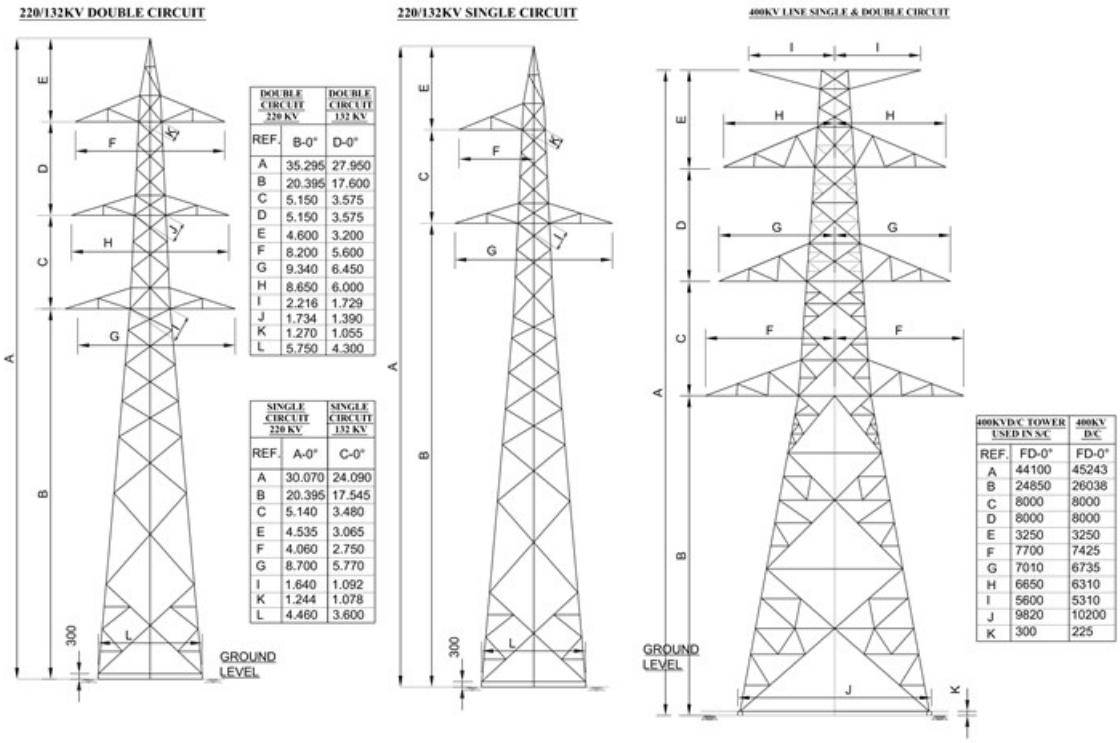
**図 2-5 400kV 送電線鉄塔（左）と 132kV 送電線鉄塔（右）**

**図 2-6　220kV 送電線（Jabalpur 変電所引込鉄塔）**

また、図 2-7 は 132kV 送電線 LILO (Line-In-Line-Out)の一例で、右の鉄塔を改造して左の鉄塔に LILO として接続したものである。本事業にも複数の LILO 送電線を含むサブプロジェクトが含まれる。

**図 2-7　132kV LILO 送電線**

MPPTCL の標準的な鉄塔構造図を図 2-8 に示す。




| REF. | B-0° | D-0° |
|---|---|---|
| A | 35.295 | 27.950 |
| B | 20.395 | 17.600 |
| C | 5.150 | 3.575 |
| D | 5.150 | 3.575 |
| E | 4.600 | 3.200 |
| F | 8.200 | 5.600 |
| G | 9.340 | 6.450 |
| H | 8.650 | 6.000 |
| I | 2.216 | 1.729 |
| J | 1.734 | 1.390 |
| K | 1.270 | 1.055 |
| L | 5.750 | 4.300 |

| REF. | A-0° | C-0° |
|---|---|---|
| A | 30.070 | 24.090 |
| B | 20.395 | 17.545 |
| C | 5.140 | 3.480 |
| E | 4.535 | 3.065 |
| F | 4.060 | 2.750 |
| G | 8.700 | 5.770 |
| I | 1.640 | 1.092 |
| K | 1.244 | 1.078 |
| L | 4.460 | 3.600 |

| REF. | FD-0° | FD-0° |
|---|---|---|
| A | 44100 | 45243 |
| B | 24850 | 26038 |
| C | 8000 | 8000 |
| D | 8000 | 8000 |
| E | 3250 | 3250 |
| F | 7700 | 7425 |
| G | 7010 | 6735 |
| H | 6650 | 6310 |
| I | 5600 | 5310 |
| J | 9820 | 10200 |
| K | 300 | 225 |

(Source: MPPTCL)

**図 2-8　標準鉄塔構造図**

### 2.3.3.　基礎

MPPTCL は黒綿土[6]や割目に富む岩盤等の地質に応じた標準的な基礎形状図を有しており、その標準的な設計に基づいて設計される。また、既設送電線は全て直接基礎で、杭基礎は使用されていない。

一般的にマディヤ・プラデシュ州のあるインド中心部は広く黒綿土に覆われており、乾季には乾いて表層に亀裂が入るが、雨季には水分を吸収・膨張し、泥濘化する。このため、地表から数 m（最大 5m）は不安定な地層で支持層として期待できないが、その下位には気象の影響を受けない風化岩の分布が期待される。MPPTCL によれば、本事業には杭基礎が適用されうる大型河川の横断箇所もなく、また冠水地帯も含まれていないとのことである。

以上のことから、本事業の鉄塔基礎も既設送電線と同様に MPPTCL の標準的な直接基礎を想定するのが妥当と判断される。

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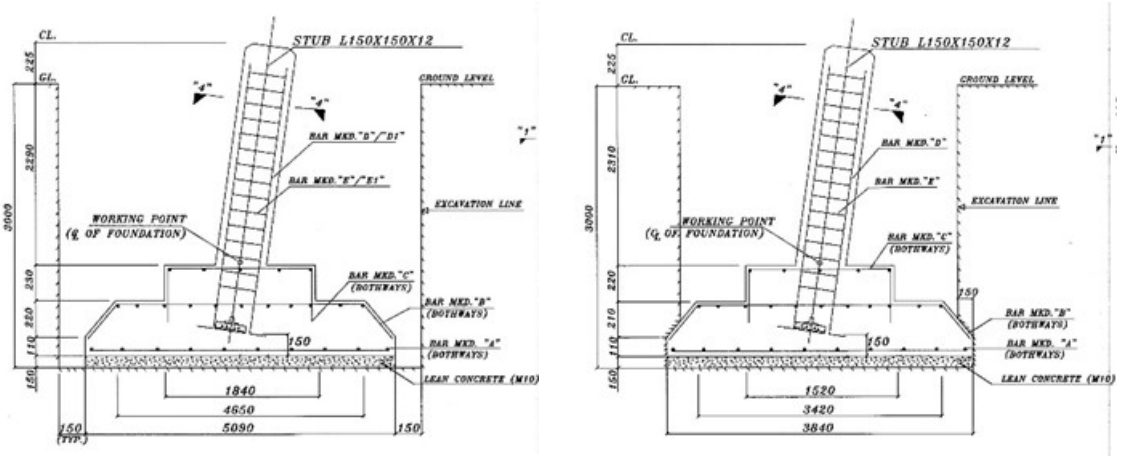
[6] 粘土質で暗色の土壌

図 2-9 は 132kV 及び 400kV 送電線の一般的な基礎形状図である。

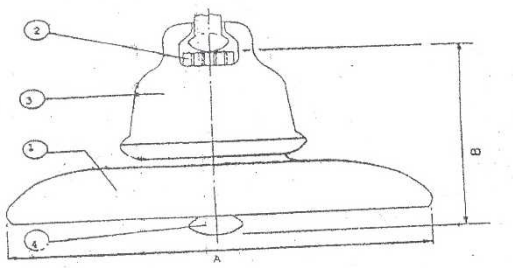



(Source: MPPTCL)

**図 2-9 132kV 鉄塔基礎図（左：黒綿湿土用 右：浸水割目岩盤用）**

2.3.4. がいし

MPPTCL ではボールソケット型磁器懸垂がいしを使用しており、磁器がいしの他に有機がいしも使用している。磁器がいし装置は懸垂・耐張とも 1 連または 2 連で、70kN、90kN、120kN 及び 160kN がいしが電圧・装置別に使い分けられている。




| Item | Description | Material |
|---|---|---|
| 1 | Shell | Porcelain |
| 2 | Security Clip | Phosphor Bronze/Stainless Steel |
| 3 | Cap | MCI |
| 4 | Ball Pin | Forged Steel |

(Source: MPPTCL)

**図 2-10 懸垂がいし**

**図 2-11　132kV がいし装置**

2.3.5.　電線

電線は、電圧階級毎に下記線種が標準電線として定められている。地線は、亜鉛めっき鋼より線（Galvanized Steel Wire: GSW）を現在使用しており、一部 OPGW（Optical Ground Wire）の導入も始めている。

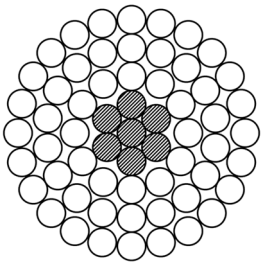
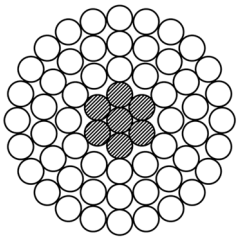
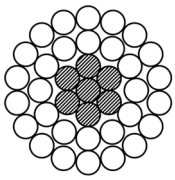
**表 2-9　電圧階級別標準電線**

| 電圧 | 標準電線 |
|---|---|
| 400 kV | ACSR Moose 複導体 |
| 220 kV | ACSR Zebra 単導体 |
| 132 kV | ACSR Panther 単導体 |

(Source: MPPTCL)

当該標準電線の技術仕様を表 2-10 示す。

**表 2-10　標準電線仕様**

| | | ACSR Moose | ACSR Zebra | ACSR Panther |
|---|---|---|---|---|
| 断面積 | 導体 | 528.5 $mm^2$ | 428.9 $mm^2$ | 212.1 $mm^2$ |
| | 鋼芯 | 68.5 $mm^2$ | 55.59 $mm^2$ | 49.5 $mm^2$ |
| | 全体 | 597.0 $mm^2$ | 484.5 $mm^2$ | 261.6 $mm^2$ |
| 電線外径 | | 31.77 mm | 28.62 mm | 21.00 mm |
| 電線重量 | | 2,004 kg/km | 1,621 kg/km | 976 kg/km |
| 電気抵抗（20℃） | | 0.05552 ohm/km | 0.06915 ohm/km | 0.139 ohm/km |
| 最小破断荷重 | | 161.2 kN | 130.32 kN | 89.67 kN |
| 弾性係数 | | 0.703x106 $kg/cm^2$ | 69 $GN/m^2$ | 80 $GN/m^2$ |
| 断面形状 | |  |  |  |

(Source: Technical Specification for Supply of Materials and Construction of 400 kV, 220 kV and 132 kV Transmission Lines of MPPTCL)

### 2.3.6. 概略送電線ルート

本事業における送電線の経過地は、大部分が田畑等の平坦な地形となっている。サブプロジェクト No. 17 を含むいくつかの送電線には最大 1km 弱の河川横断箇所が存在するが、MPPTCL の設備実績から建設は特に困難なものではないと判断される。

また、サブプロジェクト No. 10 の 132kV Mangaliya - Maharaxmi 送電線は Indore の比較的市街地にあるため、ルート選定には更なる検討が必要であるが、現時点での送電線ルートは計画断面の概略ルートであり、通常のプロセスと同じく、今後 MPPTCL は施工性や保守性等を考慮して各送電線ルートの最適化を図っていくものである。

## 2.4. 変電設備

### 2.4.1. 設計の基本方針

表 2-11 に、本事業において設置されるサブプロジェクト毎の主要変電設備一覧を示す。個々の変電所の設計は、MPPTCL の標準的な変電所設計基準に基づいている。変電所の各機器の数量は DPR に示される変電所単線結線図に基づいている。調査団は DPR の設計が、これらの図面および設計標準と整合がとれていることを確認した。

**表 2-11 プロジェクトの主要変電設備一覧表**

| Sub-project No. | 変電所名称 | 変電所タイプ | 主要変圧器 [台数、容量] | 新・増設 送電線引出し口数 | | | 新設用地 [ha] |
|---|---|---|---|---|---|---|---|
| | | | | 400 kV | 220 kV | 132 kV | |
| 1 | Chhegaon | 既設 AIS | 400kV 125MVAR×1 Reactor | 2 | | | – |
| 2 | Super Corridor | **新設 GIS** | 220/132kV 160MVA×1 | | 2 | | 3.27 |
| | | | 132/33kV 63MVA×1 | | | 2 | |
| | Pithampur | 既設 AIS | | | 2 | | – |
| 4 | Udaipura | 既設 AIS | 220/132kV 160MVA×1 | | 2 | | – |
| | Chichli | 既設 AIS | | | 2 | | – |
| 5 | Chhatarpur | 既設 AIS | | | 1 | | – |
| | Tikamgarh | 既設 AIS | | | 1 | | – |
| 6 | Bina | 既設 AIS | 400/220kV 315MVA×1 | | 2 | | – |
| 7 | Rewa | 既設 AIS | | | 2 | | – |
| | Sidhi | 既設 AIS | | | 2 | | – |
| | Rewa UMSP | 既設 AIS | | | 4 | | – |
| 9 | Pati (Silawad) | 新設 AIS | 132/33kV 50MVA×1 | | | 1 | 4.00 |
| | Julwaniya | 既設 AIS | | | | 1 | – |
| 10 | Mahalaxmi | 新設 AIS | 132/33kV 63MVA×1 | | | 2 | unknown |
| 11 | Shahpura | 新設 AIS | 132/33kV 50MVA×1 | | | 1 | 2.25 |
| | Julwaniya | 既設 AIS | | | | 1 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12 | Bhitarwr<br>Datiya | 新設 AIS<br>既設 AIS | 132/33kV 50MVA×1 | | | 1<br>1 | 2.25 |
| 13 | Mahwadia<br>Mugaliya Chhap | 新設 AIS<br>既設 AIS | 132/33kV 50MVA×1 | | | 2<br>2 | 5.00 |
| 15 | Madwas<br>Sidhi | 新設 AIS<br>既設 AIS | 132/33kV 50MVA×1 | | | 1<br>1 | 3.30 |
| 16 | Dheemarkheda<br>Panagar | 新設 AIS<br>既設 AIS | 132/33kV 50MVA×1 | | | 1<br>1 | 2.25 |
| 17 | Orchha<br>Prithvipur | 新設 AIS<br>既設 AIS | 132/33kV 50MVA×1 | | | 1<br>1 | 3.00 |
| 18 | Atraila<br>Sirmour | 新設 AIS<br>既設 AIS | 132/33kV 50MVA×1 | | | 1<br>1 | 4.00 |
| 19 | Tendukheda<br>Udaipura | 新設 AIS<br>既設 AIS | 132/33kV 50MVA×1 | | | 1<br>1 | 3.82 |
| 20 | Gormi<br>Gohad | 新設 AIS<br>既設 AIS | 132/33kV 50MVA×1 | | | 1<br>1 | 2.25 |
| 21 | Suthaliya<br>Narsinghgarh | 新設 AIS<br>既設 AIS | 132/33kV 50MVA×1 | | | 1<br>1 | 3.28 |
| 22 | Unchhera | 新設 AIS | 132/33kV 50MVA×1 | | | 2 | 6.25 |
| 23 | Sinhawal<br>Sidhi | 新設 AIS<br>既設 AIS | 132/33kV 50MVA×1 | | | 1<br>1 | unknown |
| 24 | Chachoda<br>Rajgarg(B) | 新設 AIS<br>既設 AIS | 132/33kV 50MVA×1 | | | 1<br>1 | unknown |
| 25 | Maneri<br>Mandla | 既設 AIS<br>既設 AIS | | | | 1<br>1 | |
| 26 | Sukha<br>(Jabalpur) | 既設 AIS | 220/33kV 50MVA×2 | | | | |
| 27 | Hoshangabad | 既設 AIS | 220/132kV 160MVA×1 | | | | |
| 28 | Barwaha | 既設 AIS | 220/132kV 160MVA×1 | | | | |
| 29 | Betma | 既設 AIS | 132/33kV 50MVA×1 | | | | |
| 30 | Khirkiya | 既設 AIS | 132/33kV 50MVA×1 | | | | |
| 31 | Amla | 既設 AIS | 132/33kV 50MVA×1 | | | | |
| 32 | Tejgarh | 既設 AIS | 132/33kV 50MVA×1 | | | | |
| 33 | Satwas | 既設 AIS | 132/33kV 50MVA×1 | | | | |
| 34 | Sitamau | 既設 AIS | 132/33kV 50MVA×1 | | | | |
| 35 | Baroda | 既設 AIS | 132/33kV 50MVA×1 | | | | |
| 36 | Amrawadkhurd | 既設 AIS | 132/33kV 50MVA×1 | | | | |
| | | 既設 AIS 15<br>**新設 GIS 1**<br>既設 AIS 36 | 変圧器容量合計:<br>2,281MVA | 2 | 20 | 36 | |

(Source: DPR)

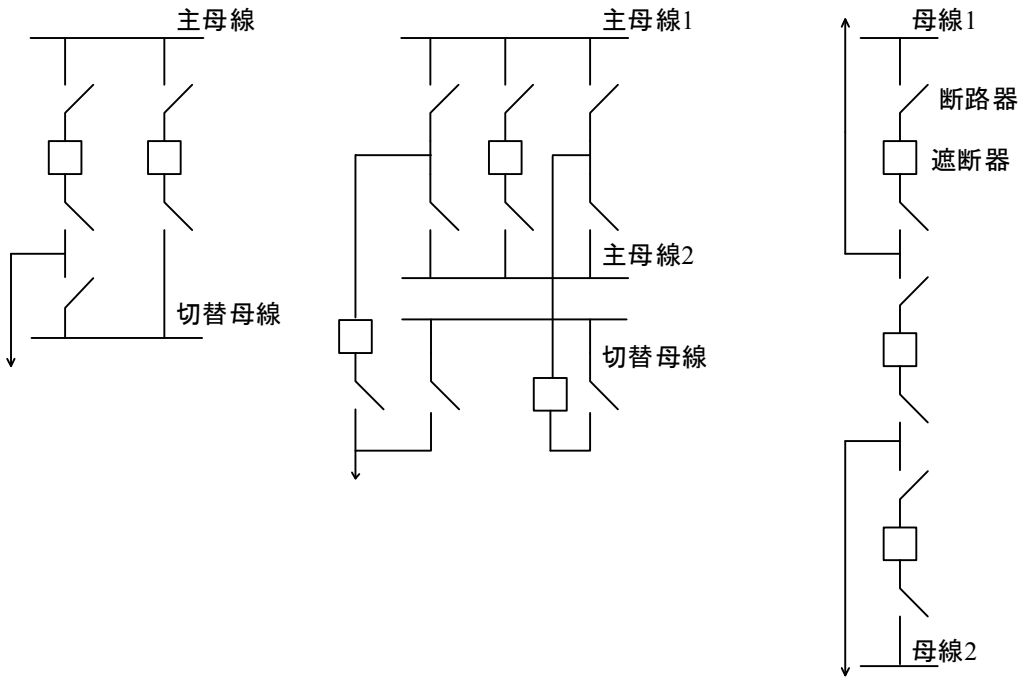
2.4.2.　変電所母線構成

MPPTCL の変電所設計の基本となる変電所の母線構成は、母線電圧に応じて、表 2-12 および図 2-12 に示す結線方式を採用している。これらの母線構成はインド国内および国際的にも一般的なものであり、特段の問題はない。

**表 2-12　MPPTCL の標準変電所母線構成**

| | |
|---|---|
| **400kV 母線** | 1.5 重母線方式<br>(2 重主母線・切替母線方式)[注] |
| **220kV 母線** | 2 重主母線・切替母線方式<br>(主母線・切替母線方式)[注] |
| **132kV、33kV 母線** | 主母線・切替母線方式 |

注、変電所用地不足などの制約がある場合に例外的に採用されることがある。




(a)主母線・切替母線方式　(c) 2 重主母線・切替母線方式　(d) 1.5 重母線方式

**図 2-12　変電所母線構成**

2.4.3.　変電所タイプ（AIS/GIS）

本事業で GIS を採用する考え方について MPPTCL に確認した。本事業では、都市部に立地し、今後の増設のための十分な用地確保が難しいサブプロジェクト No.2 の 220kV Super

Corridor 変電所に GIS を採用し、その他の新設変電所については従来型の AIS が採用される。一般に GIS には、AIS よりも用地が縮小できること、露出充電部がなく保守・運転が安全に行えるなどの利点がある一方で、建設コストは AIS の 2 倍以上となる。マディヤ・プラデシュ州では、ごく限られた都市部を除き、通常変電所用地の確保は容易であることから、投資コスト抑制の観点から AIS を採用する MPPTCL の方針は妥当である。なお、前述の表 2-11 には、本事業のサブプロジェクト毎の変電所用地面積を合わせて記載している。各変電所用地面積は、MPPTCL の既設変電所の面積[7]および、日本国内の変電所面積[8]から照らしても妥当である。

ここで、AIS、GIS 変電所ともに、主要変圧器・開閉装置等の主回路機器は屋外設置の設計となっている。MPPTCL では既設 AIS 変電所において同様の屋外配置を採用して問題なく運用されており、また今回 MPPTCL として新規採用となる GIS についても、AIS よりも外部環境の影響を受けにくい隠蔽型機器であることから、妥当な設計であると判断される。

### 2.4.4. 変電機器仕様

変電関係主要機器の仕様は、国際規格である IEC およびインド国内規格の IS に準拠した機器が調達される。このうち IS は、IEC を元に作成されたインドの国内規格であり、内容は概ね IEC に準拠したものである。MPPTCL では標準的に採用されている仕様であり、運用上特段の問題はないと考えられる。なお、本調査では、2.4.8 節に後述する通り既設機器の現場確認を行い、特殊な機器が使われていないことを確認している。なお、日本の主要メーカーを含む国際的な変電機器メーカーであれば IEC に沿った設計が可能であることから、日本企業参入の観点からも特段の問題はない。

### 2.4.5. 変圧器仕様

本事業における主要変圧器の容量は、以下の標準容量の中から、潮流解析結果に基づく需要を考慮し妥当な容量が選定されている。ここで標準容量は、インド国の CEA が定めるスタンダードであり、インド国においては妥当な選定方法である。

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[7] MPPTCL からの聞き取りによる標準的な変電所の面積は以下の通り。図面および現地調査にて、これらの変電所の機器配置が一般的であることを確認した。

- 400kV AIS（400kV-8 回線, 220kV-26, 132kV-15, 33kV-8）：500m x 380m = 19.0ha
- 220kV AIS（220kV-8 回線, 132kV-15, 33kV-16）：250m x 256m = 6.40ha
- 132kV AIS（132kV-6 回線, 33kV-8）：150m x 150m = 2.25ha

上記回線数は、将来用予備回線、変圧器引込回線、母線連結、母線 VT 回線等を含む。

[8] 今回事業の、220/132kV AIS に相当する、275/154kV AIS で所要面積 4ha 程度、GIS の場合は 1-2ha 程度

- 400/220kV 変圧器： 315MVA
- 220/132kV 変圧器： 160, 100MVA
- 220/33kV, 132/33kV 変圧器： 63, 50MVA

### 2.4.6. 送電線引出し口回線数

変電所母線から引き出される送電線の回線数は、220kV、132kV については、上位の系統計画に基づき必要十分な数の回線が接続される。配電系統側の 33kV 引出し口については、一般に 50MVA 変圧器については 4 回線、63MVA については 6 回線が標準的に引き出される。

### 2.4.7. 遮断器仕様

遮断器の仕様において重要な要素となる定格遮断電流値は、今後の系統拡大および別途 MPPTCL にて実施された系統解析結果に基づき、以下の値が採用されている。

- 400kV 遮断器: 40.0kA
- 220kV 遮断器: 40.0kA
- 132kV 遮断器: 31.0kA

### 2.4.8. 既設変電設備状況

本調査では、本事業において設置される主要変電設備を確認するため、既設変電所の現地確認を行った。132kV AIS の設備は、Crompton Greaves、Bharath Heavy Electrical Limited（BHEL）製品が、保護制御盤関係は ABB、Alstom/Areva のいずれもインド国産の機器がそれぞれ多用されている。また、MPPTCL からの聞き取りによると、主要な変電設備は、Crompton Greaves、BHEL、ABB、Siemens 等の製品が競争入札を通して採用されているとのことである。変電設備への日本製品の導入事例は少ないが、今回調査した 220kV Jabalpur 変電所においては、三菱電機製の 220kV 主要変圧器（1966 年製）、東芝戦の 220kV ディジタル保護リレーユニットが存在した。変電機器調達に関して MPPTCL はメーカーに特段の選好はなく、競争入札の結果に基づき機器を選定している様子である。

本事業に関連する変電機器の写真を図 2-13 から図 2-25 に示す。今回の現地調査で採取した写真がほとんどであるが、屋外 GIS については日本の機器を合わせて示した。

**図 2-13　220/132kV, 160MVA 三相一括型変圧器（Jabalpur 220kV 変電所）**

**図 2-14　三菱電機製 220/132kV, 40MVA×3 単相変圧器（Jabalpur 220kV 変電所）**

**図 2-15　132/33kV, 63MVA 変圧器（Marhotal 132kV 変電所）**

**図 2-16　220kV 送電線引出し設備（Jabalpur 220kV 変電所）**

**図 2-17　132kV 送電線引出し設備（Marhotal 132kV 変電所）**

**図 2-18　33kV 送電線引出し設備（Marhotal 132kV 変電所）**

図 2-19　制御室外観（Jabalpur 220kV 変電所）

図 2-20　制御室外観（Tejgarh 132kV 変電所）

図 2-21　制御盤（Tejgarh 132kV 変電所）

図 2-22　変電所 SCADA システム（Jabalpur 220kV 変電所）


**図 2-23　東芝製 220kV 送電線保護 Ry ユニット（Jabalpur 220kV 変電所）**

**図 2-24　500kV 屋外 GIS 変電所 (東京電力)**

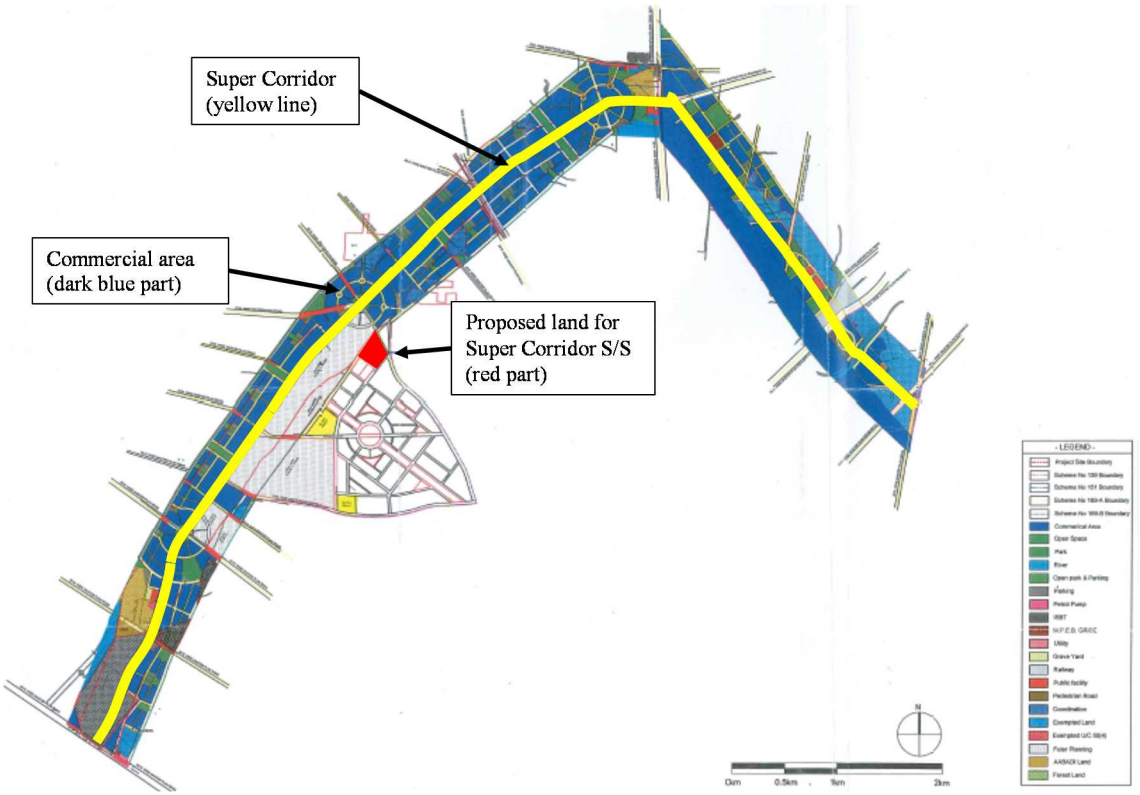

**図 2-25　500kV 屋外 GIS 変電所 (東京電力)**

## 2.5. サブプロジェクト個別検討

本調査では、サブプロジェクト No.2 の Super Corridor 新設変電所および、サブプロジェクト No.32 の 132kV Tejgarh 既設変電所（変圧器増設）のサイト調査を行った。Super Corridor 変電所については、MPPTCL が経験のない GIS 変電所を建設するサブプロジェクトであるため、調査団にて概念設計の作成を支援した。

### 2.5.1. サブプロジェクト No2 Super Corridor 新設変電所

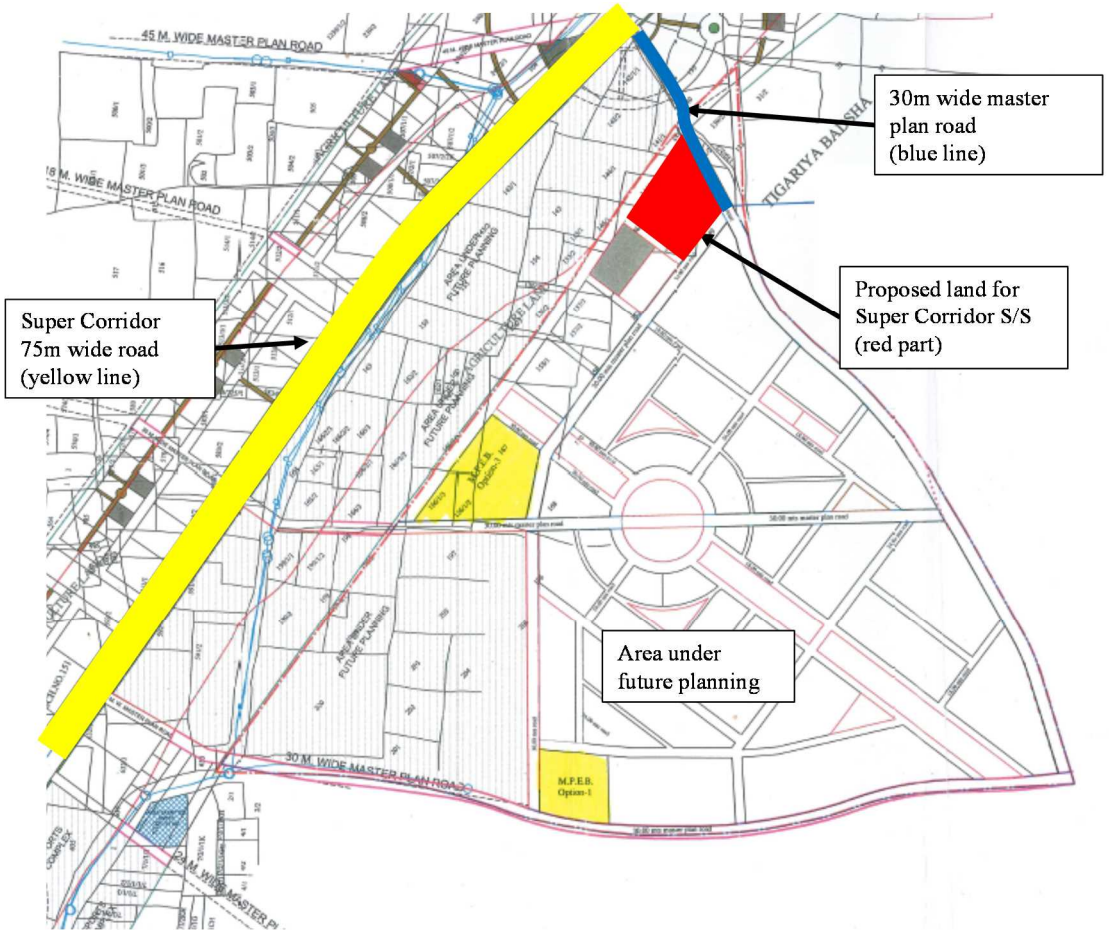
同変電所は、マディヤ・プラデシュ州最大の都市である Indore に位置する。現在は未開発であるが、今後数年で大規模な産業・商業施設が開発される計画がある[9]。図 2-26 及び図 2-27 に周辺地域の開発計画図を示す。図 2-26 に示す通り、幅員 75m の Super Corridor に沿って、図中で濃い青色で示される商業エリアが開発される計画である。また、Super Corridor 変電所近辺には大手 IT 企業の Tata Consultancy Services、Infosys が進出予定である。




(Source: MPPTCL)

**図 2-26 Super Corridor 地域開発計画図面（広域）**

[9] http://www.supercorridor.in/

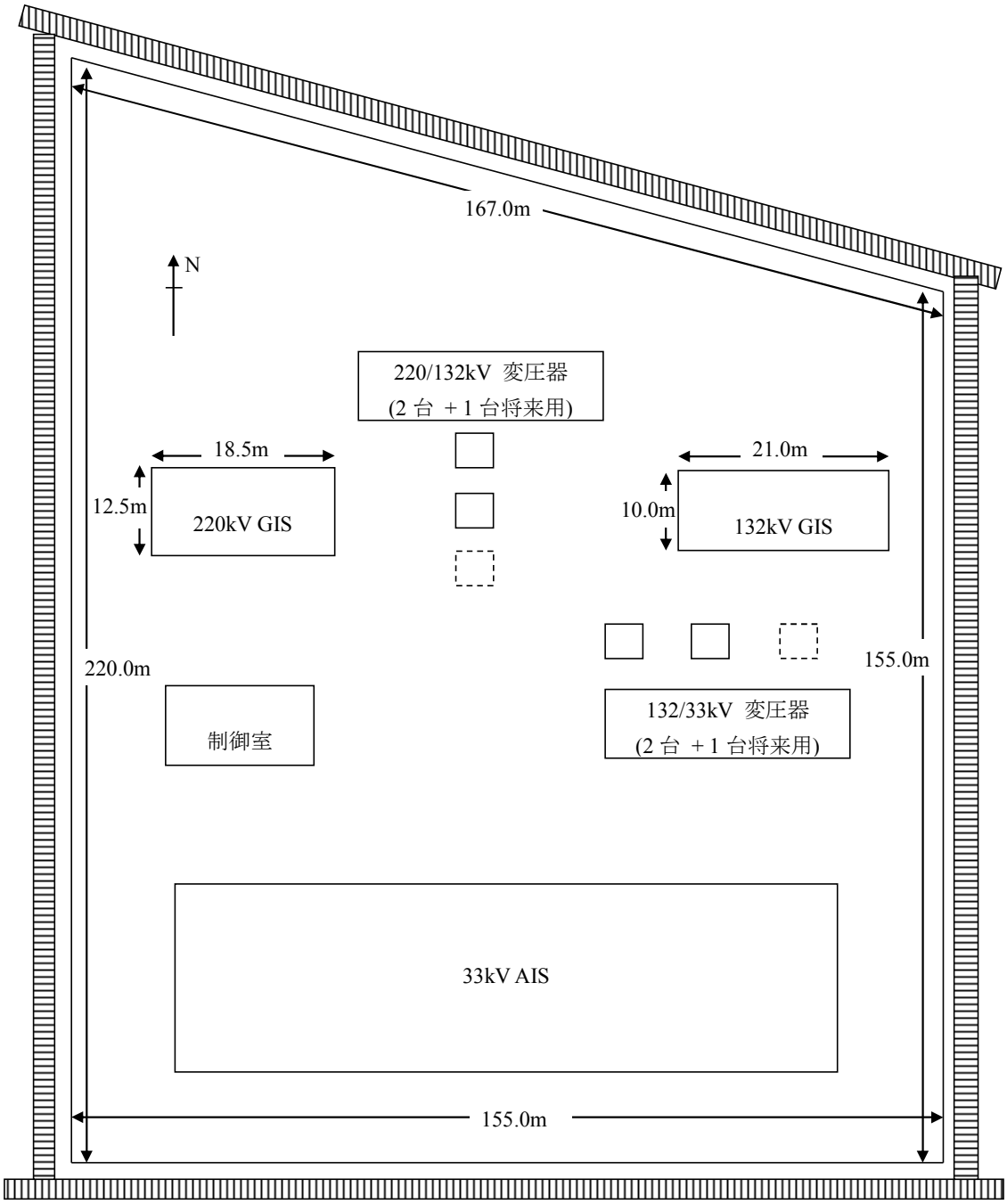



(Source: MPPTCL)

**図 2-27　Super Corridor 地域開発計画図面（詳細）**

Super Corridor 変電所用に、短辺 155m の台形型の変電所用地が既に確保されている（図 2-28、図 2-29 参照）。MPPTCL によると、同変電所は、当初は 220kV 2 回線、132kV 4 回線（内 2 回線は予備）の送電線引き込み、及び 6 回線の 33kV 配電線引出し口の設計で運転開始するが、将来的には供給先の新規開発商業・住宅地区の開発により、供給先の需要が急激に増加する可能性がある。変電所を GIS タイプとすることで、将来同地区の需要が急増した場合の送電線引出し口の増設スペースを十分に確保することができる。調査団では、MPPTCL から聞き取った上記条件に基づき GIS 変電所の概念設計を行い、機器配置が用地上問題ないことを確認した。また機器搬入道路は、幅員 75m の幹線道路から幅員 30m のアクセス道路に至り十分に確保される都市計画となっており、工事に際しての変圧器等の大型機器運搬にも問題はないと思われる。


**図 2-28　Super Corridor 変電所用地写真**




(Source: JICA Study Team)

**図 2-29 Super Corridor 変電所レイアウト**

図 2-29 のレイアウト作成にあたっては、MPPTCL の技術者と協議のうえ、以下に示す設計条件を採用した。なお、本調査におけるレイアウトは概念レベルの配置であり、実施段階では、より詳細な設計条件に基づき、MPPTCL またはコンサルタントによる機器配置の再

検討が不可欠である。

(1) 一般事項

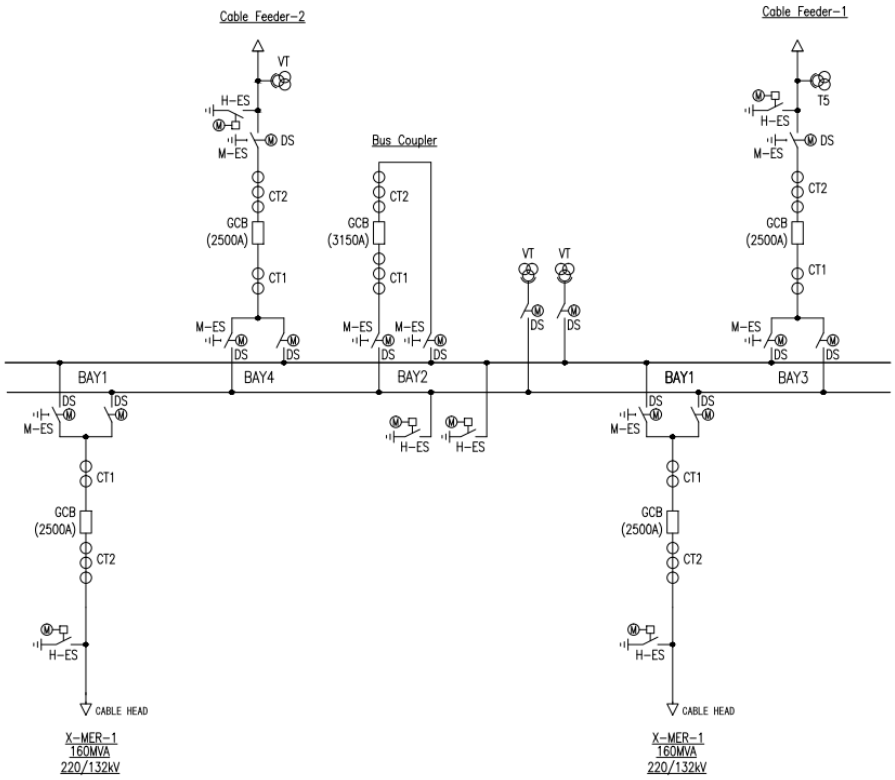
- GIS 適用箇所： 220kV および 132kV に屋外型 GIS を適用
- 設置場所外気温： 45℃
- 設置場所高度： 1,000m を超えないこと

(2) 220kV GIS 仕様（相分離 GIS）

- 回線数： 5 回線
  内訳 220kV 送電線引き込み口： 2 回線
  220/132kV 変圧器引出し口： 2 回線
  母線区分・計測用： 1 回線
- 母線構成： 2 重母線方式
- 主回路接続箇所： ケーブル接続

**表 2-13 Super Corridor 変電所における 220kV GIS の設計仕様条件**

| | |
|---|---|
| 定格電圧 | 220 kV |
| 定格常時電流 | 2,000A |
| 定格周波数 | 50 Hz |
| 定格遮断電流 | 40 kA (1 sec.) |
| 定格絶縁レベル | 雷インパルス: 1,050 kV |
| | 商用周波数: 460 kV |
| 定格 $SF_6$ ガス圧 (at 20°C, in abs.) | 0.70 MPa |
| 遮断器操作機構 | バネ方式 |
| 断路器・接地開閉器機構 | 3 位置接点方式 |
| 高速接地開閉器操作機構 | 電動バネ方式 |




(Source: JICA Study Team)

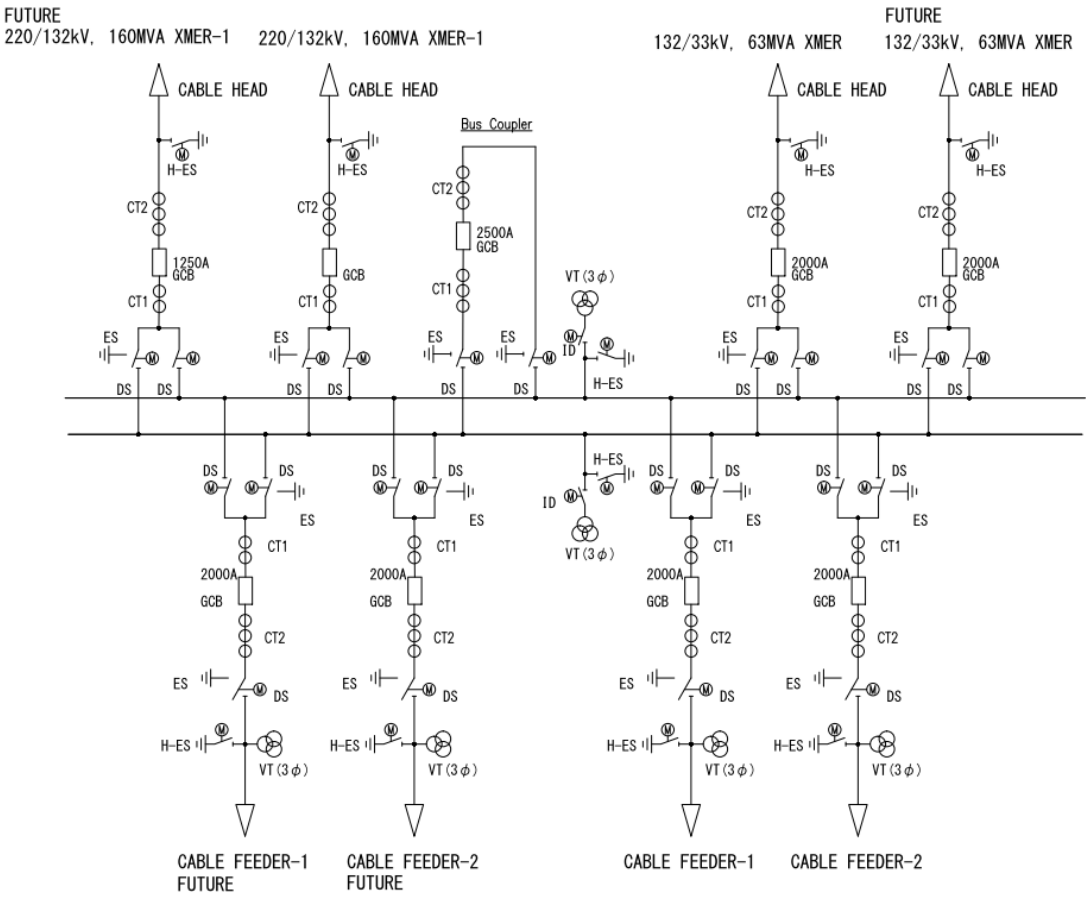
**図 2-30 Super Corridor 変電所 220kVGIS の単線結線図**

(3) 132kV GIS 仕様（三相一括 GIS）

- 回線数： 9 回線
  - 内訳 132kV 送電線引き込み口： 4 回線（予備回線 2 回線を含む）
  - 220/132kV 変圧器引出し口： 2 回線
  - 132/33kV 変圧器引出し口： 2 回線
  - 母線区分・計測用： 1 回線
- 母線構成： 2 重母線方式
- 主回路接続箇所： ケーブル接続

**表 2-14　Super Corridor 変電所における 132kV GIS の設計仕様条件**

| | |
|---|---|
| 定格電圧 | 132 kV |
| 定格常時電流 | 2,000A |
| 定格周波数 | 50 Hz |
| 定格遮断電流 | 31.5 kA (1 sec.) |
| 定格絶縁レベル | 雷インパルス: 1,050 kV |
| | 商用周波数: 460 kV |
| 定格 $SF_6$ ガス圧 (at 20ºC, in abs.) | 0.70 MPa |
| 遮断器操作機構 | バネ方式 |
| 断路器・接地開閉器機構 | 3 位置接点方式 |
| 高速接地開閉器操作機構 | 電動バネ装置 |




(Source: JICA Study Team)

**図 2-31 Super Corridor 変電所 132kVGIS の単線結線図**

送電線に関しては、サイト調査時のヒアリングによると、サブプロジェクト No. 2 に含まれる Super Corridor 変電所に連系する 220kV Pithampur – Super Corridor 送電線と 132kV LILO Indore (Jetpura) – Depalpur 送電線の併架 4 回線送電線には、一部区間の支持物として鋼管単柱を用い、拡幅する道路中央部に敷設する予定である。次図に Super Corridor 変電所付近の計画送電線ルートの概略を示す。


**図 2-32　Super Corridor 変電所付近の送電線ルート**

2.5.2.　サブプロジェクト No.32 Tejgarh 変電所（変圧器増設）

同変電所は、JICA フェーズ 1 プロジェクトで新設された変電所である。地域需要の急速な伸びが予想されていることから、132kV/33kV 50MVA の変圧器を 1 台増設する。通常、MPPTCL の標準的な変電所設計においては、将来の機器増設に備えたスペースは確保されている。同変電所においても、図 2-33 が示す通り、既設変圧器の隣に変圧器増設スペースが確保されており、作業エリアも広く、増設工事は容易である。また、大型機器の搬入経路に関しては、アクセス道路から変圧器据付位置に至るルートに障害となる機器等は見られなかった。新設時にすでに 1 台の変圧器が搬入されており、増設時の変圧器運搬に支障はない。なお、サイト調査時のヒアリングによると、大型変圧器運搬に伴いアクセス道路の増強が必要となる場合は、コントラクターにより道路拡充が行われるとのことである。通常、MPPTCL の同種工事においては、変電所は既設道路の近辺に選定され、道路増強の規模は小さいことから、費用の大幅な増加や工期遅延の原因となることはないと考えられる。


**図 2-33　Tejgarh 変電所変圧器増設スペース**

## 2.6.　事業費用の妥当性

DPR の事業費積算は、規制機関である MPERC の認可する送電線・変電機器の単価表に基づき積算されている。これは、MPPTCL の通常の事業計画手順であり、MPERC の単価表は、実際の契約価格に基づき毎年更新されていることから、妥当な市場価格が設定されていると考えられる。

本調査では、上記単価表の価格水準を確認するため、インド国内の他州のプロジェクトとのコスト比較を行った。表 2-15 に送電線建設コスト比較を、表 2-16 に変電機器コスト比較をそれぞれ示す。地域・電圧によってばらつきはあるが、至近年のオリッサ州送電公社（OPTCL）が使用している積算単価と比較して、送電建設コストは約 10%～70%高く、変電機器は約 40%高い水準である。過去 5 年の平均物価上昇率（7.8%[10]）を勘案すると、事業費単価に関しては、他州との実績からも妥当な水準であると考えられる。

[10] JICA、2015-16 年度 円借款審査調書（インド）

**表 2-15　送電線建設コスト比較**

| 電圧 | 2 回線送電線建設費 [INR Lakhs/km] | | |
|---|---|---|---|
| | 本事業 | OPTCL（2014 年単価） | TANTRANSCO（2011 年単価） |
| 400 kV | 197.0 | 130.0 | 183.9 |
| 220 kV/230kV | 92.9 | 61.5 | 64.5 |
| 132 kV/110kV | 67.9 | 41.5 | 39.8 |

(Source: DPR 及び JICA Study Team 調べ)

**表 2-16　変電機器単価比較**

| 機器 | 機器単価 [INR Lakhs] | |
|---|---|---|
| | 本事業/ | OPTCL（2014 年単価） |
| 160MVA 220/132/33kV 変圧器 | 771.5 | 536.3 |
| 63MVA 132 /33kV 変圧器 | 442.9 | 262.4 |
| 220kV ガス遮断器 | 22.1 | 13.1 |
| 132kV ガス遮断器 | 9.4 | 6.0 |
| 33kV ガス遮断器 | 3.0 | 2.0 |

(Source: DPR 及び JICA Study Team 調べ)

なお MPPTCL にとっての新技術である LL-ACSR、GIS に関する、MPPTCL で利用可能な単価表は存在しない。これらの機器については、調査団にて MPPTCL の要求仕様に基づき、本邦企業に聞き取りを行い、事業費設定を行った。

## 2.7.　日本企業への裨益

マディヤ・プラデシュ州には複数の日本企業が進出している。調査の結果、Bridgestone India Pvt. Ltd.は、Indore 地域の Pithampur 220 kV 変電所の 132 kV 母線から直接電力を送電しており、その契約電力は 8 MW で、もっとも大きな需要家であると考えられる。これに次いで、Panasonic India Pvt. Ltd.が同じ Pithampur 220 kV 変電所の 33 kV 配電線（Novino feeder）に接続しており、契約電力は 500 kVA である。その他の大規模な需要家は確認できなかった。

本事業のサブプロジェクト No. 2 は上記 2 事業者に電力を供給するための変電所の電源側の送電線の増強工事であるため、本事業の実施は一部の日本企業の電力信頼度の向上に貢献している。サブプロジェクト No. 2 の周辺の電力系統図を図 2-34 に示す。

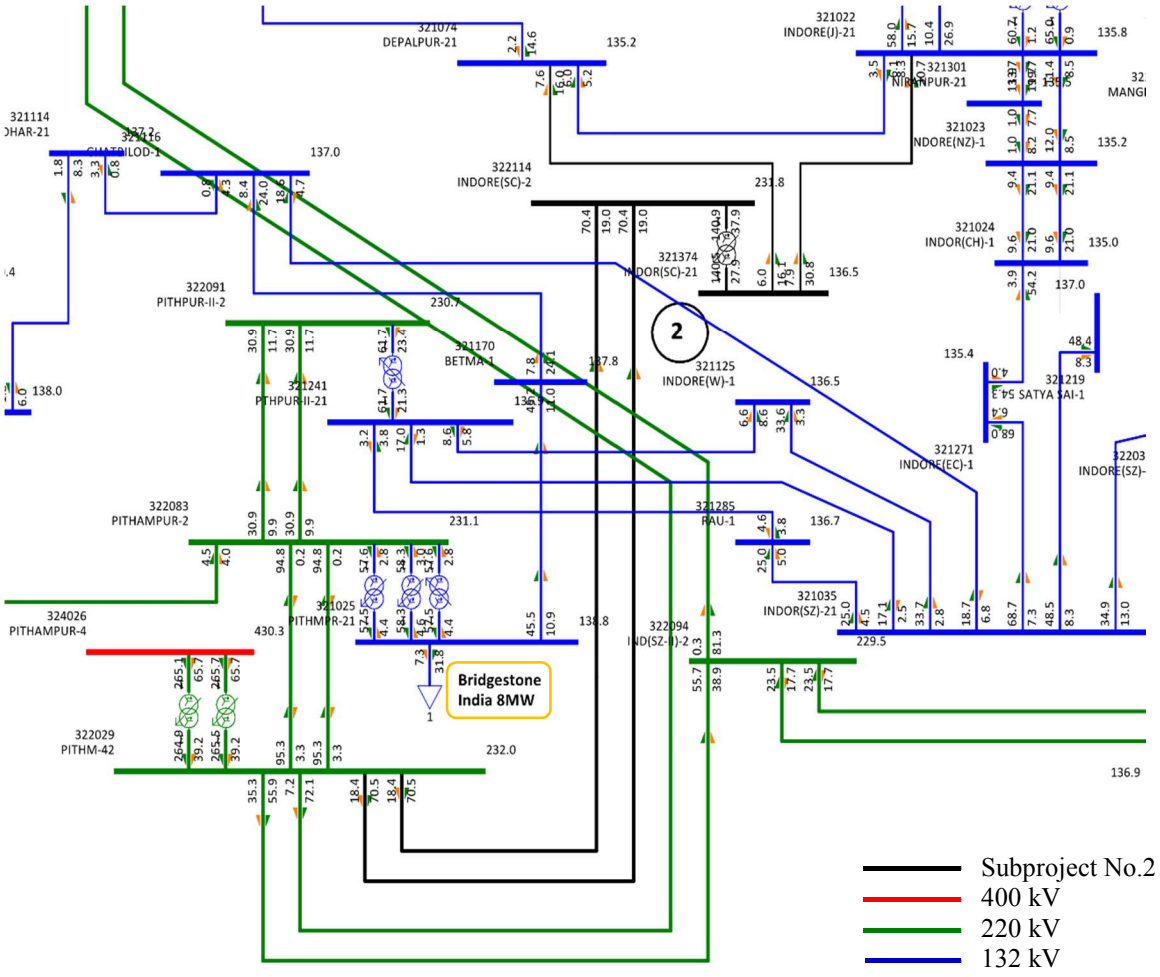
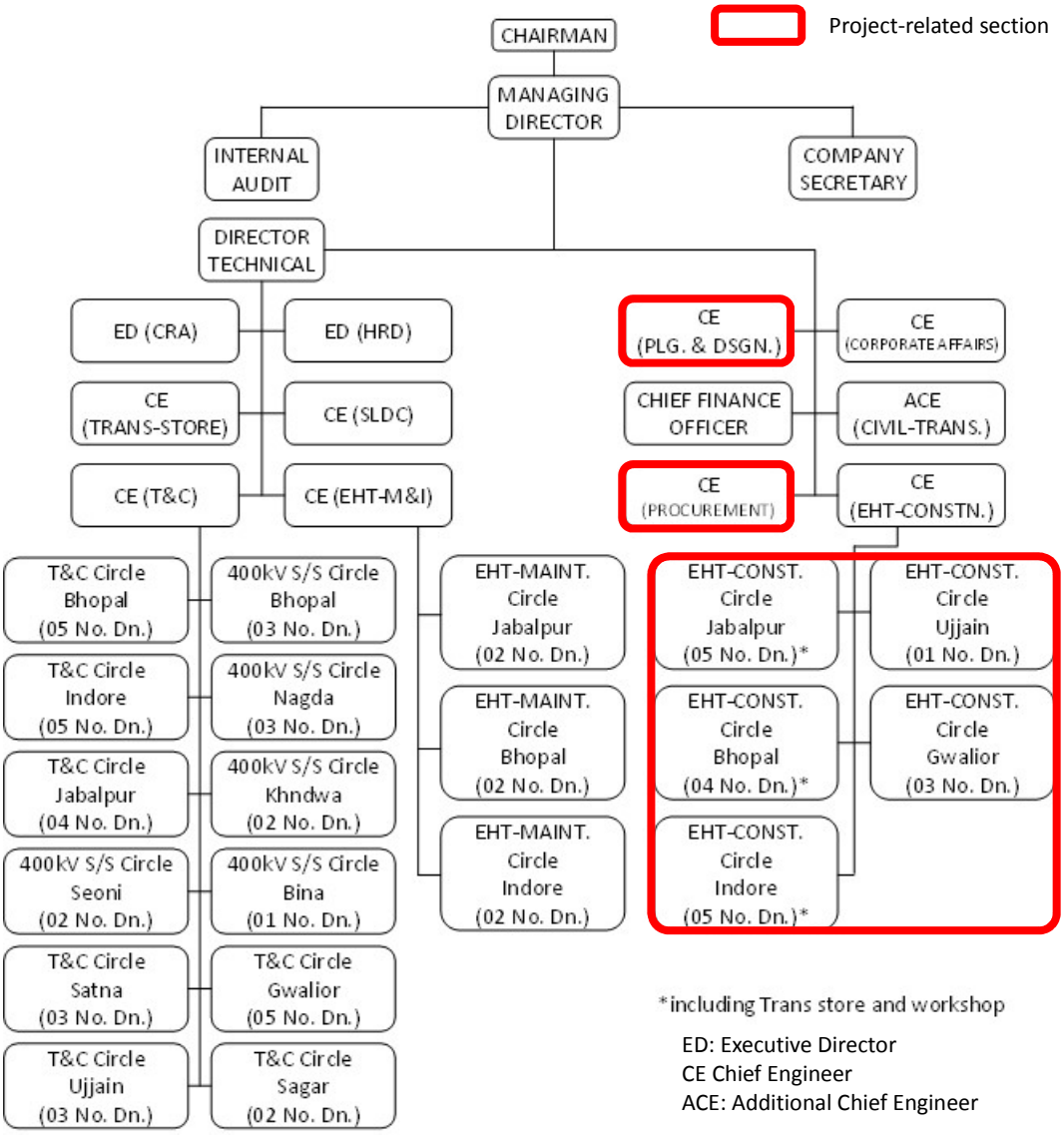



図 2-34　サブプロジェクト No.2 付近の電力系統

# 第3章 事業実施体制およびスケジュール

## 3.1. 実施機関の組織

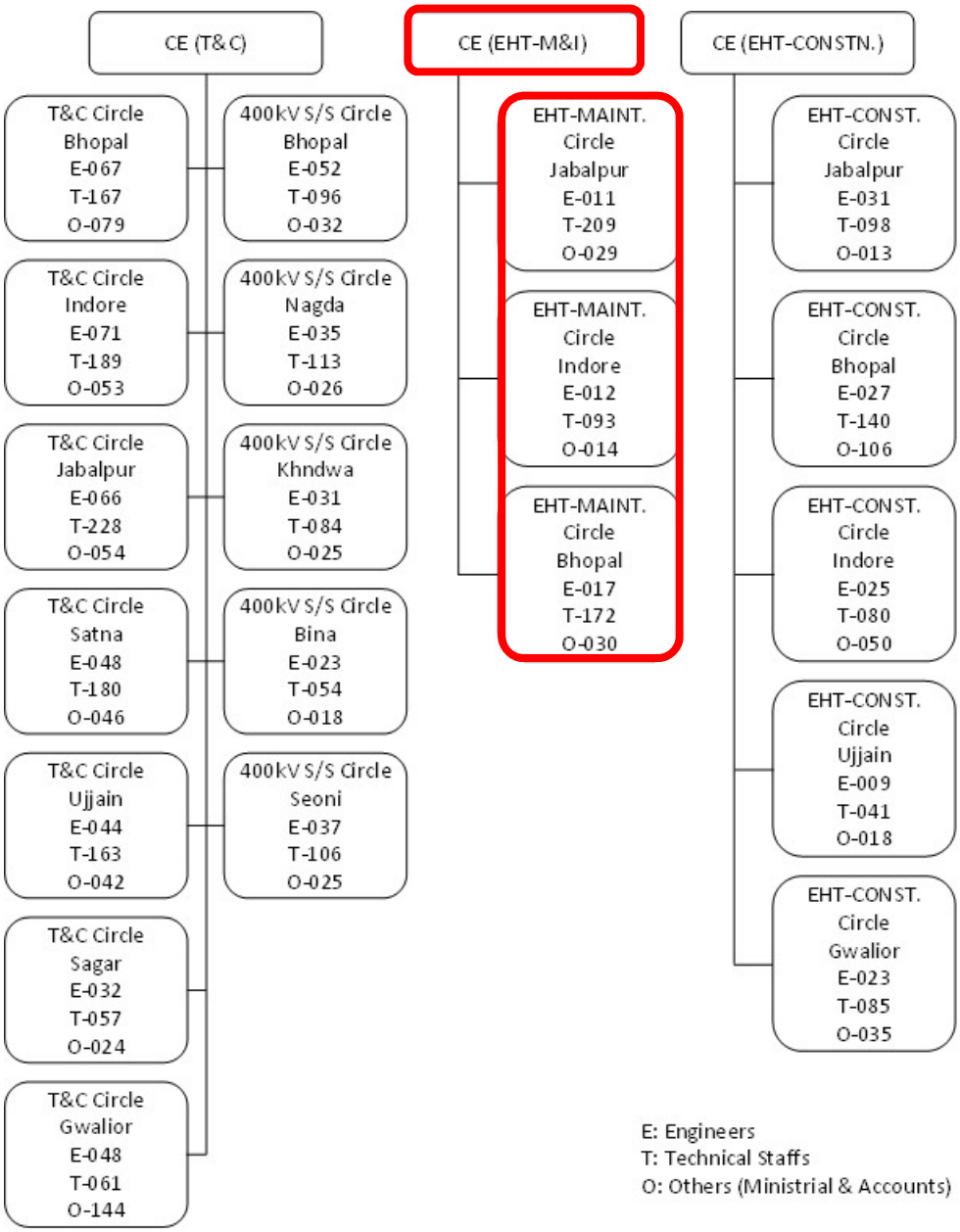
実施機関の MPPTCL は本社と現場事業所から構成され、従業員は現在約 5,000 人である。組織体制図を図 3-1 に示す。本事業を含む、送変電設備の設計は MPPTCL 本社の計画・設計部門（Planning & Design）が、調達は本社の調達部門（Procurement）がそれぞれ担当する。コントラクター決定後のプロジェクト管理は、超高圧建設部門（Extra High Tension Construction: EHT-Construction）が担当する。




（Source: MPPTCL）

**図 3-1 MPPTCL 組織体制**

現場事業所としては、前述の通り、EHT 建設、EHT 保守、T&C の 3 種類のサークルがある。各サークルの要員配置は図 3-2 の通りである。また、本事業実施後の運営・維持管理は、超高圧保守点検部門（Extra High Tension Maintenance & Inspection: EHT-M&I）が担当する。




（Source: MPPTCL）

**図 3-2　各サークルの要員配置**

MPPTCL の 2017 年までの要員計画を表 3-1 に示す。表中の CLASS-I、II、III、IV はそれぞれ、役付き Engineer、Engineer、Junior Engineer、Technical Staff に対応する。全体的に減少傾向にあるが、退職等の自然減の他、SCADA 導入に伴う自動化と、今後主に CLASS-III と IV の要員を外注していく方針であることによるものである。

**表 3-1　2017 年までの MPPTCL の要員計画**

| | | | | AS ON 31/03/2014 |
|---|---|---|---|---|
| CLASS | CE (EHT Const.) | CE (EHT-M&I) | CE (T&C) | Total |
| CLASS-I | 29 | 13 | 80 | 122 |
| CLASS-II | 93 | 36 | 154 | 283 |
| CLASS-III | 363 | 145 | 1455 | 1963 |
| CLASS-IV | 444 | 413 | 955 | 1812 |
| Total | 929 | 607 | 2644 | 4180 |
| | | | | AS ON 31/03/2015 |
| CLASS | CE (EHT Const.) | CE (EHT-M&I) | CE (T&C) | Total |
| CLASS-I | 29 | 13 | 80 | 122 |
| CLASS-II | 93 | 36 | 154 | 283 |
| CLASS-III | 363 | 145 | 1455 | 1963 |
| CLASS-IV | 452 | 419 | 969 | 1840 |
| Total | 937 | 613 | 2658 | 4208 |
| | | | | AS ON 31/03/2016 |
| CLASS | CE (EHT Const.) | CE (EHT-M&I) | CE (T&C) | Total |
| CLASS-I | 27 | 12 | 77 | 116 |
| CLASS-II | 91 | 34 | 147 | 272 |
| CLASS-III | 332 | 128 | 1386 | 1846 |
| CLASS-IV | 433 | 404 | 930 | 1767 |
| Total | 883 | 578 | 2540 | 4001 |
| | | | | AS ON 31/03/2017 |
| CLASS | CE (EHT Const.) | CE (EHT-M&I) | CE (T&C) | Total |
| CLASS-I | 26 | 11 | 74 | 111 |
| CLASS-II | 84 | 33 | 144 | 261 |
| CLASS-III | 285 | 104 | 1247 | 1636 |
| CLASS-IV | 415 | 385 | 876 | 1676 |
| Total | 810 | 533 | 2341 | 3684 |

（Source: MPPTCL）

MPPTCL は、これまで自己資金による送変電設備拡充のみならず、本事業と同規模の JICA フェーズ 1 プロジェクト及び ADB からの借り入れ資金による送電網整備事業[11]を実施してきたが、何れも工期遅延等の問題は報告されていない。実施機関の能力においては、特段の懸念はないと考えられる。

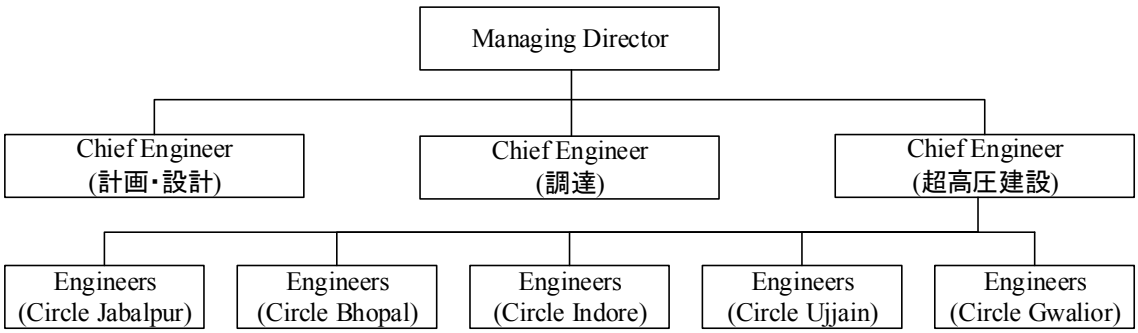
[11]上記の ADB 事業の概要は以下の通り、

(1) Madhya Pradesh Power Sector Development Program, Loans 1869, 供与額 USD 200 million, 承諾年 2001. http://www.adb.org/documents/india-madhya-pradesh-power-sector-development-program-loans-1868-1869

(2) Madhya Pradesh Power Sector Investment Program, Loans 2323/2346, 供与額 USD 250 million, 承諾年 2007. http://www.adb.org/projects/32298-023/main, http://www.adb.org/projects/32298-043/main

### 3.2. 事業実施体制

図 3-3 に、本事業の実施体制を示す。調達前の MPPTCL 内部の基本設計を計画・設計部長が、調達を調達部長が、施工管理を建設部長がそれぞれ担当する。建設部長の以下には 5 つの地域分けされた建設部門があり、それぞれの部門が管轄する工事管理を担当する。以上のプロジェクト管理体制は、MPPTCL の一般的な工事実施体制であるとともに、JICA フェーズ 1 プロジェクトと同様の体制であり、現在のところ大きな問題は発生していないことから実施に問題はないと考えられる。




（Source: JICA Study Team）

**図 3-3 事業実施体制**

コンサルタントの雇用については、既存技術に関しては、MPPTCL は JICA フェーズ 1 プロジェクト等の経験があることから、雇用は必要ない。また、新技術の LL-ACSR に関しては、調達・運用上は特別な知識・技能は必要ないことから、コンサルタント雇用は不要と考えられる。他方、GIS に関しては、MPPTCL において新規に導入されることから、GIS の基本的な構造に基づく変電所設計思想、EPC コントラクターの調達評価、運用維持管理に係るマニュアルの策定に係るコンサルタントの雇用が最低限必要と考えられる。しかしながら、本調査期間中においては、MPPTCL としては、調達が実施機関自身での設計が不要な EPC 契約であること、運用上のマニュアル等の整備はメーカーのサポートを受けながら MPPTCL 自身で策定可能と考えていることから、コンサルタントは不要と主張し、コンサルタントの要否に関する結論は出なかった。今後の協議が必要である。

建設工事の管理は、前述の通り MPPTCL の超高圧建設が Indore、Bhopal、Jabalpur、Ujjain、Gwalior の 5 箇所あり、サブプロジェクトが位置するエリアの各サークルが担当する。5 箇所の超高圧建設の担当エリアは図 3-4 の通りである。


（Source: MPPTCL）

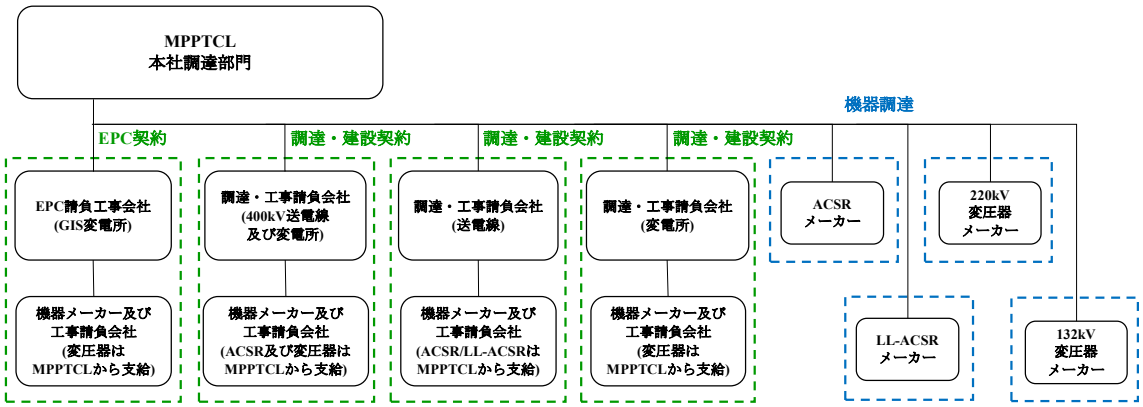
**図 3-4　超高圧建設サークル地域区分**

### 3.3.　調達パッケージ

上述の契約体制に従い、新技術の採否、機器種別、契約規模を勘案して MPPTCL と協議を行った結果、全体の調達を図 3-5 および表 3-2 に示す 8 パッケージに分割することで合意した。通常、MPPTCL における類似事業のコントラクター発注は、施工地域、機器種別および事業費規模を勘案し、パッケージングが行われている。本事業においては、これらに加え、新技術である GIS を考慮し、以下の考え方に基づくパッケージングが行われた。

- GIS を適用するプロジェクトについては、送電と変電を別パッケージに分け、GIS については EPC コントラクターの応札が可能とする。
- 従来型の送変電設備は MPPTCL 自身が設計を行い、コントラクターが調達・施工を行う契約をとる。
- 変電所の 220kV、132kV 各変圧器、LL-ACSR、ACSR 送電線に関しては、MPPTCL が直接メーカーから調達し、コントラクターに支給する方式をとる。
- LL-ACSR と ACSR は応札社が異なることが考えられることから、別パッケージに分ける。

- 変圧器調達については、メーカーの製造ラインのキャパシティを考慮し、220kV と 132kV の 2 つのパッケージに分ける。
- 施工のパッケージについては送電と変電を分けるが、但し 400kV のサブプロジェクトは対象が限られることから、送電と変電で 1 つのパッケージとする。
- 各パッケージの事業費規模は、MPPTCL が適切に管理できるよう、MPPTCL の過去の工事実績と照らして、著しく大きすぎない規模とする。なお、MPPTCL によると、平均的な調達のパッケージは Rs.60～70Crores（約 12 億円～14 億円）、大規模な調達で Rs.250Crores（約 50 億円）である。




（Source: JICA Study Team）

**図 3-5　調達パッケージ**

## 表 3-2　パッケージ案

| Subproject | NAME OF LINE WORKS | Line Work | | New/Upgrading Substation Work | | Feeder Bay Extension | | Total Cost [INR Lakhs] | | | | | | | Procurement Package | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Route Length [km] | LL-ACSR | Substation Name, Capacity & Associated Feeder Bays | GIS | Name of Sub-station | No. of Bays | Transmission Line | ACSR/ LL-ACSR (procured by MPPTCL) | Substation | 220kV Transformer (procured by MPPTCL) | 132kV Transformer (procured by MPPTCL) | Feeder Bay Extension | Total | 1 (GIS, EPC) | 2 (LL-ACSR) | 3 (ACSR) | 4 (220kV Transformer) | 5 (132kV Transformer) | 6 (P+C, 400kV) | 7 (P+C, T/L) | 8 (P+C, S/S) |
| 1 | LILO of one circuit of 400kV Khandwa - Rajgarh PGCIL line at Chhegaon 400kV Substation (D/C) | 5 | | | | | | 1072.42 | 276.35 | | | | | 1348.77 | | | 1 | | | 1 | | |
| | | | | | | Chhegaon400(2) | 2 | | | | | | 1061.98 | 1061.98 | | | | | | 1 | | |
| | 400kV Bus Reactor at Chhegaon 400kV S/S | | | 1x125 MVAR | | | | | | 985.60 | | | | 985.60 | | | | | | 1 | | |
| 2 | Pithampur400-Super Corridor 220kV DCDS line | 50 | LL-ACSR | | | | | 5442.92 | 1623.70 | | | | | 7066.62 | | 1 | | | | | 1 | |
| | | | | | | Pithampur400(2) | 2 | | | | | | 404.94 | 404.94 | | | | | | | | 1 |
| | | | | Super Corridor (Indore) 220/132kV with GIS (1x160+1x63) + 220kV FB(2) +132kV FB(2) | GIS | | | | | 7589.69 | 781.43 | 442.88 | | 8814.00 | 1 | | | 1 | 1 | | | |
| | LILO of One ckt of Indore(Jetpura) - Depalpur 132kV DCDS Line at Super Corridor (Indore) 220kV S/s.(D/C) | 13 | | | | | | 710.28 | 135.80 | | | | | 846.08 | | | 1 | | | | 1 | |
| 4 | Charging/Upgradation of Chichli220 - Udaipura DCDS line on 220kV level | - | | Udaipura 220kV S/s (Upgradation) (1x160) MVA + 220kV FB(2) | | Chichli220(2) | 2 | | | 1572.43 | 771.46 | | 347.69 | 2691.58 | | | | 1 | | | | 1 |
| 5 | Chhatarpur-Tikamgarh 220kV DCSS line | 110 | LL-ACSR | | | | | 7630.24 | 1541.37 | | | | | 9171.61 | | 1 | | | | | 1 | |
| | | | | | | Chhatarpur (1) Tikamgarh (1) | 2 | | | | | | 413.11 | 413.11 | | | | | | | | 1 |
| 6 | 400/220kV Additional Transformer at Bina 400kV S/S | | | 1x315 MVA | | | | | | 2983.90 | | | | 2983.90 | | | | | | 1 | | |
| | LILO of Bina220 - Ganjbasoda 220kV line at Bina(MPPTCL) 400kV S/s | 10 | | | | | | 1056.09 | 189.05 | | | | | 1245.14 | | | 1 | | | | 1 | |
| | | | | | | Bina(MP)400 (2) | 2 | | | | | | 448.57 | 448.57 | | | | | | | | 1 |
| 7 | Rewa220 - Rewa UMSP 220kV DCDS line | 30 | LL-ACSR | | | | | 2458.35 | 841.58 | | | | | 3299.93 | | 1 | | | | | 1 | |
| | Rewa UMSP - Sidhi 220kV DCDS line | 60 | | | | | | 4690.93 | 1122.11 | | | | | 5813.04 | | | 1 | | | | 1 | |
| | | | | | | Rewa220 (2) Sidhi220 (2) Rewa UMSP (4) | 8 | | | | | | 1575.69 | 1575.69 | | | | | | | | 1 |
| 9 | Julwania400 - Pati(Silawad) 132kV DCSS Line | 40 | | | | | | 2032.27 | 215.65 | | | | | 2247.92 | | | 1 | | | | 1 | |
| | | | | Pati(Silawad) 132/33kV 50MVA + 132kV FB(1) | | Julwaniya400(1) | 1 | | | 982.66 | | 342.60 | 97.45 | 1422.71 | | | | | 1 | | | 1 |
| 10 | LILO of Mangliya - IndoreSZ 132kV line at Mahalaxmi | 3 | | | | | | 218.66 | 32.26 | | | | | 250.92 | | | 1 | | | | 1 | |
| | | | | Mahalaxmi 132/33kV 63MVA + 132kV FB(2) | | | | | | 1127.17 | | 452.85 | | 1580.02 | | | | | 1 | | | 1 |
| 11 | Julwania400 - Shahpura 132kV DCSS Line | 65 | | | | | | 3795.84 | 346.39 | | | | | 4142.23 | | | 1 | | | | 1 | |
| | | | | Shahpura 132/33kV 50MVA + 132kV FB(1) | | Julwaniya400(1) | 1 | | | 985.23 | | 342.60 | 97.45 | 1425.28 | | | | | 1 | | | 1 |
| 12 | Datia220 - Bhitarwar 132kV DCSS Line | 40 | | | | | | 2074.63 | 215.65 | | | | | 2290.28 | | | 1 | | | | 1 | |
| | | | | Bhitarwar 132/33kV 50MVA + 132kV FB(1) | | Datiya220(1) | 1 | | | 985.23 | | 342.60 | 104.07 | 1431.90 | | | | | 1 | | | 1 |
| 13 | MugaliaChhap220 - Mahwadia 132kV DCDS Line | 10 | | | | | | 709.44 | 105.28 | | | | | 814.72 | | | 1 | | | | 1 | |
| | | | | Mahwadia 132/33kV 50MVA + 132kV FB(2) | | MugaliyaChhap(2) | 2 | | | 1051.60 | | 342.60 | 194.89 | 1589.09 | | | | | 1 | | | 1 |
| 15 | Sidhi220 - Madwas 132kV DCSS Line | 50 | | | | | | 2991.23 | 268.28 | | | | | 3259.51 | | | 1 | | | | 1 | |
| | | | | Madwas 132/33kV 50MVA + 132kV FB(1) | | Sidhi220(1) | 1 | | | 985.23 | | 342.60 | 97.26 | 1425.09 | | | | | 1 | | | 1 |
| 16 | Panagar220 - Dheemarkheda 132kV DCSS Line | 65 | | | | | | 3652.61 | 346.39 | | | | | 3999.00 | | | 1 | | | | 1 | |
| | | | | Dheemarkheda 132/33kV 50MVA + 132kV FB(1) | | Panagar220(1) | 1 | | | 985.23 | | 342.60 | 104.07 | 1431.90 | | | | | 1 | | | 1 |

| Subproject | NAME OF LINE WORKS | Line Work | | New/Upgrading Substation Work | | Feeder Bay Extension | | Total Cost [INR Lakhs] | | | | | | | Procurement Package | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Route Length [km] | LL-ACSR | Substation Name, Capacity & Associated Feeder Bays | GIS | Name of Sub-station | No. of Bays | Transmission Line | ACSR/ LL-ACSR (procured by MPPTCL) | Substation | 220kV Transformer (procured by MPPTCL) | 132kV Transformer (procured by MPPTCL) | Feeder Bay Extension | Total | 1 (GIS, EPC) | 2 (LL-ACSR) | 3 (ACSR) | 4 (220kV Transformer) | 5 (132kV Transformer) | 6 (P+C, 400kV) | 7 (P+C, T/L) | 8 (P+C, S/S) |
| 17 | Prithivipur-Orchha 132kV DCSS Line | 30 | | | | | | 2189.65 | 164.71 | | | | | 2354.36 | | | 1 | | | | 1 | |
| | | | | Orchha 132/33kV 50MVA + 132kV FB(1) | | Prithvipur(1) | 1 | | | 985.23 | | 342.60 | 99.57 | 1427.40 | | | | | 1 | | | 1 |
| 18 | Sirmour220 - Atraila 132kV DCSS line | 35 | | | | | | 2056.22 | 190.18 | | | | | 2246.40 | | | 1 | | | | 1 | |
| | | | | Atraila 132/33kV 50MVA + 132kV FB(1) | | Sirmour220 (1) | 1 | | | 985.23 | | 342.60 | 95.63 | 1423.46 | | | | | 1 | | | 1 |
| 19 | Udaipura - Tendukheda 132kV DCSS line | 45 | | | | | | 2433.51 | 242.81 | | | | | 2676.32 | | | 1 | | | | 1 | |
| | | | | Tendukheda 132/33kV S/s (1x50) MVA + 132kV FB(1) | | Udaipura (1) | 1 | | | 985.23 | | 342.60 | 96.19 | 1424.02 | | | | | 1 | | | 1 |
| 20 | Gohad - Gormi 132kV DCSS line | 25 | | | | | | 1494.08 | 139.24 | | | | | 1633.32 | | | 1 | | | | 1 | |
| | | | | Gormi 132/33kV S/s (1x50) MVA + 132kV FB(1) | | Gohad (1) | 1 | | | 985.23 | | 342.60 | 91.69 | 1419.52 | | | | | 1 | | | 1 |
| 21 | Narsinghgarh - Suthaliya 132kV DCSS line | 50 | | | | | | 2725.60 | 268.28 | | | | | 2993.88 | | | 1 | | | | 1 | |
| | | | | Suthaliya 132/33kV S/s (1x50) MVA + 132kV FB(1) | | Narsinghgarh (1) | 1 | | | 985.23 | | 342.60 | 95.63 | 1423.46 | | | | | 1 | | | 1 |
| 22 | LILO of Satna220 - Kymore 132kV line at Unchhera 132kV S/s | 5 | | | | | | 497.82 | 52.64 | | | | | 550.46 | | | 1 | | | | 1 | |
| | | | | Unchhera 132/33kV S/s (1x50) MVA + 132kV FB(2) | | | | | | 1077.76 | | 342.60 | | 1420.36 | | | | | 1 | | | 1 |
| 23 | Sidhi - Sinhawal 132kV DCSS line | 50 | | | | | | 3137.77 | 268.28 | | | | | 3406.05 | | | 1 | | | | 1 | |
| | | | | Sinhawal 132/33kV S/s (1x50) MVA + 132kV FB(1) | | Sidhi220(1) | 1 | | | 985.23 | | 342.60 | 97.26 | 1425.09 | | | | | 1 | | | 1 |
| 24 | 2nd ckt of Rajgarh(B) - Raghogarh 132kV DCSS line up to Chachoda 132kV S/s | 61 | | | | | | 1516.20 | 326.02 | | | | | 1842.22 | | | 1 | | | | 1 | |
| | | | | Chachoda 132/33kV S/s (1x50) MVA + 132kV FB(1) | | Rajgarg(B)(1) | 1 | | | 985.23 | | 342.60 | 104.07 | 1431.90 | | | | | 1 | | | 1 |
| 25 | Maneri - Mandla 132kV DCSS line | 80 | | | | | | 5067.37 | 424.50 | | | | | 5491.87 | | | 1 | | | | 1 | |
| | | | | | | Maneri(1) Mandla(1) | 2 | | | | | | 195.20 | 195.20 | | | | | | | | 1 |
| 26 | Sukha (Jabalpur) | | | + 2x50 MVA | | | | | | 1051.50 | 1133.88 | | | 2185.38 | | | | 1 | | | | 1 |
| 27 | Hoshangabad 220kV (2nd) | | | + 1x160 MVA | | | | | | 590.35 | 771.46 | | | 1361.81 | | | | 1 | | | | 1 |
| 28 | Barwaha 220kV (3rd) | | | + 1x160 MVA | | | | | | 616.67 | 771.46 | | | 1388.13 | | | | 1 | | | | 1 |
| 29 | Betma 132kV | | | + 50 MVA | | | | | | 268.20 | | 332.63 | | 600.83 | | | | | 1 | | | 1 |
| 30 | Khirkiya 132kV | | | + 50 MVA | | | | | | 272.47 | | 332.63 | | 605.10 | | | | | 1 | | | 1 |
| 31 | Amla 132kV | | | + 50 MVA | | | | | | 252.00 | | 332.63 | | 584.63 | | | | | 1 | | | 1 |
| 32 | Tejgarh 132kV | | | + 50 MVA | | | | | | 268.13 | | 332.63 | | 600.76 | | | | | 1 | | | 1 |
| 33 | Satwas 132kV | | | + 50 MVA | | | | | | 260.80 | | 332.63 | | 593.43 | | | | | 1 | | | 1 |
| 34 | Sitamau 132kV | | | + 50 MVA | | | | | | 264.43 | | 332.63 | | 597.06 | | | | | 1 | | | 1 |
| 35 | Baroda 132kV | | | + 50 MVA | | | | | | 276.24 | | 332.63 | | 608.87 | | | | | 1 | | | 1 |
| 36 | Amrawadkhurd 132kV | | | + 50 MVA | | | | | | 263.81 | | 332.63 | | 596.44 | | | | | 1 | | | 1 |
| | **TOTAL** | | | | | | | 59654.13 | 9336.52 | 32592.94 | 4229.69 | 8353.17 | 5822.41 | 119988.86 | 7589.69 | 4006.65 | 5329.87 | 4229.69 | 8353.17 | 6103.90 | 58581.71 | 25794.18 |

(Source: MPPTCL and JICA Study Team)

### 3.4. 事業実施スケジュール

図 3-6 にプロジェクト実施工程（案）を示す。本工程は、MPPTCL との協議の結果、以下の条件を勘案し設定されている。ただし、コンサルタント雇上の合意が取れなかったため、今後の協議状況によっては変更になる可能性がある。

- Package 1: GIS 変電所の EPC、Package 2: LL-ACSR の機材調達に関しては、コンサルタントを雇上したうえで、コンサルタントによる MPPTCL への調達支援が行われることを想定している。ただし、MPPTCL 自体はコンサルタントの必要性を否定しており、今後の協議が必要である。
- Package 2: LL-ACSR、Package 3: ACSR の機材調達は、本事業の調達物量から勘案し、最短で契約後 8 ヶ月程度で納入開始と想定される。納期は、施工業者（Package 1、6、7、8）の工程に併せて随時納入され、遅くとも竣工の 6 ヶ月前までには納入されるべきである。
- Package 4: 220kV 変圧器、Package 5: 132kV 変圧器の機材調達は、最短で契約後 8 ヶ月程度で納入可能と想定される。220kV 変圧器については毎月 1 台、132kV 変圧器については毎月 2 台が納入される想定である。納期は、施工業者（Package 1、7、8）の工程に併せて随時納入され、遅くとも竣工の 6 ヶ月前までには納入されるべきである。
- Package 6、7、8 の調達・施工コントラクターの工事実施期間は、MPPTCL の過去の工事実績および調査団の経験に基づき、最長 26 か月と想定される。

| FY | 2015-16 | | | | | | 2016-17 | | | | | | | | | | | | 2017-18 | | | | | | | | | | | | 2018-19 | | | | | | | | | | | | 2019-20 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| JICA Pledge | | | | | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| E/N | | | | | | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| L/A | | | | | | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Project Completion | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ■ | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pkg. 1: EPC for GIS Substation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (1-a) Consultant Selection | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (1-b) Consultancy Service | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | |
| (1-c) EPC Contractor Selection | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.Preparation of Tender Documents & JICA's Approval without Pre-qualification | | | | | | | | | | | | | | | | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.Tender Period | | | | | | | | | | | | | | | | | | | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.Evaluation of Bids | | | | | | | | | | | | | | | | | | | | | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.JICA Approval of Bid Evaluation | | | | | | | | | | | | | | | | | | | | | | | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.Contract Negotiation | | | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6.JICA Approval of Contract | | | | | | | | | | | | | | | | | | | | | | | | | | ■ | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.Opening of Letter of Credit and Issuance of Letter of Commitment | | | | | | | | | | | | | | | | | | | | | | | | | | | ■ | | | | | | | | | | | | | | | | | | | | | | | | |
| (1-b) EPC Work | | | | | | | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pkg. 2: LL-ACSR Procurement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (2-a) Consultant Selection | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (2-b) Consultancy Service | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | |
| (2-c) Manufacture Selection | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | |
| (2-d) Manufacturing | | | | | | | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pkg. 3: ACSR Procurement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (3-a) Manufacture Selection | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (3-b) Manufacturing | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pkg. 4: 220kV Transformer Procurement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (4-a) Manufacture Selection | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (4-b) Manufacturing | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pkg. 5: 132kV Transformer Procurement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (5-a) Manufacture Selection | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (5-b) Manufacturing | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pkg. 6: Procurement & Construction for 400kV T/L and S/S | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (6-a) Detailed Design by MPPTCL | | | | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (6-b) P+C Contractor Selection | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (6-c) Contractor Work | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pkg. 7: Procurement & Construction for 220kV and 132kV T/L | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (7-a) Detailed Design by MPPTCL | | | | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (7-b) P+C Contractor Selection | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (7-c) Contractor Work | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pkg. 8: Procurement & Construction for 220kV and 132kV S/S | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (8-a) Detailed Design by MPPTCL | | | | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (8-b) P+C Contractor Selection | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (8-c) Contractor Work | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

（Source: JICA Study Team）

**図 3-6　プロジェクト実施工程（案）**

## 3.5. 調達・施工方法

調達は、機器メーカーとの直接の機材購入契約、およびコントラクターとの契約が締結される。いずれも調達条件は、PQ 無しの国際競争入札（International Competition Bidding: ICB）である。コントラクターの到達は、FIDIC Yellow に基づくデザイン・ビルドが採用される。以上の条件は、本調査と並行して 2015 年 9 月に行われた JICA の Fact Finding Mission において協議・確認された。

## 3.6. 運営維持管理体制

### 3.6.1. 運営維持管理体制

本事業完成後の送変電設備は、通常の MPPTCL の工事同様、MPPTCL の現場組織である超高圧保守サークルに設備が移管される。Indore、Bhopal、Jabalpur の 3 つの超高圧保守サークルがあり、当該サークルが各担当エリアの設備保守を行っている。本事業で建設される送電線及び変電所の保守も各エリアの超高圧保守サークルが同様に担当して行う。超高圧保守サークルのエリア分けは図 3-7 の通りである。前述の通り MPPTCL は託送料金収入で事業運営を行っているが、定期的な設備の点検・保守も実施されており、維持管理に係る費用は健全に確保されているものと思われる。


（Source: MPPTCL）

**図 3-7　超高圧保守サークル担当エリア**

また、現場には 7 つの T&C（Testing & Communication）サークルと 5 つの 400kV 変電所サークルがあり、超高圧保守サークルと同様に担当エリアが決められている。


（Source: MPPTCL）

**図 3-8　T&C サークル担当エリア**

### 3.6.2.　送変電設備点検・保守

MPPTCL は標準的な保守手順に則り、計画的な設備の予防保全を行っている。また国内で初めて送電線の活線保守作業を採用したのは MPPTCL である。

送電線の点検については、不良碍子検出を 1 回/年、短絡/地絡巡視を 3 日以内等、作業別に周期を定めて実施している。保守についても同様に、基礎補修や部材取替、碍子交換、碍子洗浄等、不具合や作業別に即時、半年毎、1 年毎等の周期を定めて実施している。

変電設備の点検についても、同様に定められた周期に従い点検を実施している。例えば、変圧器の絶縁油特性試験、油中ガス分析を半年に 1 回行っている。遮断器については、絶縁抵抗測定、動作時間測定を半年に 1 回行っている。全般的に、日本で行われている点検周期よりも短周期で実施されている傾向にあるが、これは機器の品質が日本と比べて比較的悪いことに起因すると思われる。今回 MPPTCL からの聴き取りでは、CT の不良が頻繁に起こっているとの意見が聞かれた。この対策として、MPPTCL では、CT 調達時のメーカー補償期間を 5 年と長くするといった措置をとっている。他方、国際的には送変電機器の補償期間

は 1〜2 年が通常であり、機器メーカーに一般的ではない長期間の機器補償を求めることは、入札に参加するメーカーを制限する可能性がある。

### 3.7. 運用･効果指標

本事業の運用状況を監視し、発現効果を確認するための指標として、サブプロジェクト別の把握が困難であるとの MPPTCL の意向を踏まえ、MPPTCL 全系に係る以下の運用･効果指標を提案する。

**表 3-3 運用･効果指標**

| 指標 | 単位 | ベースライン | 目標 |
|---|---|---|---|
| 設備稼働率 | % | N/A | 99.35 |
| 送電損失率 | % | N/A | 2.82 |

各目標には MPPTCL の過去の運用実績を基に、本事業に最低限求められる数値をその初期値として設定した。また、事業の進捗に合わせて目標値自体についてレビューを行い、最終目標を達成するべく継続的な努力が求められる。

# 第4章 送変電設備の新技術提案

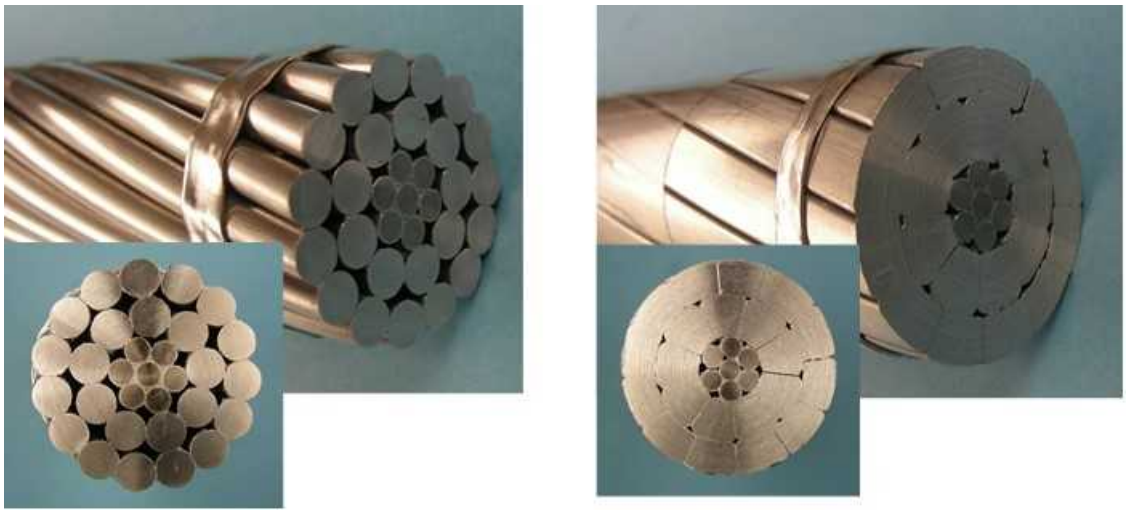
## 4.1. 低ロス電線

### 4.1.1. 低ロス電線（LL-ACSR）の特徴

LL-ACSR は台形アルミ素線を撚り合わせた鋼芯アルミより線（ACSR）で、従来型よりも導体であるアルミ断面積の占有率が高く、従来型 ACSR と同一外径で比較した場合、送電ロスを低減できるものである。

また、LL-ACSR を従来型 ACSR と同抵抗値で比較した場合、電線小型化による風圧荷重の低減などで、支持物の小型化が期待できる。

図 4-1 に従来型 ACSR 電線と LL-ACSR の形状を示す。



(Source: Courtesy of SEI LTD.)

**図 4-1 従来型 ACSR 電線（左）と LL-ACSR（右）**

### 4.1.2. 本事業における LL-ACSR の仕様

前述の通り MPPTCL では全電圧階級において標準化された鉄塔を使用しており、それらは標準電線である ACSR Moose 複導体（400kV）、ACSR Zebra（220kV）及び ACSR Panther（132kV）の各電線に対応している。このため、本事業において提案する LL-ACSR は、MPPTCL の標準鉄塔をそのまま適用できる仕様とする必要がある。

そこで、高強度の細径鋼線を用いて鋼芯の重量･断面積を減らしつつ、標準電線と同等の引張強度を確保し、アルミ断面積を増加させながらも、電線重量及び外径を標準電線と同等以下に抑えた仕様の LL-ACSR を提案した。これにより、10～20%程度の抵抗値低減が実現している。なお、最大限のロス低減効果を得られるよう、鋼芯には 1,960MPa 以上の亜鉛めっき鋼線（UGS）または 1,770MPa 以上のアルミ覆鋼線（14AC）を用いる必要がある。

各標準電線相当の LL-ACSR の技術仕様を表 4-1 から表 4-3 に示す。

**表 4-1　(400 kV 用) ACSR Moose 相当低ロス電線の技術仕様**

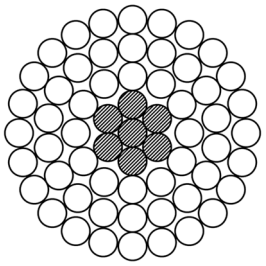
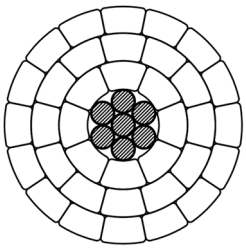
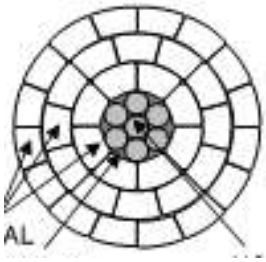
| | | (参考) ACSR Moose | LL-ACSR/AS | LL-ACSR/UGS |
|---|---|---|---|---|
| 断面積 | 導体 | 528.5 $mm^2$ | 589.2 $mm^2$ | 606.78 $mm^2$ |
| | 鋼芯 | 68.5 $mm^2$ | 49.48 $mm^2$ | 40.08 $mm^2$ |
| | 全体 | 597.0 $mm^2$ | 638.7 $mm^2$ | 646.86 $mm^2$ |
| 電線外径 | | 31.77 mm | 29.8 mm | 30.2 mm |
| 電線重量 | | 2,004 kg/km | 1,991 kg/km | 1,998 kg/km |
| 電気抵抗（20℃） | | 0.05552 ohm/km | 0.0484 ohm/km | 0.0477 ohm/km |
| 最小破断荷重 | | 161.2 kN | 163.2 kN | 160.7 kN |
| 弾性係数 | | GPa | 70.2 GPa | 70.7 GPa |
| 線膨張係数 | | 19.5 x $10^{-6}$/deg.C | 20.9 x $10^{-6}$/deg.C | 20.9 x $10^{-6}$/deg.C |
| 断面形状 | |  |  |  |

**表 4-2　(220 kV 用) ACSR Zebra 相当低ロス電線の技術仕様**

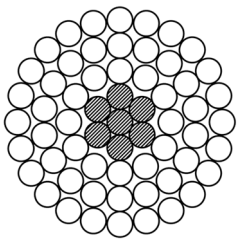
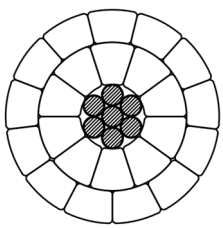
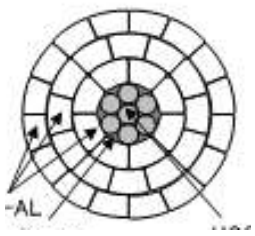
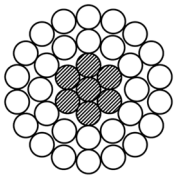
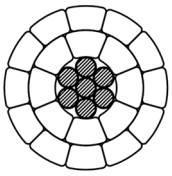
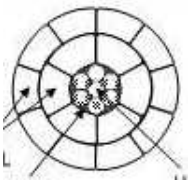
| | | (参考) ACSR Zebra | LL-ACSR/AS | LL-ACSR/UGS |
|---|---|---|---|---|
| 断面積 | 導体 | 428.9 $mm^2$ | 480.4 $mm^2$ | 491.84 $mm^2$ |
| | 鋼芯 | 55.59 $mm^2$ | 40.08 $mm^2$ | 33.00 $mm^2$ |
| | 全体 | 484.5 $mm^2$ | 520.5 $mm^2$ | 524.84 $mm^2$ |
| 電線外径 | | 28.62 mm | 26.9 mm | 27.21 mm |
| 電線重量 | | 1,621 kg/km | 1,620 kg/km | 1,623 kg/km |
| 電気抵抗（20℃） | | 0.06915 ohm/km | 0.0592 ohm/km | 0.0588 ohm/km |
| 最小破断荷重 | | 130.32 kN | 132.6 kN | 132.8 kN |
| 弾性係数 | | 70.9 GPa | 70.1 GPa | 70.9 GPa |
| 線膨張係数 | | 20.9 x $10^{-6}$/deg.C | 20.9 x $10^{-6}$/deg.C | 20.9 x $10^{-6}$/deg.C |
| 断面形状 | |  |  |  |

**表 4-3　(132 kV 用) ACSR Panther 相当低ロス電線の技術仕様**

| | | (参考) ACSR Panther | LL-ACSR/AS | LL-ACSR/UGS |
|---|---|---|---|---|
| 断面積 | 導体 | 212.1 $mm^2$ | 243.4 $mm^2$ | 260.16 $mm^2$ |
| | 鋼芯 | 49.5 $mm^2$ | 35.75 $mm^2$ | 31.67 $mm^2$ |
| | 全体 | 261.6 $mm^2$ | 279.2 $mm^2$ | 291.83 $mm^2$ |
| 電線外径 | | 21.00 mm | 19.8 mm | 20.48 mm |
| 電線重量 | | 976 kg/km | 931.5 kg/km | 972.2 kg/km |
| 電気抵抗（20℃） | | 0.139 ohm/km | 0.1152 ohm/km | 0.111 ohm/km |
| 最小破断荷重 | | 89.67 kN | 92.2 kN | 93.57 kN |
| 弾性係数 | | 89.1 GPa | 75.7 GPa | 77.4 GPa |
| 線膨張係数 | | 18.0 x $10^{-6}$/deg.C | 19.8 x $10^{-6}$/deg.C | 19.7 x $10^{-6}$/deg.C |
| 断面形状 | |  |  |  |

(Source: Courtesy of FUJIKURA LTD./SEI LTD.)

4.1.3.　弛度比較

LL-ACSR 採用時においても電線弛度は従来電線と同等である必要がある。標準径間における従来型 ACSR Zebra と LL-ACSR（Zebra 相当）の弛度比較を図 4-2 に示す。

同図に示す通り従来電線と LL-ACSR の弛度は同程度であり、電線変更によって弛度増加の問題がないことが確認された。


**図 4-2　従来型 ACSR と LL-ACSR の弛度比較**

### 4.1.4. 建設コスト

本事業の送電線建設（2 回線鉄塔 2 回線架線）コストを基に LL-ACSR 導入時の建設コストを試算した。表 4-4 に示す通り、LL-ACSR 導入に伴う送電線建設コストは、電線資材代の増により標準電線と比較して 13%程度の増加となる。

**表 4-4 送電線建設コスト試算**

| 電圧 | 建設費用（Lakhs/km）［INR］ | | 低ロス電線適用による価格上昇率 |
|---|---|---|---|
| | 標準電線 | 低ロス電線 | |
| 400 kV | 197.0 | 212.7 | 8.0 % |
| 220 kV | 92.9 | 105.1 | 13.1 % |
| 132 kV | 67.9 | 77.0 | 13.4 % |

(標準電線コストの Source: DPR)

### 4.1.5. LL-ACSR 導入基準

本調査では、対象送電線のピーク時の潮流のみで LL-ACSR の有効性の判定が可能な、簡易で分かりやすい評価手法を提案した。各電圧階級における LL-ACSR 導入の基準を策定し、基準値以上であるか、基準値未満であるかにより、各サブプロジェクトにおける LL-ACSR の採用可否を決定する。

送電ロスの低減は、発電投資の抑制および燃料費の抑制につながる。本調査では、下記に示す通り、初期投資コストの回収を 20 年と設定（MPPTCL の送電線耐用年数は 50 年であり、MPPTCL と協議の結果、これよりも早い期間で投資回収可能であれば LL-ACSR を導入）し、この期間内で初期投資が回収可能かどうかを、2018-19 年断面の潮流を初期潮流としてこの潮流が対象期間の 20 年間一定であると仮定し、LL-ACSR 適用基準を評価した。ただし、これは非常に保守的な仮定であり、本プロジェクトに含まれる送電線は地方部が多く、今後電力使用量の増加が想定されること、送電線は長期間にわたり使用されることから、MPPTCL と協議の結果、導入基準を計算する際に使用する初期潮流を、解析結果から得られた潮流の 1.25 倍とした。

以下に、LL-ACSR 導入基準の決定のために用いた計算条件および仮定を示す。電線の許容電流計算は表 4-5 に示す条件を適用した。下記の計算条件および仮定から、電圧階級毎に計算した LL-ACSR 適用基準を表 4-6 に、その計算根拠を表 4-7 から表 4-9 に示す。

LL-ACSR 適用基準計算条件

a) 電力潮流: Year 2018-19 (Amended: Year 2018-2019×1.25)
b) ピーク発電コスト（PPC）: 5.0 INR/kWh
c) 負荷率（LF）: 0.700 (MPPTCL の想定)
d) 損失係数（LLF）: 0.532 ( = 0.8×LF×LF + 0.2×LF ) (MPPTCL の想定)
e) 力率（PF）: 95%
f) 交流抵抗: $R_{ac} = R_{dc20}\times$ (1×0.004×(Temp.-20)) [ohm/km]
g) 送電線コスト: 本事業における想定加重平均コスト（2 回線送電線）
h) 初期投資回収期間: 20 年
i) ピーク発電コストは対象期間中一定（保守的想定）
j) 電力潮流は対象期間中一定（保守的想定）
k) ディスカウントレートは非考慮（低金利の JICA ODA 円借款）
l) 鉄塔設計は変更なし

**表 4-5 電線許容電流計算条件**

| | |
|---|---|
| **Elevation above sea level** | 0 m |
| **Ambient temperature** | 45 deg C |
| **Solar absorption coefficient** | 0.8 |
| **Solar radiation** | 1045 watt/sq.m |
| **Emissivity constant** | 0.45 |
| **Wind velocity** | 0.6 m/sec |
| **Wind direction (right angle to conductor)** | 90 deg. |
| **Effective angle of incidence of sun's rays** | 90 deg. |

(Source: Manual on Transmission Planning Criteria CEA and JICA Study Team)

**表 4-6 LL-ACSR 適用基準**

| 電圧 | LL-ACSR 導入基準 |
|---|---|
| 400kV | 250 MW |
| 220kV | 76 MW |
| 132kV | 25 MW |

(Source: JICA Study Team)

## 表 4-7　132kV LL-ACSR 適用基準計算根拠

| Voltage | | | 132 [kV] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Transmission Line | | | Cost / Line | | Max. capacity @75°C | | | Conductor DC resistance @ 20°C | | |
| ACSR PANTHER 210mm2 | | | 6,636,598 | [INR/km/tower] | 375[A] | 86 [MVA] | | 0.1363 | [ohm/km] | |
| LL ACSR 240mm2 | | | 7,544,495 | [INR/km/tower] | 404[A] | 92 [MVA] | | 0.1152 | [ohm/km] | |
| Incremental cost | | | 453,949 | [INR/km/circuit] | | | | | | |
| Number of circuits in tower | | | 2 | | | | | | | |
| (A) | Peak power flow per circuit | | | [MW] | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
| (B) | Peak current per circuit | (B)=(A) / Volt / sqrt(3) / PF / 1000 | | [A] | 92.1 | 101.3 | 110.5 | 119.7 | 128.9 | 138.1 | 147.3 |
| (C) | Conductor temperature | ACSR PANTHER 210mm2 | | [°C] | 58.5 | 58.7 | 59.0 | 59.3 | 59.6 | 60.0 | 60.3 |
| (D) | Conductor temperature | LL ACSR 240mm2 | | [°C] | 57.9 | 58.2 | 58.4 | 58.7 | 59.0 | 59.3 | 59.6 |
| (E) | Conductor resistance Rac | ACSR PANTHER 210mm2 | | [ohm/km] | 0.157 | 0.157 | 0.158 | 0.158 | 0.158 | 0.158 | 0.158 |
| (F) | Conductor resistance Rac | LL ACSR 240mm2 | | [ohm/km] | 0.133 | 0.133 | 0.133 | 0.133 | 0.133 | 0.133 | 0.133 |
| (G) | Power loss　3 x (B) x (B) x Rac / 1000 | ACSR PANTHER 210mm2 | | [kW/km] | 4.0 | 4.8 | 5.8 | 6.8 | 7.9 | 9.0 | 10.3 |
| (H) | Power loss　3 x (B) x (B) x Rac / 1000 | LL ACSR 240mm2 | | [kW/km] | 3.4 | 4.1 | 4.9 | 5.7 | 6.6 | 7.6 | 8.7 |
| (I) | Peak loss reduction per circuit | (I)=(G)-(H) | | [kW/km] | 0.6 | 0.8 | 0.9 | 1.1 | 1.2 | 1.4 | 1.6 |
| (J) | Annual loss reduction per circuit | (J)=(I) x 8760hrs x LLF x PPC | | [INR/km/year] | 14587 | 17673 | 21061 | 24755 | 28755 | 33065 | 37688 |
| (K) | Recovery years | (K)=Incremental cost / (J) | | [Year] | 31.1 | 25.7 | 21.6 | 18.3 | 15.8 | 13.7 | 12.0 |
| (L) | Annual energy saved | (J)=(I) x 8760hrs x LLF x 40km | | [kWh/40km/year] | 116695 | 141383 | 168492 | 198037 | 230041 | 264523 | 301507 |

(Source: JICA Study Team)

## 表 4-8　220kV LL-ACSR 適用基準計算根拠

| Voltage | | | 220 [kV] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Transmission tower cost | | | Cost / Line | | Max. capacity @75° C | | | Conductor DC resistance @ 20° C | | |
| ACSR ZEBRA 400mm2 | | | 9,135,159 | [INR/km/tower] | 550[A] | 210 [MVA] | | 0.0674 | [ohm/km] | |
| LL ACSR 480mm2 | | | 10,354,885 | [INR/km/tower] | 583[A] | 222 [MVA] | | 0.0592 | [ohm/km] | |
| Incremental cost | | | 609,863 | [INR/km/circuit] | | | | | | |
| Number of circuits in tower | | | 2 | | | | | | | |
| (A) | Peak power flow per circuit | | | [MW] | 60 | 65 | 70 | 75 | 80 | 85 | 90 |
| (B) | Peak current per circuit | (B)=(A) / Volt / sqrt(3) / PF / 1000 | | [A] | 165.7 | 179.6 | 193.4 | 207.2 | 221.0 | 234.8 | 248.6 |
| (C) | Conductor temperature | ACSR ZEBRA 400mm2 | | [°C] | 61.0 | 61.2 | 61.5 | 61.8 | 62.1 | 62.4 | 62.8 |
| (D) | Conductor temperature | LL ACSR 480mm2 | | [°C] | 60.4 | 60.7 | 60.9 | 61.2 | 61.5 | 61.8 | 62.1 |
| (E) | Conductor resistance Rac | ACSR ZEBRA 400mm2 | | [ohm/km] | 0.078 | 0.079 | 0.079 | 0.079 | 0.079 | 0.079 | 0.079 |
| (F) | Conductor resistance Rac | LL ACSR 480mm2 | | [ohm/km] | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 |
| (G) | Power loss　3 x (B) x (B) x Rac / 1000 | ACSR ZEBRA 400mm2 | | [kW/km] | 6.5 | 7.6 | 8.8 | 10.1 | 11.5 | 13.0 | 14.6 |
| (H) | Power loss　3 x (B) x (B) x Rac / 1000 | LL ACSR 480mm2 | | [kW/km] | 5.7 | 6.7 | 7.7 | 8.9 | 10.1 | 11.4 | 12.8 |
| (I) | Peak loss reduction per circuit | (I)=(G)-(H) | | [kW/km] | 0.8 | 0.9 | 1.1 | 1.3 | 1.4 | 1.6 | 1.8 |
| (J) | Annual loss reduction per circuit | (J)=(I) x 8760hrs x LLF x PPC | | [INR/km/year] | 18585 | 21839 | 25363 | 29157 | 33226 | 37571 | 42196 |
| (K) | Recovery years | (K)=Incremental cost / (J) | | [Year] | 32.8 | 27.9 | 24.0 | 20.9 | 18.4 | 16.2 | 14.5 |
| (L) | Annual energy saved | (J)=(I) x 8760hrs x LLF x 40km | | [kWh/40km/year] | 148682 | 174714 | 202901 | 233260 | 265810 | 300571 | 337564 |

(Source: JICA Study Team)

## 表 4-9　400kV LL-ACSR 適用基準計算根拠

| Voltage | | | 400 [kV] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Transmission tower cost | | | Cost / Line | | Max. capacity @75° C | | | Conductor DC resistance @ 20° C | | |
| ACSR Twin MOOSE 520mm2 | | | 19,700,212 | [INR/km/tower] | 1231[A] | 853 [MVA] | | 0.0274 | [ohm/km] | |
| LL ACSR Twin 590mm2 | | | 21,231,125 | [INR/km/tower] | 1301[A] | 901 [MVA] | | 0.0242 | [ohm/km] | |
| Incremental cost | | | 765,457 | [INR/km/circuit] | | | | | | |
| Number of circuits in tower | | | 2 | | | | | | | |
| (A) | Peak power flow per circuit | | | [MW] | 200 | 220 | 240 | 260 | 280 | 300 | 320 |
| (B) | Peak current per circuit | (B)=(A) / Volt / sqrt(3) / PF / 1000 | | [A] | 303.9 | 334.3 | 364.6 | 395.0 | 425.4 | 455.8 | 486.2 |
| (C) | Conductor temperature | ACSR Twin MOOSE 520mm2 | | [°C] | 61.2 | 61.4 | 61.6 | 61.8 | 62.1 | 62.3 | 62.6 |
| (D) | Conductor temperature | LL ACSR Twin 590mm2 | | [°C] | 60.6 | 60.8 | 61.0 | 61.2 | 61.5 | 61.7 | 62.0 |
| (E) | Conductor resistance Rac | ACSR Twin MOOSE 520mm2 | | [ohm/km] | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 |
| (F) | Conductor resistance Rac | LL ACSR Twin 590mm2 | | [ohm/km] | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 |
| (G) | Power loss　3 x (B) x (B) x Rac / 1000 | ACSR Twin MOOSE 520mm2 | | [kW/km] | 8.8 | 10.7 | 12.7 | 14.9 | 17.3 | 19.9 | 22.7 |
| (H) | Power loss　3 x (B) x (B) x Rac / 1000 | LL ACSR Twin 590mm2 | | [kW/km] | 7.8 | 9.4 | 11.2 | 13.2 | 15.3 | 17.6 | 20.0 |
| (I) | Peak loss reduction per circuit | (I)=(G)-(H) | | [kW/km] | 1.0 | 1.2 | 1.5 | 1.7 | 2.0 | 2.3 | 2.7 |
| (J) | Annual loss reduction per circuit | (J)=(I) x 8760hrs x LLF x PPC | | [INR/km/year] | 24024 | 29095 | 34661 | 40723 | 47286 | 54352 | 61926 |
| (K) | Recovery years | (K)=Incremental cost / (J) | | [Year] | 31.9 | 26.3 | 22.1 | 18.8 | 16.2 | 14.1 | 12.4 |
| (L) | Annual energy saved | (J)=(I) x 8760hrs x LLF x 40km | | [kWh/40km/year] | 192188 | 232762 | 277286 | 325785 | 378285 | 434815 | 495408 |

(Source: JICA Study Team)

### 4.1.6. LL-ACSR 導入送電線

本事業の LL-ACSR 適用送電線を表 4-10 に示す。また、評価結果を表 4-11 に示す。表 4-11 に示す通り、2018-19 年の潮流を用いて LL-ACSR の導入を評価すると、本事業における LL-ACSR 適用箇所は 9 送電線となる。ただし、4.1.5 節で説明したとおり、MPPTCL と協議の上、2018-19 年の潮流を 1.25 倍した潮流を初期潮流とすることで合意した。この結果、低ロス送電線適用送電線は、同表に示す通り 12 送電線となる。

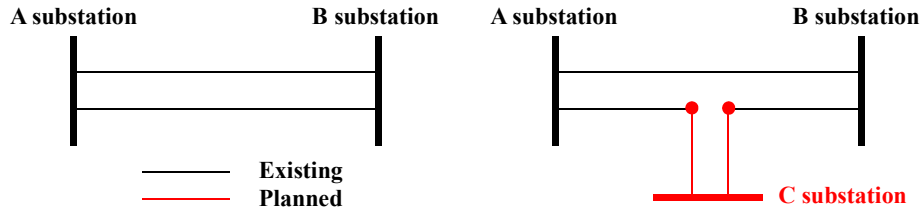
本事業では多くの送電線において、図 4-3 に示すような、既設送電線への送電線への接続 LILO（Line-In-Line-Out）が適用されている。既設送電線には、標準送電線（Moose、Zebra、Panther）が使用されていること、送電線距離が短いことから、MPPTCL との協議の結果、本事業では、LILO は LL-ACSR の適用除外とした[12]。また、132 kV 系統についても適用対象送電線の検討を実施したものの、MPPTCL にとって低ロス電線の適用は初めてであることから、220 kV 系統への低ロス電線の適用をパイロット事業とし、132 kV 系統への LL-ACSR 電線は適用除外とした。

この結果、表 4-10 に示す 220 kV 系統の 3 送電線、亘長 187 km、回線延長 264 km の送電線が本事業における LL-ACSR 適用送電線として選定された。

**表 4-10 LL-ACSR 適用送電線**

| SN | kV | subproject No. | From | To | Length [km] | No. of circuit | Description |
|---|---|---|---|---|---|---|---|
| 3 | 220 | 2 | Indore | Pithanpur | 50 | 2 | DCDS |
| 10 | 220 | 5 | Chhatarpur | Tikamgarh | 110 | 1 | DCSS |
| 13 | 220 | 7 | Rewa UMSP | Rewa (existing) | 27 | 2 | DCDS |
| | | | Transmission Line Length | | | 187 km | |
| | | | Circuit Length | | | 264 km | |

(Source: JICA Study Team)




(Source: JICA Study Team)

**図 4-3 LILO 概念図**

[12] 本事業で提案する LL-ACSR は標準電線と鋼芯径等が異なるため、一部工具のサイズが異なってくるため、保守効率を優先されたとも考えられる。

表 4-11　LL-ACSR 適用評価

| SN | kV | sub-project No. | From | To | Line Length (km) | No. of cct | Criteria (MW) | Initial MW in 2018-2019 | | Initial MW × 1.25 in 2018-2019 | | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | MW | LL-ACSR | MW | LL-ACSR | |
| 1 | 400 | 1 | Cheggaon | Khandwa | 5 | 1 | 250 | 411.7 | Applicable | 514.6 | Applicable | DCDS/LILO |
| 2 | 400 | 1 | | Rajgarh (PGCIL) | 5 | 1 | 250 | 307.8 | Applicable | 384.8 | Applicable | DCDS/LILO |
| 3 | 220 | 2 | Indore | Pithanpur | 50 | 2 | 76 | 70.5 | N/A | 88.1 | Applicable | DCDS |
| 4 | 132 | 2 | (Super corridor) | Indore J | 13 | 1 | 25 | 30.8 | Applicable | 38.5 | Applicable | DCDS/LILO |
| 5 | 132 | 2 | | Depalpur | 13 | 1 | 25 | 16.1 | N/A | 20.1 | N/A | DCDS/LILO |
| 6 | 220 | 4 | Udaipura | Chichli | - | 2 | 76 | 24.5 | N/A | 30.6 | N/A | No line work |
| 7 | 220 | 5 | Chhatarpur | Tikamgarh | 110 | 1 | 76 | 65.8 | N/A | 82.3 | Applicable | DCSS |
| 8 | 220 | 6 | Bina | Bina (existing) | 10 | 1 | 76 | 143.8 | Applicable | 179.8 | Applicable | DCDS/LILO |
| 9 | 220 | 6 | | Ganjbasoda | 10 | 1 | 76 | 109.6 | Applicable | 137.0 | Applicable | DCDS/LILO |
| 10 | 220 | 7 | Rewa UMSP | Rewa (existing) | 30 | 2 | 76 | 138.6 | Applicable | 173.3 | Applicable | DCDS |
| 11 | 220 | 7 | | Sidhi | 60 | 2 | 76 | 73.0 | N/A | 91.3 | Applicable | DCDS |
| 12 | 132 | 9 | Pati | Julwaniya | 40 | 1 | 25 | 14.0 | N/A | 17.5 | N/A | DCSS |
| 13 | 132 | 10 | Inodre SZ | Magliya | 3 | 2 | 25 | 7.0 | N/A | 8.8 | N/A | DCDS/LILO |
| 14 | 132 | 11 | Shahpura | Julwaniya | 65 | 1 | 25 | 11.9 | N/A | 14.9 | N/A | DCSS |
| 15 | 132 | 12 | Bhirarwar | Datiya | 40 | 1 | 25 | 9.6 | N/A | 12.0 | N/A | DCSS |
| 16 | 132 | 13 | Mahwadiya | Mugaliyachhap | 10 | 1 | 25 | 13.0 | N/A | 16.3 | N/A | DCSS |
| 17 | 132 | 15 | Madwas | Sidhi | 50 | 1 | 25 | 13.5 | N/A | 16.9 | N/A | DCSS |
| 18 | 132 | 16 | Dheemarkheda | Panagar | 65 | 1 | 25 | 12.7 | N/A | 15.9 | N/A | DCSS |
| 19 | 132 | 17 | Orchha | Prithvipur | 30 | 1 | 25 | 15.3 | N/A | 19.1 | N/A | DCSS |
| 20 | 132 | 18 | Atraila | Sirmour | 30 | 1 | 25 | 12.4 | N/A | 15.5 | N/A | DCSS |
| 21 | 132 | 19 | Tendukheda | Udaipura | 45 | 1 | 25 | 18.9 | N/A | 23.6 | N/A | DCSS |
| 22 | 132 | 20 | Gormi | Gohad | 25 | 1 | 25 | 18.8 | N/A | 23.5 | N/A | DCSS |
| 23 | 132 | 21 | Suthaliya | Narsinghgarh | 50 | 1 | 25 | 18.9 | N/A | 23.6 | N/A | DCSS |
| 24 | 132 | 22 | Unchhera | Satna | 5 | 1 | 25 | 30.8 | Applicable | 38.5 | Applicable | DCSS/LILO |
| 25 | 132 | 22 | | Kymore | 5 | 1 | 25 | 11.8 | N/A | 14.8 | N/A | DCSS/LILO |
| 26 | 132 | 23 | Sinhawal | Sidhi | 50 | 1 | 25 | 19.5 | N/A | 24.4 | N/A | DCDS/LILO |
| 27 | 132 | 23 | | Deosar | 50 | 1 | 25 | 0.6 | N/A | 0.8 | N/A | DCDS/LILO |
| 28 | 132 | 24 | Chachoda | Rajgarh | 61 | 1 | 25 | 25.4 | Applicable | 31.8 | Applicable | DCSS |
| 29 | 132 | 25 | Maneri | Mandla | 80 | 1 | 25 | 33.7 | Applicable | 42.1 | Applicable | DCSS |

(Source: JICA Study Team)

### 4.1.7.　LL-ACSR の送電線定数

本事業に提案する LL-ACSR 送電線の送電線定数および送電線容量を下表に示す。なお、送電線容量は表 4-5 に示す条件で計算した。表 4-12 に示す通り、本事業では MPPTCL の既存の鉄塔設計を適用するため導体配置が変化しないことから、低ロス電線の適用による抵抗値の低減以外は送電線定数に大きな変化はない。低ロス電線の採用により電流の流れるアルミ面積が大きくなるため、表 4-13 の通り送電容量が 5%程度増加する。

表 4-12 送電線定数

| Type | | R [ohm/km] | X [ohm/km] | Y [uF/km] |
|---|---|---|---|---|
| LL-ACSR | 400 kV LL-ACSR 580 Twin | 0.02952 | 0.31057 | 0.01186 |
| | 220 kV LL-ACSR 490 Single | 0.07222 | 0.39964 | 0.00911 |
| | 132 kV LL-ACSR 240 Single | 0.14054 | 0.39593 | 0.00920 |
| ACSR | 400 kV ACSR Moose Twin | 0.03337 | 0.30856 | 0.01194 |
| | 220 kV ACSR Zebra Single | 0.08223 | 0.39575 | 0.00920 |
| | 132 kV ACSR Panther Single | 0.16629 | 0.39223 | 0.00929 |

| Type | | R [pu] | X [pu] | Y [pu] |
|---|---|---|---|---|
| LL-ACSR | 400 kV LL-ACSR 580 Twin | 0.0000185 | 0.0001941 | 0.0059624 |
| | 220 kV LL-ACSR 490 Single | 0.0001492 | 0.0008257 | 0.0013852 |
| | 132 kV LL-ACSR 240 Single | 0.0008066 | 0.0022723 | 0.0005035 |
| ACSR | 400 kV ACSR Moose Twin | 0.0000209 | 0.0001928 | 0.0060034 |
| | 220 kV ACSR Zebra Single | 0.0001699 | 0.0008177 | 0.0013994 |
| | 132 kV ACSR Panther Single | 0.0009544 | 0.0022511 | 0.0005085 |

注、100 MVA Base, Resistance at 75 ˚C

(Source: JICA Study Team)

表 4-13 送電線熱容量

| Types - LL-ACSR | Ambient Temp. | Current [A] at Conductor Temp. | | | Active Power [MW] at Power Factor 95% | | |
|---|---|---|---|---|---|---|---|
| | ˚C | 65˚C | 75˚C | 85˚C | 65˚C | 75˚C | 85˚C |
| 400 kV LL-ACSR 580 Twin | 30 | 1492 | 1809 | 2066 | 324 | 393 | 449 |
| | 40 | 1066 | 1492 | 1806 | 232 | 324 | 392 |
| | 45 | 762 | 1301 | 1658 | 166 | 283 | 360 |
| | 48 | 494 | 1171 | 1562 | 107 | 254 | 339 |
| 220 kV LL-ACSR 490 Single | 30 | 666 | 803 | 915 | 145 | 174 | 199 |
| | 40 | 483 | 665 | 802 | 105 | 145 | 174 |
| | 45 | 355 | 583 | 737 | 77 | 127 | 160 |
| | 48 | 247 | 527 | 695 | 54 | 114 | 151 |
| 132 kV LL-ACSR 240 Single | 30 | 458 | 545 | 616 | 100 | 118 | 134 |
| | 40 | 344 | 456 | 542 | 75 | 99 | 118 |
| | 45 | 267 | 404 | 501 | 58 | 88 | 109 |
| | 48 | 208 | 369 | 474 | 45 | 80 | 103 |

| Types - ACSR | Ambient Temp. | Current [A] at Conductor Temp. | | | Active Power [MW] at Power Factor 95% | | |
|---|---|---|---|---|---|---|---|
| | ˚C | 65˚C | 75˚C | 85˚C | 65˚C | 75˚C | 85˚C |
| **400 kV ACSR Moose Twin** | **30** | 1415 | 1722 | 1971 | 307 | 374 | 428 |
| | **40** | 1001 | 1416 | 1721 | 217 | 308 | 374 |
| | **45** | 701 | 1231 | 1578 | 152 | 267 | 343 |
| | **48** | 426 | 1104 | 1485 | 93 | 240 | 323 |
| **220 kV ACSR Zebra Single** | **30** | 630 | 762 | 870 | 137 | 165 | 189 |
| | **40** | 453 | 629 | 761 | 98 | 137 | 165 |
| | **45** | 327 | 550 | 699 | 71 | 119 | 152 |
| | **48** | 219 | 496 | 658 | 48 | 108 | 143 |
| **132 kV ACSR Panther Single** | **30** | 425 | 507 | 574 | 92 | 110 | 125 |
| | **40** | 317 | 424 | 505 | 69 | 92 | 110 |
| | **45** | 245 | 375 | 466 | 53 | 81 | 101 |
| | **48** | 187 | 342 | 441 | 41 | 74 | 96 |

(Source: JICA Study Team)

4.1.8. LL-ACSR の入札条件

LL-ACSR 導入にあたり、当該電線の品質及び機能を確保するため、次の入札条件を MPPTCL に提案した。

a) 鋼芯に 1,960MPa 以上の亜鉛メッキ鋼線（UGS）または 1,770MPa 以上のアルミ覆鋼線（14AC）を使用かつアルミ素線に成型（台形）素線を使用
b) 外径及び電気抵抗値は同等の従来型 ACSR 電線未満
c) 上記 LL-ACSR の製造・納入実績を 20 年以上有する製造業者
d) 上記 LL-ACSR のエンドユーザーによる運転実績が 3 年以上
e) 上記 LL-ACSR の納入実績が合計 2,000km 以上

まず、LL-ACSR の機能を担保するための条件を設定した。上記 a)は引張強度を確保し、電線外径を従来型 ACSR と同等に抑え、電線断面積に占めるアルミ専有面積を高めて十分なロス低減効果を得るために必要な条件である。b)は a)により実現されるが、具体的な目標値の設定が好ましい。

次に LL-ACSR の品質を担保するため、電線製造業者に係る c)～e)の条件を設定した。提案した LL-ACSR は鋼芯に高張力炭素鋼素線を使用しており、加工には高い技術が必要である。そこで、安定した品質で LL-ACSR を製造できる技術力と経験を有する業者が選定されるよう、送電線のライフサイクルを考慮してなるべく長い実績を求めることとし、20 年

以上の LL-ACSR の製造及び納入実績と、納入した LL-ACSR の運転実績が 3 年以上あることを条件とした。これらの実績条件は、導入後の長期間に亘る健全な設備運用に繋がるものと考える。仮に製造実績を短く、例えば 5 年と設定した場合、製造に重大な欠点があったとしてもその問題が顕在化している可能性は低く、品質を担保する条件としては不十分と考えられる。

また、経験豊富な製造業者を選択するため、本事業では当該 LL-ACSR の納入実績を合計 2,000km 以上持つ製造業者を条件とした。

#### 4.1.9. LL-ACSR 導入に伴う保守工具の留意点

MPPTCL が所有している緊線工具は標準電線サイズに対応したもので、LL-ACSR に対して同様の能力を発揮することが確認できていない。LL-ACSR 導入に当たっては、引張試験等による緊線工具の機能確認を行うことを推奨する。また、電線圧縮接続に使用する圧縮ダイスについても標準電線に対応したものであるため、LL-ACSR 用に新調する必要がある。

## 4.2. GIS

### 4.2.1. GIS の特徴

GIS は、変電所の主回路開閉設備の一種であり、主回路導体、遮断器、断路器、接地開閉器、CT、VT が全て SF6 ガスを充てんさせた金属タンク内部に密閉された設備である。GIS は気中開閉設備（AIS）と比較して、以下の利点を有している。

- 機器が小型である: 変電所レイアウトのサイズを大幅に削減できる。
- 汚損などの環境影響を受けにくい: すべての導体が密閉されていることから、気中汚損、砂嵐、湿潤の影響が少ない。また、操作時の騒音などの環境影響も小さい。
- 作業安全性が高い:充電部が露出していないことから、巡視、点検時の安全が図られる。
- 耐震性、耐風圧性が高い。

### 4.2.2. GIS に適用される一般規格

GIS の設計には、一般に以下の国際規格が採用される。本事業の GIS 変電所概念設計にも同様の規格が考慮された。以下に加えて、当該国の基準・規格にも準拠すべきである。

- IEC 62271-203: Gas-insulated Metal-enclosed Switchgear for Rated Voltages of 52 kV & above.
- IEC 60694: Common Specifications for High-Voltage Switchgear and Control gear Standards.
- IEC 62271-100: High Voltage Alternative Current Circuit Breakers.
- IEC 62271-102: Alternating Current Disconnectors & Earthing Switches.
- IEC 60044-1: Instrument Transformer, Part-1 : Current Transformer

- IEC 60044-2 : Instrument Transformer, Part-2 : Voltage Transformer
- IEC 62271-209: Cable Connection for Gas-insulated Metal-enclosed Switchgear for Rated Voltages of 72.5kV & above.
- GIS タンクは、当該国の基準に準拠

4.2.3. 調査団の提案する GIS 仕様、調達条件

本事業の GIS 調達にあたり、高品質の機器を、実績のあるメーカーから調達するという観点から、以下の仕様、調達条件の適用を提案した。

a) GIS 本体からの SF6 ガス漏れ率を 0.1%/年とする（工場試験にて 1 回線について試験を実施する）
b) ガス遮断器の操作機構部構造は、内部点検時に機構部を解体することなく実施できる構造とする（操作機構部の保守にあたっては、内部部品の取り換えはほとんどないことが望ましい）
c) ガス遮断器の両端に事故検出用の CT を配置する（遮断器と送電線側 CT の間の事故同定を確実にするため）
d) 現地操作盤を GIS 本体から離して設置する
e) GIS メーカー（またはその親会社）は、同程度の電圧階級の GIS を 18 年以上納入している経験を有すること
f) GIS メーカー（またはその親会社）は、同程度の電圧階級の GIS の過去の納入先系統運用者から 18 年以上の運用証明書を提出させること

各条件の詳細については次節で説明する。MPPTCL との協議の結果、a)～d)については特に異論は出なかったが、e)～f)については、応札者を限定してしまうことに対し異論が出さ、結論に至らなかった。今後の継続協議が必要である。

4.2.4. 調査団の提案する GIS 仕様についての解説

a) GIS 本体からの SF6 ガス漏れ率を 0.1%/年とする（工場試験にて 1 回線について試験を実施する）。

IEC 規格では GIS の SF6 ガス漏れ率は 0.5%/年とされているが、より厳しい 0.1%/年の設計を課し、工場試験時に少なくとも 1 回線について上記性能を証明させる。GIS で使用される SF6 ガスが温室効果ガスであるため、ガス漏れ率をできるだけ低く設計することにより、地球温暖化への影響を限定することができる。また、GIS のライフサイクルに渡る総使用ガス量を減らすことが可能である。参考に、日本の GIS におけ

るガス漏れ量の実績例を示す。なお、海外の主要な GIS メーカーであれば、上記仕様への対応は十分可能である。

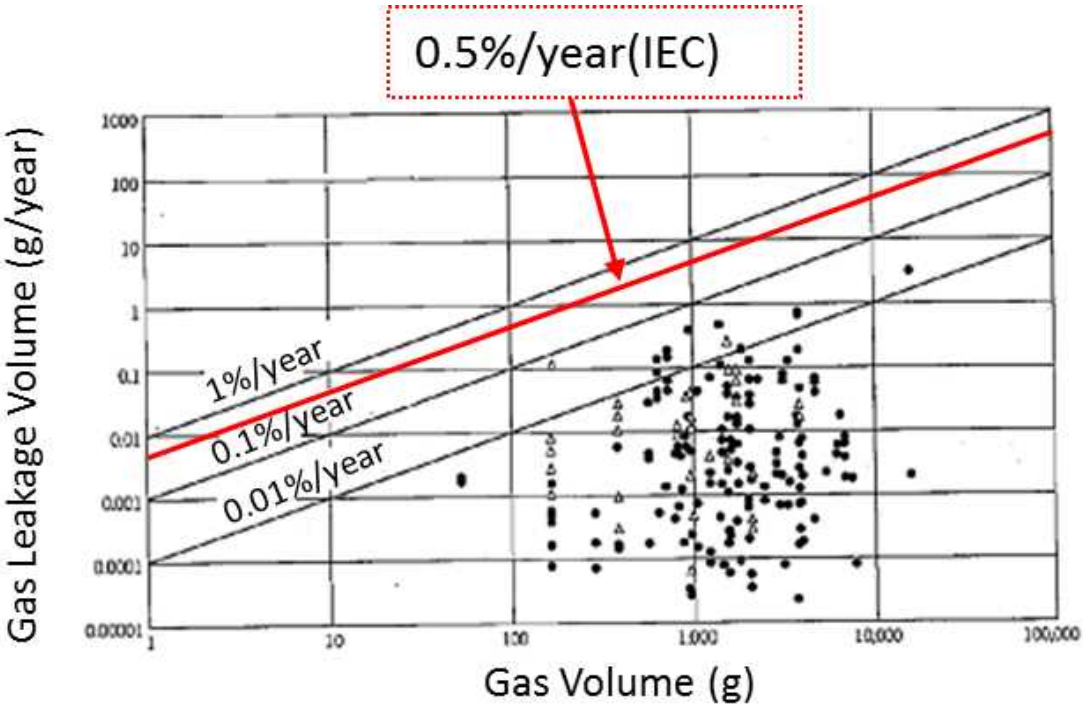



**図 4-4　日本における SF6 ガス漏れ量の実績例**

b) ガス遮断器の操作機構部構造は、内部点検時に機構部を解体することなく実施できる構造とする（操作機構部の保守にあたっては、内部部品の取り換えはほとんどないことが望ましい）。

遮断器の操作機構部は、多数の可動部品から構成されている。もし、操作機構部が点検等のために現場で解体されるならば（クリーンルームのような、工場に準じた適切な環境で行われることは難しいため）、操作機構部の設定に影響を及ぼし、その信頼性に影響を与える。したがって、下図に示すように、操作機構部を遮断器の下部に配置し、内部点検時に機構部を解体することなく実施できる構造とすることで、機構部内へのごみやほこりの侵入を防止でき、事故・障害のリスクを低減できる。本仕様は特に、132kVGIS において、仕様に明記することが推奨される。一般に 220kV GIS の遮断部は横置き型であるので、操作機構部は容易に取り外しできる構造となっている。

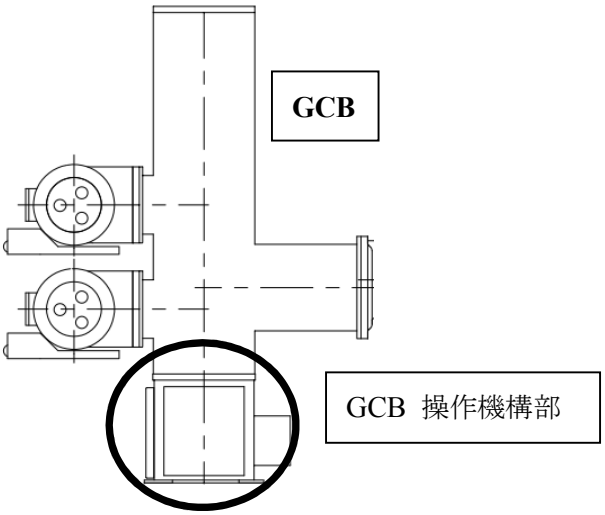



**図 4-5　GIS の遮断器本体と操作機構部の配置例**

c) ガス遮断器の両端に事故検出用の CT を配置する（遮断器と送電線側 CT の間の事故同定を確実にするため）。

遮断器両端に CT を配置することで、遮断器線路側の至近端で内部事故が起きた際に（下図）、母線側の CT1 で事故を検知することで、線路側保護が確実に動作させ、線路事故点を適切に除去できる。

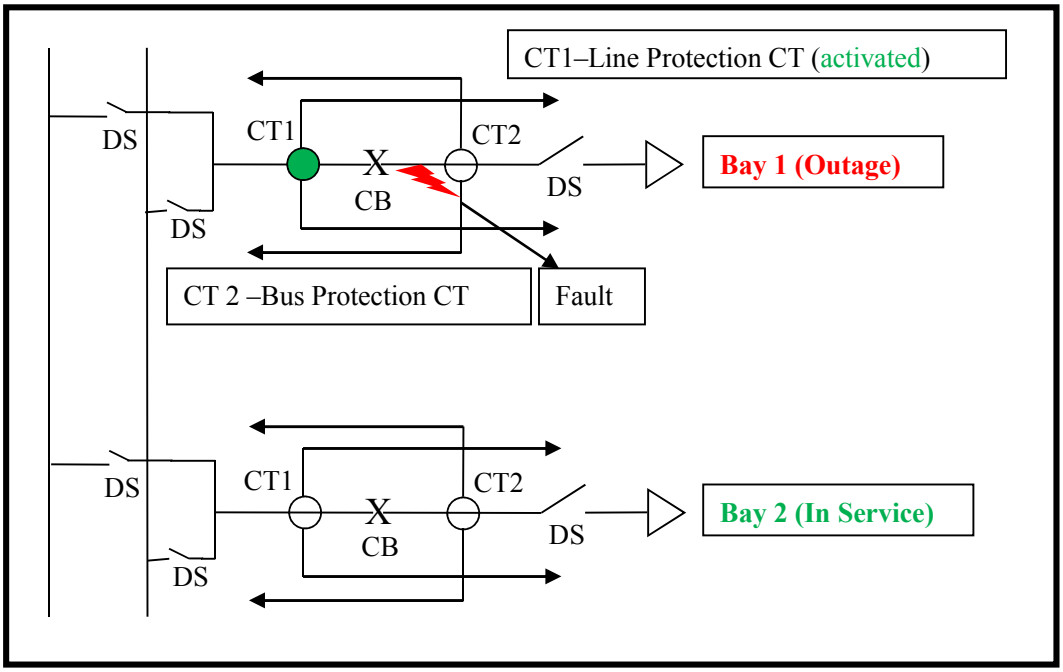



**図 4-6　CT を遮断器両端に配置した場合の事故検出例**

下図のようにCTが遮断器の片側に配置される設計もあり得るが、この場合、遮断器とCT間の事故が母線事故と判断され、変電所全停に発展する（下図参照）。

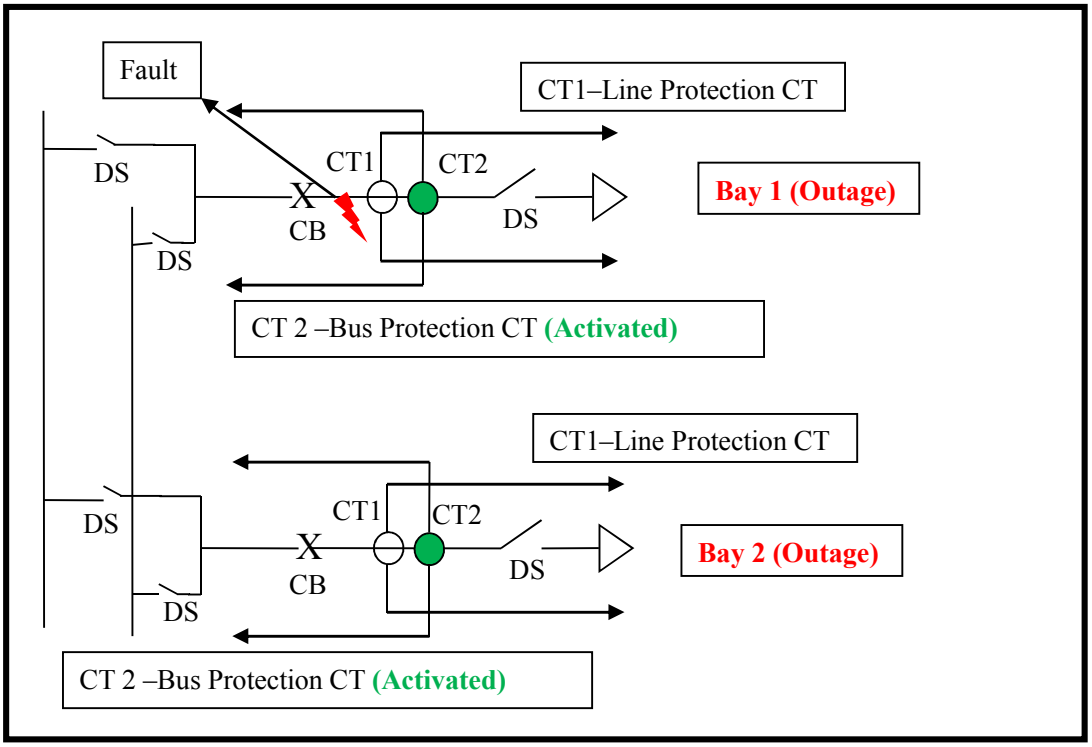



**図 4-7　CTを遮断器片側に配置した場合の事故検出例**

以上より、遮断器両端にCTを配置することにより、遮断器と線路側CT間の盲点事故をなくし、母線保護リレー動作による変電所全停に発展することを防ぐことができる。

d) 現地操作盤をGIS本体から離して設置する。

遮断器操作時の振動が現地操作盤に振動を与え、不要動作に至る事故を減ずるため、GIS本体とGISの現地制御盤は離して設置されるべきである。

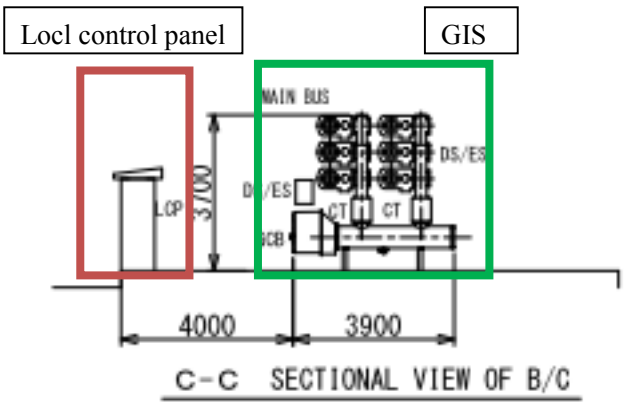



**図 4-8 GIS 操作箱の配置例**

e) GIS メーカー（またはその親会社）は、同程度の電圧階級の GIS を 18 年以上納入している経験を有すること。

GIS メーカーが、過去に世界でより多くの GIS を納入した実績を有していれば、そのメーカーは製品品質に関して一定の信頼度があると考えられる。また、その子会社についても、通常、親会社の設計、品質・製造管理の技術が移転されていると考えられることから重要である。このため、メーカーは最低でも 18 年以上の機器納入経験を有するという条件を提案した。ここで、18 年という年数は、一般的なメーカーの推奨する遮断器の分解内部点検周期を前提にしている。遮断器の内部点検を問題なく経過しているメーカーであれば、十分な経験を有していると考えられる。なお、遮断器の内部点検基準はメーカーごとに異なり、以下のような基準もある。

- 定格短絡電流遮断回数がメーカー推奨回数に達した場合
- 定格不可電流遮断がメーカー推奨回数に達した場合
- 小電流遮断回数がメーカー推奨回数に達した場合

f) GIS メーカー（またはその親会社）は、同程度の電圧階級の GIS の過去の納入先系統運用者から 18 年以上の運用証明書を提出させること

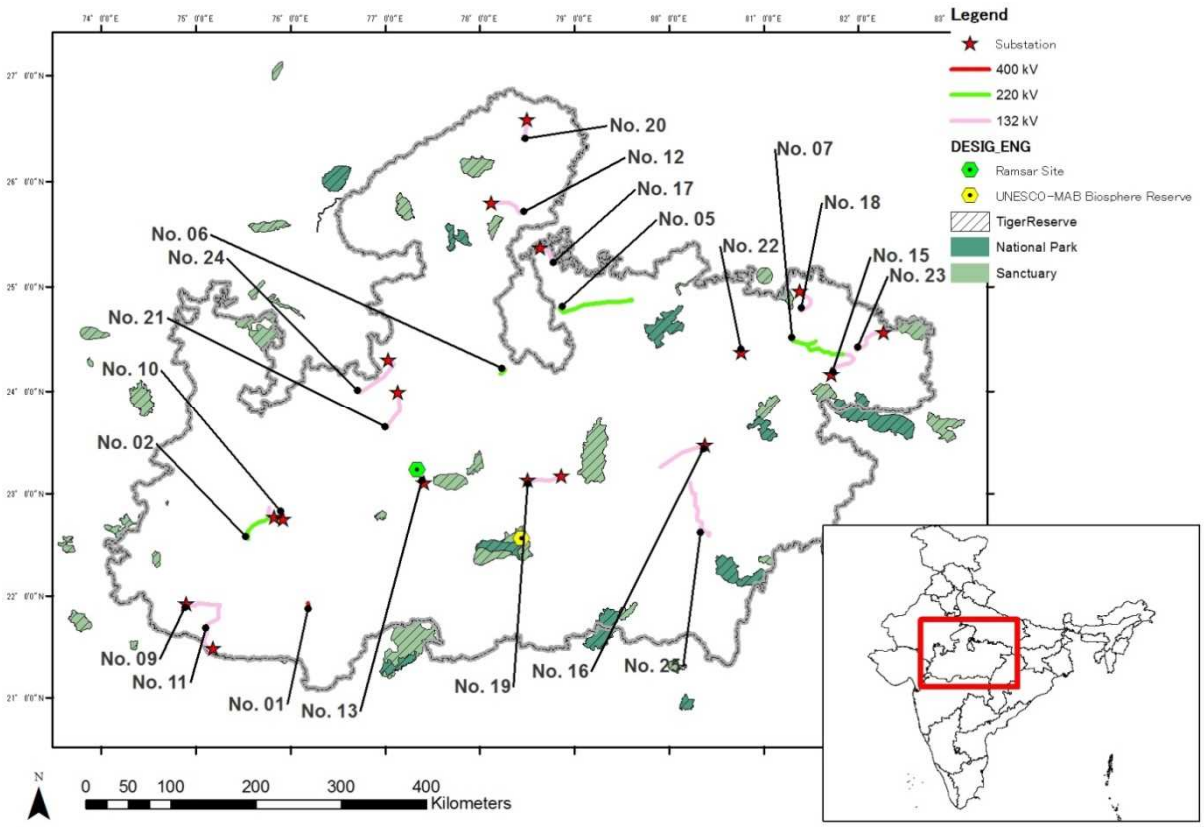
# 第5章 環境社会配慮

## 5.1. 環境社会関連書類

インドの環境影響評価にかかる公告(The Environmental Impact Assessment Notification, 2006 and further amendments in Jan 2009, Dec 2009, Apr 2011, and Jan 2012)によると、送電線事業は、環境影響評価をする必要がない。一方、JICA の環境社会配慮ガイドラインの要求事項を満たすため、MPPTCL は初期環境影響評価書案(添付資料 1)とスクリーニングフォーム(添付資料 2)を作成した。初期環境影響評価書は 2015 年 9 月時点では素案の段階であり、今後最終化される予定である。また調査団は調査結果を基に、Checklist を作成し、添付資料 3 に示した。

## 5.2. 保護区への影響

MPPTCL は保護区への影響を回避するため、当初提案されていたいくつかのサブプロジェクトを除外した。結果的に、全てのサブプロジェクトは国立公園、サンクチュアリなどの保護区外に位置している(図 5-1 参照)。インド国内の州によっては、これら国立公園、サンクチュアリの周辺 10km の範囲をバッファーゾーンもしくはエコセンシティブエリアとして指定しているところもあるが、マディヤ・プラデシュ州はこれらの指定をしていない。そのため、これらすべての保護区への直接的影響は発生しない。




(Source: JICA Study Team)

**図 5-1　保護エリアと事業計画地**

## 5.3.　保護生物への影響

国際自然保護連合（International Union for Conservation of Nature:IUCN）の希少哺乳類情報によると、インドには 1,333 種のレッドリスト種(準絶滅危惧以上)が存在し、分布図の公表されている種の中でマディヤ・プラデシュ州に分布するものは 46 種類ある(表 5-1 参照)。これらの分布域と事業の位置の関係を調査した結果、いずれのサブプロジェクトも 16 種から 27 種の保護生物の分布域と重複する。このうち、マディヤ・プラデシュ州内での生息が限られている 3 種(Lindsaea malabarica, Panthera tigris, Panthera pardus)についてみると、サブプロジェクト No. 5, No.12, No.13, No.15, No.18, No.19, No.22, No.25 で、生息地域内もしくは Tiger の移動路として利用される可能性がある場所に位置しており、これら保護生物への直接・間接的影響が懸念される。重要な移動路が分断される場合、地域個体群の遺伝子多様性の低下からこれらの地域絶滅確率が上昇する。餌場の減少が起きる場合も個体数維持が困難になり、地域個体数の減少につながる。また事業による居住エリアの拡大が希少な生物の生息地近くまで広がる場合は、希少生物が人に危害を加える確率も高まる。さらに ROW によって人が希少な生物の生息地にアクセスしやすくなる場合、密猟などによる個体数の減少も懸念される。

これらの影響を最小限にとどめるため、トラの移動路として利用される可能性のある場所の事業計画にあたっては、森林局（Forest Department）だけでなく野生生物局（Wildlife Department）と事前に十分に協議をしたうえでルート選定を行うことが望ましい。また鉄塔の高さ、ROW 内の植生の高さ、ROW 内の植生の管理方法、人のアクセスの制限方法、密猟の取り締まり等を慎重に検討する必要がある。また、その他の生物がどの程度事業計画エリア内に生育・生息する可能性があるかが不明であるため、トラ以外の生物も対象とした十分な生物調査を行ったうえで影響が最小となるようなルート選定を行うことが望ましい。

**表 5-1　マディヤ・プラデシュ州で分布の知られている IUCN レッドリスト種**

| | Scientific Name | Common Name | IUCN Red List category |
|---|---|---|---|
| Plants | Ammannia nagpurensis | | EN |
| | Lindsaea malabarica | | NT |
| | Utricularia praeterita | | NT |
| Mammals | Cuon alpinus | Indian Wild Dog | EN |
| | Hipposideros durgadasi | Durga Das's Leaf-nosed Bat | EN |
| | Manis crassicaudata | Indian Pangolin | EN |
| | Panthera tigris | Tiger | EN |
| | Bos gaurus | Indian Bison | VU |
| | Lutrogale perspicillata | Indian Smooth-coated Otter | VU |
| | Melursus ursinus | Sloth Bear | VU |
| | Prionailurus rubiginosus | Rusty-spotted Cat | VU |
| | Rucervus duvaucelii | Barasingha, Swamp Deer | VU |
| | Rusa unicolor | Sambar Deer | VU |
| | Tetracerus quadricornis | Four-horned Antelope | VU |
| | Antilope cervicapra | Blackbuck | NT |
| | Hyaena hyaena | Striped Hyaena | NT |
| | Panthera pardus | Leopard | NT |
| Reptiles | Gavialis gangeticus | Indian Gharial | CR |
| | Crocodylus palustris | Mugger | VU |
| Turtles | Batagur dhongoka | Three-striped Roofed Turtle | EN |
| | Chitra indica | Indian Narrow-headed Softshell Turtle | EN |
| | Batagur kachuga | Bengal Roof Turtle | CR |
| | Nilssonia gangetica | Indian Softshell Turtle | VU |

| | Scientific Name | Common Name | IUCN Red List category |
|---|---|---|---|
| | Hardella thurjii | Crowned River Turtle | VU |
| | Geoclemys hamiltonii | Black Pond Turtle | VU |
| | Nilssonia hurum | Indian Peacock Softshell Turtle | VU |
| | Nilssonia leithii | Leith's Softshell Turtle | VU |
| Anura | Philautus sanctisilvaticus | Sacred Grove Bushfrog | CR |
| Fish | Tor khudree | Black Mahseer | EN |
| | Thynnichthys sandkhol | Sandkhol Carp | EN |
| | Silonia childreni | | EN |
| | Clarias magur | Wagur | EN |
| | Amblyceps arunchalensis | | EN |
| | Ailia coila | Gangetic ailia | NT |
| | Anguilla bengalensis | Indian Mottled Eel | NT |
| | Anguilla bicolor | Shortfin Eel | NT |
| | Bagarius bagarius | | NT |
| | Bagarius yarrelli | | NT |
| | Chitala chitala | | NT |
| | Labeo pangusia | Pangusia labeo | NT |
| | Microphis deocata | | NT |
| | Ompok bimaculatus | | NT |
| | Ompok pabo | | NT |
| | Parambassis lala | Highfin Glassy Perchlet | NT |
| | Wallago attu | | NT |
| Odonata | Indothemis carnatica | | NT |

*: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT)

(Source: IUCN)

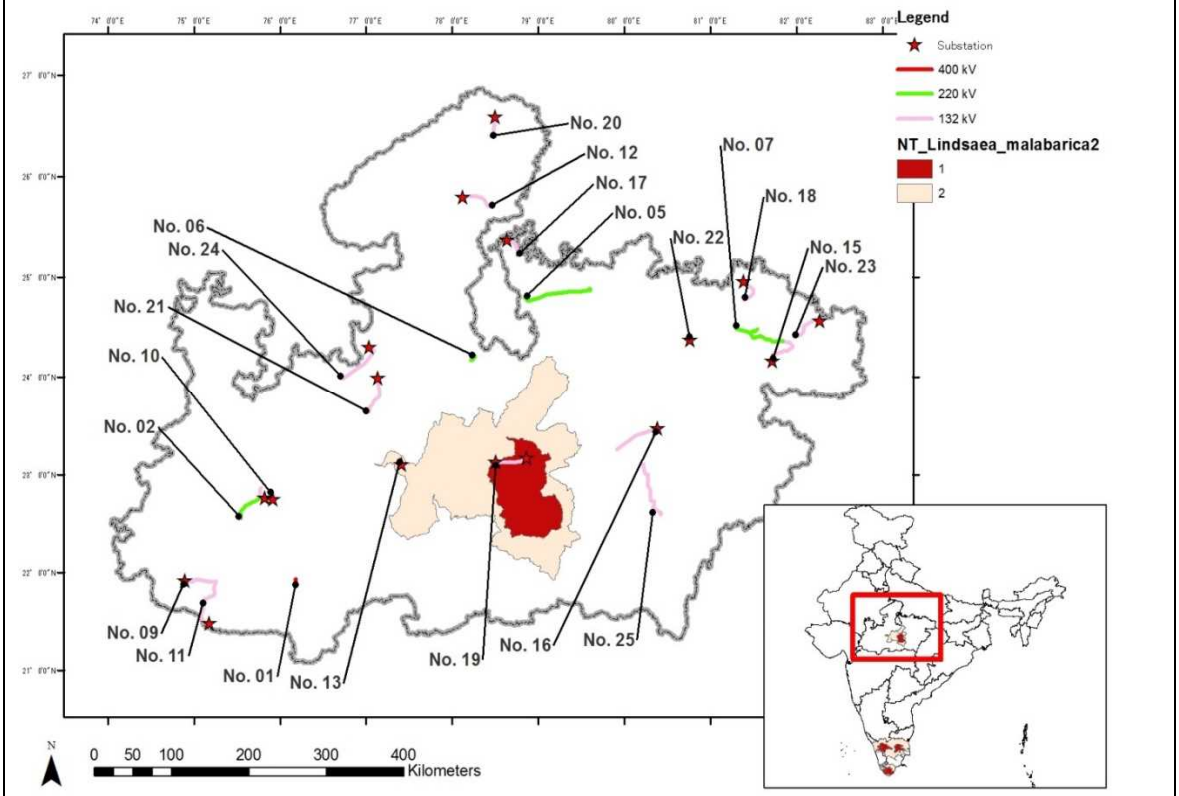
表 5-2　事業による影響を受ける可能性のある分布の限られた IUCN レッドリスト種

| Project No | Project Name | Lindsaea malabarica | Panthera tigris (Tiger) | Panthera pardus (Leopard) |
|---|---|---|---|---|
| 1 | LILO of one circuit of 400kV Khandwa - Rajgarh PGCIL line at Chhegaon 400kV Substation (D/C) | - | - | - |
| | 400kV Bus Reactor at Chhegaon 400kV S/S | - | - | - |
| 2 | Pithampur400-Super Corridor 220kV DCDS line | - | - | - |
| | LILO of One ckt of Indore(Jetpura) - Depalpur 132kV DCDS Line at Super Corridor (Indore) 220kV S/s.(D/C) | - | - | - |
| 4 | Charging/Upgradation of Chichli220 - Udaipura DCDS line on 220kV level | - | - | - |
| 5 | Chhatarpur-Tikamgarh 220kV DCSS line | - | - | Extant |
| 6 | 400/220kV Additional Transformer at Bina 400kV S/S | - | - | - |
| | LILO of Bina220 - Ganjbasoda 220kV line at Bina(MPPTCL) 400kV S/s | - | - | - |
| 7 | Rewa220 - Sidhi 220kV DCDS line through Rewa UMSP | - | - | - |
| 9 | Julwania400 - Pati(Silawad) 132kV DCSS Line | - | - | - |
| 10 | LILO of Mangliya - IndoreSZ 132kV line at Mahalaxmi | - | - | - |
| 11 | Julwania400 - Shahpura 132kV DCSS Line | - | - | - |
| 12 | Datia220 - Bhitarwar 132kV DCSS Line | - | - | Extant |
| 13 | MugaliaChhap220 - Mahwadia 132kV DCDS Line | Probably Extant | - | - |
| 15 | Sidhi220 - Madwas 132kV DCSS Line | - | Near* | Extant |
| 16 | Panagar220 - Dheemarkheda 132kV DCSS Line | - | Near* | - |
| 17 | Prithivipur-Orchha 132kV DCSS Line | - | - | - |
| 18 | Sirmour220 - Atraila 132kV DCSS line | - | Near* | - |
| 19 | Udaipura - Tendukheda 132kV DCSS line | Extant | - | - |
| 20 | Gohad - Gormi 132kV DCSS line | - | - | - |

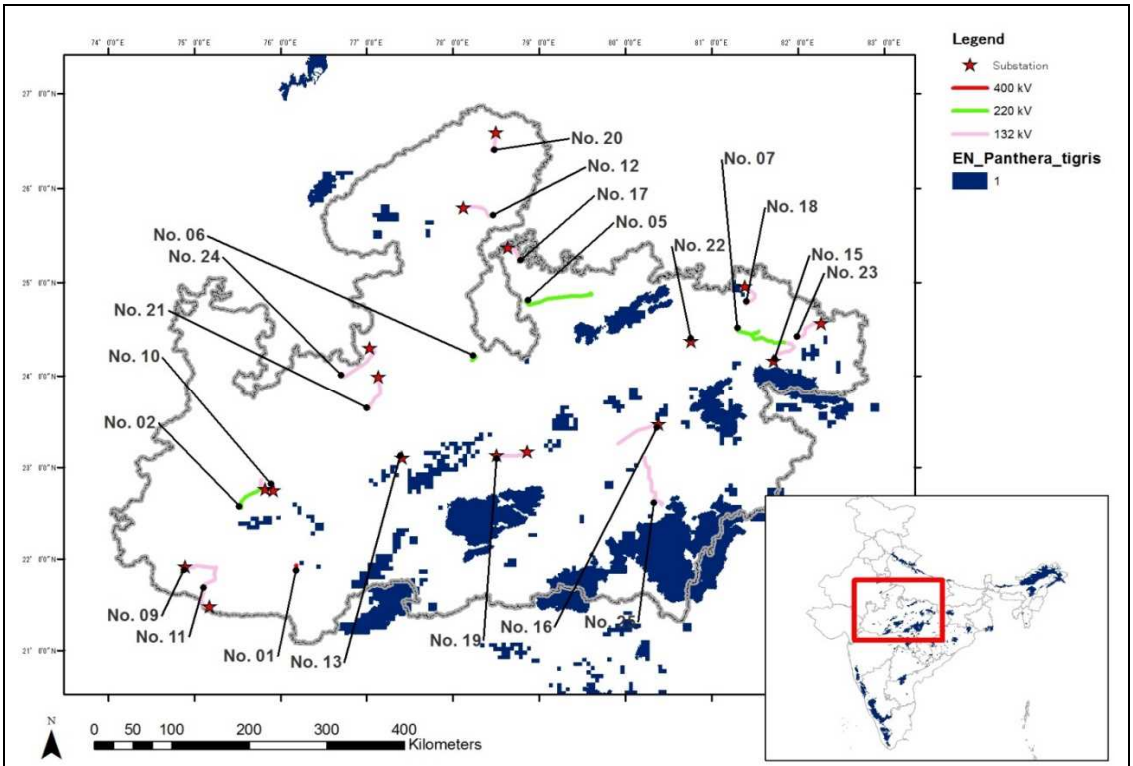
| | | | | |
|---|---|---|---|---|
| 21 | Narsinghgarh - Suthaliya 132kV DCSS line | - | - | - |
| 22 | LILO of Satna220 - Kymore 132kV line at Unchhera 132kV S/s | - | - | Extant |
| 23 | LILO of one ckt of Sidhi220 - Deosar 132kV line at Sinhawal 132kV S/s | - | - | - |
| 24 | 2nd ckt of Rajgarh(B) - Raghogarh 132kV DCSS line up to Chachoda 132kV S/s | - | - | - |
| 25 | Maneri - Mandla 132kV DCSS line | - | Near* | Extant |

*: Estimated by JICA Study Team

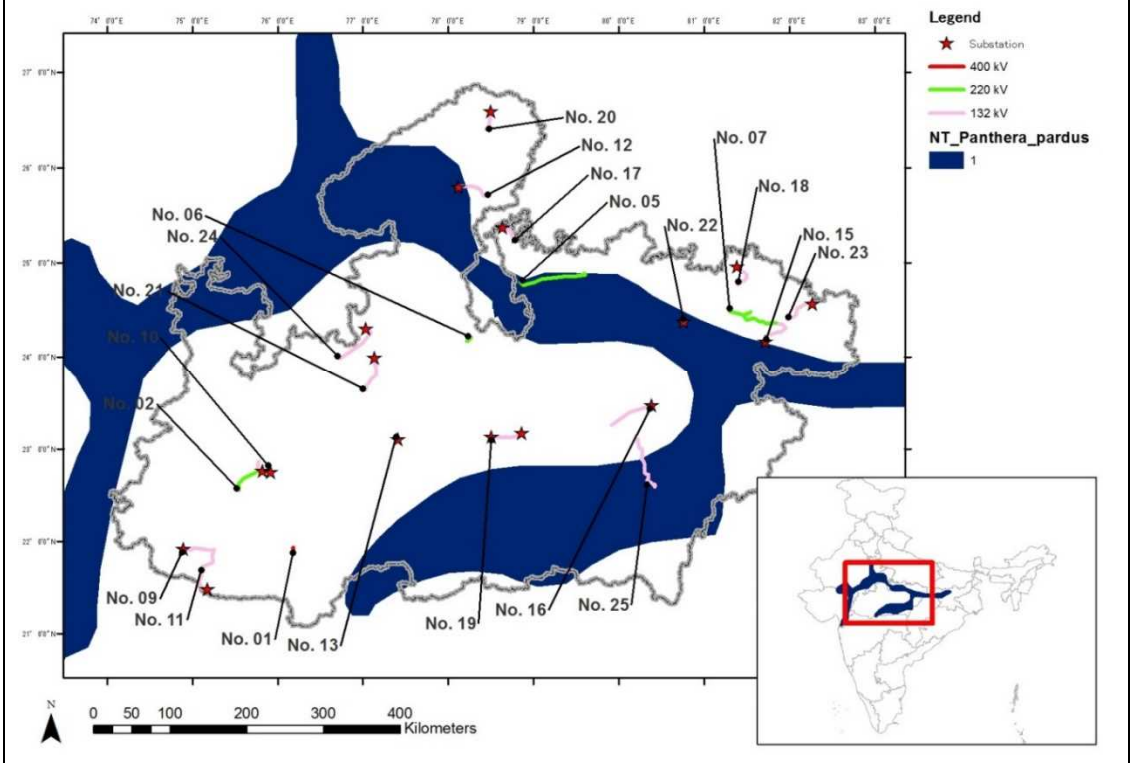
(Source: JICA Study Team)




（a）Lindsaea Malabarica の州内分布図




（b）Panthera Tigris の州内分布図




1: Extant　　2: Probably Extant（c）Panthera Pardus の州内分布図

(Source: IUCN)

**図 5-2　分布合比較的限られており影響を受ける可能性のある種の州内分布図**

## 5.4. 森林への影響

当初の計画では、複数の変電所と送電線ルートが森林区域内に分布していたが、これらへの影響を回避するため MPPTCL はいくつかのサブプロジェクトを取りやめたほか、立地やルートを変更することによって森林エリアへの影響が最小限となるよう計画を変更した。2015 年 9 月時点でのルート図によると表 5-3 に示す通り、送電線の 9 サブプロジェクト、約 24.2km、67.7ha が森林エリアにかかることになる。送電線下の樹木はすべて伐採する必要があるため、森林局から森林承認(Forest Clearance)を取得する必要がある。Online Submission & Monitoring of Environmental, Forests and Wild Life Clearance User Manual (2015)によると、森林承認機関は、影響面積によって異なり、40ha 以上の場合は国の承認が必要であるが 40ha 未満の場合は州の森林局が承認手続きを行う。また、5ha 未満の場合は、より簡単な手続きで承認が取得可能である。

**表 5-3 送電線と変電所の保護区外の森林への影響**

| No | Project Name | Transmission line [km] | ROW [ha] |
|---|---|---|---|
| 7 | Rewa220 – Sidhi 220kV DCDS line through Rewa UMSP | 3.0 | 10.5 |
| 9 | Julwania400 – Pati(Silawad) 132kV DCSS Line | 0.5 | 1.4 |
| 11 | Julwania400 – Shahpura 132kV DCSS Line | 6.0 | 16.2 |
| 13 | MugaliaChhap220 - Mahwadia 132kV DCDS Line | 1.5 | 4.1 |
| 15 | Sidhi220 - Madwas 132kV DCSS Line | 0.2 | 0.5 |
| 17 | Prithivipur-Orchha 132kV DCSS Line | 2.0 | 5.4 |
| 18 | Sirmour220 - Atraila 132kV DCSS line | 1.0 | 2.7 |
| 23 | Sidhi220 - Sinhawal 132kV DCSS line | 1.0 | 2.7 |
| 25 | Maneri - Mandla 132kV DCSS line | 9.0 | 24.3 |
| | Total | 24.2 | 67.7 |

(Source: MPPTCL)

森林に対する影響が発生する箇所は、森林局による森林の査定が行われ、失われた樹林を別の場所に復元させるための植林に必要な金額が算出される。事業者はこれら補償金額を支払い、森林局が適切な場所を選んで植林を実施することになる。

### 5.5. 住民移転

最終的な送電線ルートが決定していないため、2015 年 9 月現在、計画地と家屋の関係は確認できない。ただし、MPPTCL はこれまで極力住民移転を避けて事業を進めており、不法居住者も含め、移転が発生する可能性がある場合は事業の位置を変更して対応する予定になっている。そのため、大量の移転が発生する可能性は低いと推測される。事業実施にあたり、確実に住民移転が避けられているか、もし発生した場合は法に基づいた補償がされるかどうかを JICA が確認することが望ましい。住民移転が発生した場合には、法律に従った補償が行われることになる。

### 5.6. 土地収用

インド電力法(Indian Electricity Act, 2003)によると、変電所建設では用地取得が必要であるが、送電鉄塔の用地や送電線下(ROW)の用地は事業者が取得する必要はない。MPPTCL は変電所用地を全て政府所有の土地から選ぶことにしているため、いずれのサブプロジェクトも用地取得が発生する可能性は低い。

### 5.7. 土地利用に対する影響

インド電力法(Indian Electricity Act, 2003)によると、送電鉄塔の用地や送電線下(ROW)の用地は工事中に一時利用できなくなるものの、工事後は再び農地として利用できる。ただし土地所有者は鉄塔用地での構造物の設置や送電線下の家屋の建設、4m 以上の構造物の建設が制限される。工事中土地利用制限に対し、MPPTCL はインド電力法(Indian Electricity Act, 2003)に基づき作物補償を行う。工事中の作物補償額は推定で INR 183,497,000-程度になる予定である。一方供用後の土地利用制限に対する補償は行われない。

表 5-4　工事中の作物補償の推定額

| No. | Name | Length [km] | ROW [ha] | Unit Cost*1 [INR/ha] | Cost As per Estimate [INR] |
|---|---|---|---|---|---|
| 1 | LILO of one circuit of 400kV Khandwa - Rajgarh PGCIL line at Chhegaon 400kV Substation (D/C)<br>400kV Bus Reactor at Chhegaon 400kV S/S | 5.0 | 26.0 | 40,192 | 1,045,000 |
| 2 | Pithampur 400-Super Corridor 220kV DCDS line<br>LILO of One ckt of Indore (Jetpura) - Depalpur 132kV DCDS Line at Super Corridor (Indore) 220kV S/s. (D/C) | 63.0 | 210.1 | 60,995 | 12,815,000 |
| 5 | Chhatarpur-Tikamgarh 220kV DCSS line | 110.0 | 385.0 | 56,000 | 21,560,000 |
| 6 | 400/220kV Additional Transformer at Bina 400kV S/S<br>LILO of Bina 220 - Ganjbasoda 220kV line at Bina (MPPTCL) 400kV S/s | 10.0 | 35.0 | 64,429 | 2,255,000 |
| 7 | Rewa 220 - Sidhi 220kV DCDS line through Rewa UMSP | 90.0 | 315.0 | 58,342 | 18,378,000 |
| 9 | Julwania 400 - Pati (Silawad) 132kV DCSS Line | 40.0 | 108.0 | 72,199 | 7,798,000 |
| 10 | LILO of Mangliya 220 –Indore 132kV Line at Mahalaxmi | 3.0 | 8.1 | 74,691 | 605,000 |
| 11 | Julwania 400 - Shahpura 132kV DCSS Line | 65.0 | 175.5 | 78,374 | 13,755,000 |
| 12 | Datia 220 - Bhitarwar 132kV DCSS Line | 40.0 | 108.0 | 72,315 | 7,810,000 |
| 13 | MugaliaChhap 220 - Mahwadia 132kV DCDS Line | 10.0 | 27.0 | 83,878 | 2,265,000 |
| 15 | Sidhi 220 - Madwas 132kV DCSS Line | 50.0 | 135.0 | 73,219 | 9,885,000 |
| 16 | Panagar 220 - Dheemarkheda 132kV DCSS Line | 65.0 | 175.5 | 72,707 | 12,760,000 |
| 17 | Prithivipur-Orchha 132kV DCSS Line | 30.0 | 81.0 | 83,664 | 6,777,000 |
| 18 | Sirmour 220 - Atraila 132kV DCSS line | 35.0 | 94.5 | 74,292 | 7,021,000 |
| 19 | Udaipura - Tendukheda 132kV DCSS line | 45.0 | 121.5 | 71,523 | 8,690,000 |
| 20 | Gohad - Gormi 132kV DCSS line | 25.0 | 67.5 | 74,963 | 5,060,000 |
| 21 | Narsinghgarh - Suthaliya 132kV DCSS line | 50.0 | 135.0 | 72,111 | 9,735,000 |
| 22 | LILO of Satna 220 - Kymore 132kV line at Unchhera 132kV S/s | 5.0 | 13.5 | 89,630 | 1,210,000 |
| 23 | Sidhi 220 - Sinhawal 132kV DCSS line 132kV | 50.0 | 135.0 | 74,414 | 10,046,000 |
| 24 | 2nd ckt of Rajgarh (B) - Raghogarh 132kV DCSS line up to Chachoda 132kV S/s | 61.0 | 164.7 | 40,540 | 6,677,000 |
| 25 | Maneri - Mandla 132kV DCSS line | 80.0 | 216.0 | 80,334 | 17,353,000 |
| total | | 932.0 | 2,736.9 | 1,468,810 | 183,497,000 |

註*1：　Unit Cost は、MPPTCL から提供された Cost As per Estimate より算出。

（Source: MPPTCL）

添付資料 1：初期環境影響評価書案
添付資料 2：環境スクリーニングフォーム
添付資料 3：環境 Check list

**Initial Environmental Examinations**

**for**

**Madhya Pradesh Power Sector Transmission Project**

# [Draft version]

October 2015

Madhya Pradesh Power Transmission Company Limited

[This document is prepared only for JICA's contact mission. This document is not officially required for the Government of India based on The Environmental Impact Assessment Notification, 2006 and further amendments in Jan 2009, Dec 2009, Apr 2011, and Jan 2012.]

CONTRIBUTORS

| No. | Full name | Title | Signature |
|---|---|---|---|
| 1 | S. P. Gupta | Chief Engineer (Procurement) | |

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ACRONYMS

| | | |
|---|---|---|
| AIS | : | Air Insulated Substation |
| AP | : | Affected People |
| BOD | : | Biochemical oxygen demand |
| EIA | : | Environmental Impact Assessment |
| EMP | : | Environment management plan |
| GIS | : | Gas Insulated Substation |
| GOI | : | Government of India |
| HHs | : | Households |
| IEE | : | Initial Environmental Examination |
| IPP | : | Independent Power Producer |
| IUCN | : | The International Union for Conservation of Nature |
| JICA | : | Japan International Cooperation Agency |
| MPPTCL | : | Madhya Pradesh Power Transmission Corporation Limited |
| PMU | : | Project Management Unit |
| ROW | : | Right-of-Way |
| SF6 | : | Sulfur hexafluoride |
| SIA | : | Social Impact Assessment |
| SS | : | Substation |
| TML | : | Transmission line |

# 1 General Introduction

Madhya Pradesh, with an area of 308,000 sq.km is the second largest state in India after Rajasthan. It is part of the peninsular plateau of India, lying in the north central part, whose boundary can be classified in the north by the plains of Ganga-Yamuna, in the west by the Aravali, in the east by the Chhattisgarh plain and in the south by the Tapti valley and the plateau of Maharashtra.

About 80% of the population earns income from agriculture. Recent rapid development of Value Adding Industries utilizing rich mineral resources (17% of India's total), teak wood and bamboo etc. from vast forests of about 7.9 million hectares, points to additional bulk power demand. For the sustainable development of the state of Madhya Pradesh, an electricity power supply gap of 1,344MW (2011) and T&D loss of 43% (2011) will be the urgent issues.

To cope with the increasing demand for electricity in Madhya Pradesh state, Madhya Pradesh Power Transmission Corporation Limited (MPPTCL) prepared a Detailed Project Report (DPR) for the Madhya Pradesh Power Sector Transmission Project for expected financial cooperation from the Japanese government, concerning transmission system development with new technologies like Low electrical power Loss Conductor (LLC), High Temperature Low Sag (HTLS), or Gas Insulated Switchgear (GIS), to stabilize and reduce losses in the power transmission system. Further refinement is needed for the project.

## 1.1 Objectives of The Initial Environmental Examination

MPPTCL has proposed the following 33 subprojects in the DPR. As per EIA notification 2006, Environmental clearance is not necessary for a transmission project. An IEE is prepared to learn whether there are any Environmental Impacts caused by the subprojects in consideration of JICA GUIDELINES FOR ENVIRONMENTAL AND SOCIAL CONSIDERATIONS (2010).

The objective of the IEE report for the Project is to determine and assess preliminarily potential impacts on the environment, propose suitable mitigation measures against negative impacts, and prepare the environment monitoring system.

## 1.2 IEE Study Implementation Arrangement

The Construction Department of MPPTCL has prepared the IEE based on literature survey and desk study. Neither physical environmental site survey nor biological site survey is conducted.

# 2 Policy and Legal Framework

## 2.1 Indian Laws

Environmental Impact Assessment Notification 2006 stipulates the projects which require Environmental Clearance based on a reviewed Environmental Impact Assessment Report. According to the Notification, transmission line projects and substation projects do not require Environmental Clearance or an Environmental Impact Assessment Report. Land acquisition for substations has to follow Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013. If the projects fall in forest areas, MPPTCL has to follow the Indian Forest Act for the compensation. The following are the major Acts and Notifications relevant to the Project.

- The Environment (Protection) Act, 1986, amended 1991
- The Environmental Impact Assessment Notification, 2006 and further amendments in Jan 2009, Dec 2009, Apr 2011, and Jan 2012
- The Water (Prevention and Control of Pollution) Cess (Amendment) Act, 2003
- The Air (Prevention and Control of Pollution) Act 1981, amended 1987
- Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013
- Indian Forest Act, 1927
- Scheduled Castes and Scheduled Tribes (Prevention of Atrocities Act), 1989
- The National Green Tribunal Act, 2010
- S.O No. 1035 (E), [12/05/2011] - E-waste Management and Handling Rules 2011

The workflow for Forest Clearance Process

(1) User Agency can register to get the login credentials from http://efclearance.nic.in. Thereafter, project details can be submitted along with all required documents [Form-A (Part-I)/Form-B (Part-I)/Form-C (Part-I) etc.]. When U.A. submits all these details, an acknowledgement letter would be sent (by System) to email-id of (Applicant) User Agency. Acknowledgement letter may contain some information including unique proposal number. U.A. may refer this unique proposal number for future reference.

(2) Nodal Officer scrutinizes the proposal (within 10 days) and sends an acceptance letter to User Agency, if all relevant documents are uploaded properly by U.A. If any document is missing or any other information is needed, Nodal Officer may ask U.A. to upload those missing information. Timeline will start only if Nodal officer accepts the proposal.

(3) When, Nodal Officer sends the acceptance letter to U.A., proposal details are forwarded automatically to concerned

DFOs and DCs for their necessary action.

(4) DFO can view the proposal after logging in to portal and can take print out (if needed) of the entire details and then process it. After that, he/she uploads the part-II of Form-A/Form-B/Form-C on the portal along with his/her recommendation and Site Inspection report.

(5) When, DFO uploads his/her recommendation and Site Inspection Reports on the portal, proposal details are forwarded automatically to concerned CF/CCF for the necessary action.

(6) District Collector (DC) can view the proposal after logging in to portal. He/she has to upload FRA document (that must include Forest rights settlement details) on the portal. and can take print out (if needed) of the entire details and then process it. After that, he/she uploads the part-III of Form-A on the portal along with his/her recommendation and Site Inspection report (if site inspection done).

(7) When, CF/CCF uploads his/her recommendation and Site Inspection Reports on the portal, proposal details are forwarded automatically to concerned Nodal Officer for the necessary action.

(8) Nodal Officer can view the proposal and recommendations of DFO and CF/CCF after logging in to portal and can take print out (if needed) of the entire details and then process it. After that, he/she uploads the part-IV of Form-A on the portal along with his/her recommendation and Site Inspection report (if site inspection done).

(9) When, Nodal Officer uploads his/her recommendation and Site InspectionReports on the portal, proposal details are forwarded automatically to concerned State Secretary for the necessary action.

(10) State Secretary can view the proposal and recommendations of DFO, CF/CCF and Nodal Officer after logging in to portal and can take print out (if needed) of the entire details and then process it. After that, he/she uploads the part-V of Form-A on the portal along with his/her recommendation.

(11) When, State Secretary uploads his/her recommendation on the portal, proposal details are forwarded automatically to concerned Regional Office or Head Office, Delhi as per the flow defined in the system.

Source (OSMEFWC User Mannual Version 1)

## 2.2 JICA Guidelines

JICA GUIDELINES FOR ENVIRONMENTAL AND SOCIAL CONSIDERATIONS (2010) provides JICA's policy and requirements. Appendix 3 of the JICA guidelines shows sensitive projects and "Power transmission and distribution lines involving large-scale involuntary resettlement, large-scale logging, or submarine electrical cables" is listed in Appendix 3. The Project might not cause large-scale involuntary resettlement (it has not been confirmed by site survey) or large-scale logging (Forest area would be around 69.9 ha). Therefore, it might be categorized as B.

# 3 Project Description

MPPTCL has proposed the following 33 subprojects in the DPR, as shown in Table 3-1.

***Table 3-1 List of 33 sub-projects***

| No. | Project description |
|---|---|
| 1 | LILO of one circuit of 400kV Khandwa - Rajgarh PGCIL line at Chhegaon 400kV Substation (D/C)<br>400kV Bus Reactor at Chhegaon 400kV S/S |
| 2 | Pithampur400-Super Corridor 220kV DCDS line<br>LILO of One ckt of Indore (Jetpura) - Depalpur 132kV DCDS Line at Super Corridor (Indore) 220kV S/s.(D/C) |
| 4 | Charging/Upgradation of Chichli 220 - Udaipura DCDS line on 220kV level |
| 5 | Chhatarpur-Tikamgarh 220kV DCSS line |
| 6 | 400/220kV Additional Transformer at Bina 400kV S/S<br>LILO of Bina220 - Ganjbasoda 220kV line at Bina (MPPTCL) 400kV S/s |
| 7 | Rewa220 - Sidhi 220kV DCDS line through Rewa UMSP |
| 9 | Julwania400 - Pati (Silawad) 132kV DCSS Line |
| 10 | LILO of Mangliya 220 –Indore 132kV Line at Mahalaxmi |
| 11 | Julwania400 - Shahpura 132kV DCSS Line |
| 12 | Datia220 - Bhitarwar 132kV DCSS Line |
| 13 | MugaliaChhap 220 - Mahwadia 132kV DCDS Line |
| 15 | Sidhi 220 - Madwas 132kV DCSS Line |
| 16 | Panagar 220 - Dheemarkheda 132kV DCSS Line |
| 17 | Prithivipur-Orchha 132kV DCSS Line |
| 18 | Sirmour220 - Atraila 132kV DCSS line |
| 19 | Udaipura - Tendukheda 132kV DCSS line |
| 20 | Gohad - Gormi 132kV DCSS line |
| 21 | Narsinghgarh - Suthaliya 132kV DCSS line |
| 22 | LILO of Satna 220 - Kymore 132kV line at Unchhera 132kV S/s |
| 23 | Sidhi 220 - Sinhawal 132kV DCSS line 132kV |
| 24 | 2nd ckt of Rajgarh(B) - Raghogarh 132kV DCSS line up to Chachoda 132kV S/s |
| 25 | Maneri - Mandla 132kV DCSS line |
| 26 | Sukha (Jabalpur) |
| 27 | Hoshangabad 220kV (2nd) |
| 28 | Barwaha 220kV (3rd) |
| 29 | Betma 132kV |
| 30 | Khirkiya 132kV |
| 31 | Amla 132kV |
| 32 | Tejgarh 132kV |
| 33 | Satwas 132kV |
| 34 | Sitamau 132kV |
| 35 | Baroda 132kV |
| 36 | Amrawadkhurd 132kV |

(Source: DPR)

## 3.1 Background

In India, national energy consumption has continued to grow due to recent annual economic growth of over 8%, becoming the 4th largest in the world at the end of 2012. Supply has not kept up with the demand growth, with an 8.7% shortage in energy and 9.0% shortage in capacity, and a high national transmission and distribution (T&D) loss of 23.7% (2011) has also been an urgent issue.

To counter these problems, in energy sector reforms after the New Electricity Act was introduced in the 12th Five year Plan (2012-2017), new power developments will be focused exclusively on supercritical technology after the 13th Five year Plan (2018-2023) and T&D reinforcement and rural electrification will also be critical domestic issues.

Located in the central part of India, the State of Madhya Pradesh has the 2nd largest surface area in India and the 6th largest population, of 73 million. The state constitutes part of the Delhi-Mumbai Industrial Corridor, which is a mega-infrastructure project initiated by India and Japan, and has plans for industrial development in the future, including the development of a Special Economic Zone near Indore airport, a distribution center near Dewas and the industrial area of Pithampur. To achieve sustainable development in the state of Madhya Pradesh, a stable electricity power supply will be the urgent issue, but a power supply deficit of 455MW (2016-17, plan) is forecasted. In addition, the T&D loss of 27% (2014-15) should be reduced in the future. To strengthen the power system, the Japan International Cooperation Agency (JICA) provided a loan for the transmission project phase I in 2012. Since the phase I project was implemented successfully, JICA is now considering a phase II loan, which will include additional new technologies in transmission and substation equipment, to improve the power system further.

## 3.2 Project's Objectives

To cope with the increasing demand for electricity in Madhya Pradesh state, Madhya Pradesh Power Transmission Company Limited (MPPTCL) prepared a Detailed Project Report (DPR) for Transmission System Strengthening Works in Madhya Pradesh for expected financial cooperation from the Japanese government, concerning transmission system development with new technologies like Low Loss type ACSR (LL-ACSR) conductor, High Temperature Low Sag (HTLS) conductor, or Gas Insulated Switchgear (GIS), to stabilize and reduce losses in the power transmission system. Further refinement is needed for the project.

## 3.3 Project Location

MPPTCL has proposed the 33 subprojects in the DPR shown in Table 3-1. 21 of them contain construction of new transmission lines and 16 of them contain construction of new Sub-stations. 11 projects, No. 26 to No.36, are installing additional transformers, which are planned for the existing sub-stations. These projects will not require any new land or resettlement. Therefore, this IEE is mainly focused on the remaining 22 projects.

***Table 3-2 List of 33 sub-projects***

| No. | Project description | TML (km) | | | Substation | | Additional Transformer |
|---|---|---|---|---|---|---|---|
| | | 400 kV | 220 kV | 132 kV | Name | Required Area (ha) | |
| 1 | LILO of one circuit of 400kV Khandwa - Rajgarh PGCIL line at Chhegaon 400kV Substation (D/C) 400kV Bus Reactor at Chhegaon 400kV S/S | 5 | - | - | - | - | 1x125 MVAR |
| 2 | Pithampur400-Super Corridor 220kV DCDS line LILO of One ckt of Indore (Jetpura) - Depalpur 132kV DCDS Line at Super Corridor (Indore) 220kV S/s.(D/C) | - | 50 | 13 | Super Corridor (Indore) | 3.27 | |
| 4 | Charging/Upgradation of Chichli 220 - Udaipura DCDS line on 220kV level | - | | | Udaipura | - | |
| 5 | Chhatarpur-Tikamgarh 220kV DCSS line | - | 110 | | - | - | |
| 6 | 400/220kV Additional Transformer at Bina 400kV S/S LILO of Bina 220 - Ganjbasoda 220kV line at Bina (MPPTCL) 400kV S/s | - | 10 | | - | - | 1x315 MVA |
| 7 | Rewa 220 - Sidhi 220kV DCDS line through Rewa UMSP | - | 90 | | - | - | |
| 9 | Julwania 400 - Pati (Silawad) 132kV DCSS Line | - | | 40 | Pati (Silawad) | 4.00 | |
| 10 | LILO of Mangliya 220 –Indore 132kV Line at Mahalaxmi | - | | 3 | Mahalaxmi | unknown | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 11 | Julwania400 - Shahpura 132kV DCSS Line | - | | 65 | Shahpura | 2.25 | |
| 12 | Datia220 - Bhitarwar 132kV DCSS Line | - | | 40 | Bhitarwar | 2.25 | |
| 13 | MugaliaChhap 220 - Mahwadia 132kV DCDS Line | - | | 10 | Mahwadia | 5.00 | |
| 15 | Sidhi 220 - Madwas 132kV DCSS Line | - | | 50 | Madwas | 3.30 | |
| 16 | Panagar 220 - Dheemarkheda 132kV DCSS Line | - | | 65 | Dheemarkheda | 2.25 | |
| 17 | Prithivipur-Orchha 132kV DCSS Line | - | | 30 | Orchha | 3.00 | |
| 18 | Sirmour 220 - Atraila 132kV DCSS line | - | | 35 | Atraila | 4.00 | |
| 19 | Udaipura - Tendukheda 132kV DCSS line | - | | 45 | Tendukheda | 3.82 | |
| 20 | Gohad - Gormi 132kV DCSS line | - | | 25 | Gormi | 2.25 | |
| 21 | Narsinghgarh - Suthaliya 132kV DCSS line | - | | 50 | Suthaliya | 3.28 | |
| 22 | LILO of Satna 220 - Kymore 132kV line at Unchhera 132kV S/s | - | | 5 | Unchhera | 6.25 | |
| 23 | Sidhi 220 - Sinhawal 132kV DCSS line 132kV | - | | 50 | Sinhawal | unknown | |
| 24 | 2nd ckt of Rajgarh (B) - Raghogarh 132kV DCSS line up to Chachoda 132kV S/s | - | | 61 | Chachoda | unknown | |
| 25 | Maneri - Mandla 132kV DCSS line | - | | 80 | - | - | |
| 26 | Sukha (Jabalpur) | - | - | - | - | - | + 2x50 MVA |
| 27 | Hoshangabad 220kV (2nd) | - | - | - | - | - | + 1x160 MVA |
| 28 | Barwaha 220kV (3rd) | - | - | - | - | - | + 1x160 MVA |
| 29 | Betma 132kV | - | - | - | - | - | + 50 MVA |
| 30 | Khirkiya 132kV | - | - | - | - | - | + 50 MVA |
| 31 | Amla 132kV | - | - | - | - | - | + 50 MVA |
| 32 | Tejgarh 132kV | - | - | - | - | - | + 50 MVA |
| 33 | Satwas 132kV | - | - | - | - | - | + 50 MVA |
| 34 | Sitamau 132kV | - | - | - | - | - | + 50 MVA |
| 35 | Baroda 132kV | - | - | - | - | - | + 50 MVA |
| 36 | Amrawadkhurd 132kV | - | - | - | - | - | + 50 MVA |

(Source: DPR)

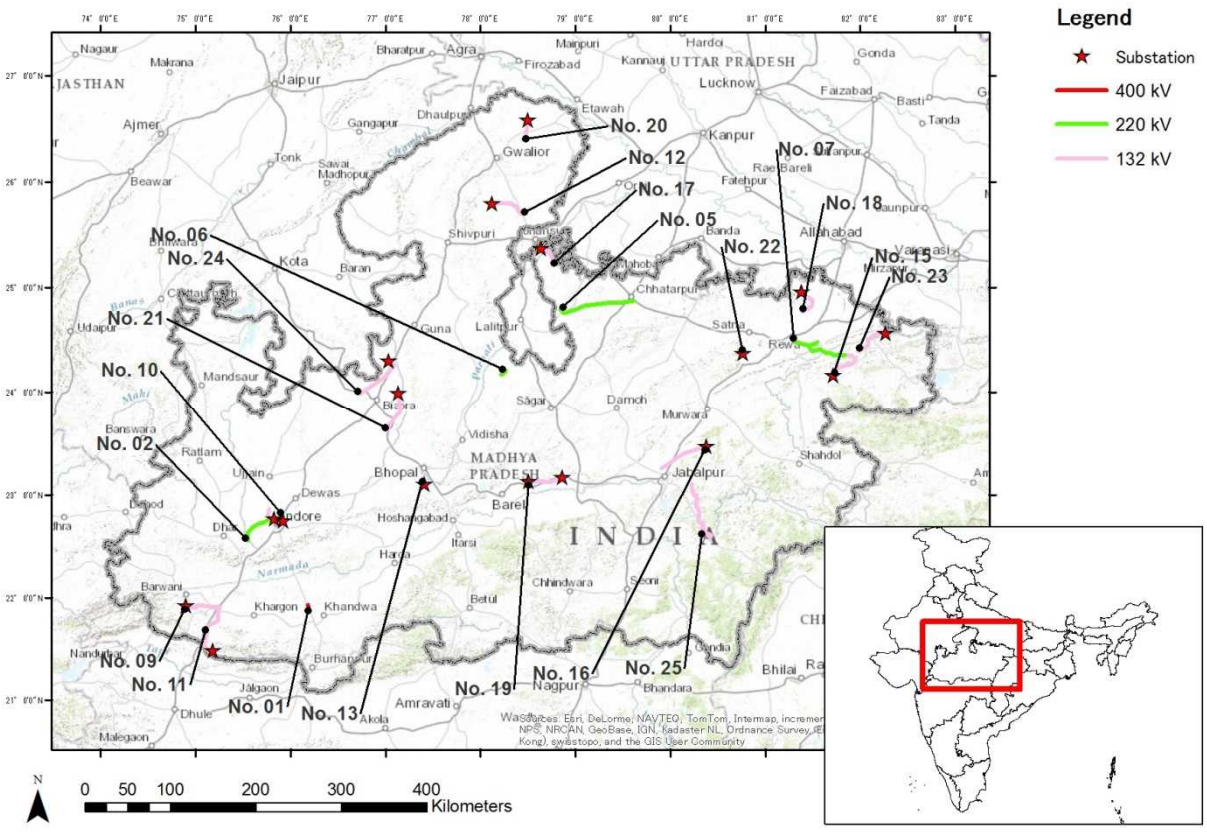



*Figure 3-1 Project Location*

## 3.4 Project area type and activities

### 3.4.1 Substations

16 new substations are proposed. Some of the locations are already identified but some of them are in the selection stage. All of the land planned is government-owned. The exact locations of the sub-stations will be finalized after site surveys. Residential areas and private land will be avoided and only government land without any houses will be selected for substations. The procedures from land selection to construction are as follows.

*Table 3-3 Area Required for Substations*

| No. | Project description | Substation | | Status* |
|---|---|---|---|---|
| | | Name | Required Area (ha) | |
| 2 | Pithampur400-Super Corridor 220kV DCDS line LILO of One ckt of Indore (Jetpura) - Depalpur 132kV DCDS Line at Super Corridor (Indore) 220kV S/s.(D/C) | Super Corridor (Indore) | 3.27 | (i) |
| 9 | Julwania400 - Pati (Silawad) 132kV DCSS Line | Pati (Silawad) | 4.00 | (i) |
| 10 | Mangliya 220 - Mahalaxmi 132kV DCDS Line | Mahalaxmi | - | (i) |
| 11 | Julwania400 - Shahpura 132kV DCSS Line | Shahpura | 2.25 | (i) |
| 12 | Datia220 - Bhitarwar 132kV DCSS Line | Bhitarwar | 2.25 | (ii) |
| 13 | MugaliaChhap 220 - Mahwadia 132kV DCDS Line | Mahwadia | 5.00 | (v) |
| 15 | Sidhi 220 - Madwas 132kV DCSS Line | Madwas | 3.30 | (ii) |
| 16 | Panagar 220 - Dheemarkheda 132kV DCSS Line | Dheemarkheda | 2.25 | (ii) |
| 17 | Prithivipur-Orchha 132kV DCSS Line | Orchha | 3.00 | (i) |
| 18 | Sirmour 220 - Atraila 132kV DCSS line | Atraila | 4.00 | (ii) |

| | | | | |
|---|---|---|---|---|
| 19 | Udaipura - Tendukheda 132kV DCSS line | Tendukheda | 3.82 | (iv) |
| 20 | Gohad - Gormi 132kV DCSS line | Gormi | 2.25 | (i) |
| 21 | Narsinghgarh - Suthaliya 132kV DCSS line | Suthaliya | 3.28 | (i) |
| 22 | LILO of Satna 220 - Kymore 132kV line at Unchhera 132kV S/s | Unchhera | 6.25 | (i) |
| 23 | LILO of one ckt of Sidhi 220 - Deosar 132kV line at Sinhawal 132kV S/s | Sinhawal | Land is being identified | (i) |
| 24 | 2nd ckt of Rajgarh (B) - Raghogarh 132kV DCSS line up to Chachoda 132kV S/s | Chachoda | Land to be identified | (i) |

*: (i) MPPTCL conducts site survey and selects government land without houses for substations. (1 month)

(ii) MPPTCL, the Site Selection Committee comprising SE (EHT-Constn), SE (T & C) and Civil Authority inspect the land and identify the location.

(iii) MPPTCL intimates the details of the land to the Energy of Government of MP. Energy department of Govt. of MP submits requisition to Revenue Department, GoMP for allotment of identified land.

(iv) The relevant Revenue Authority (Collector) allots the land to MPPTCL.

(v) Subsequent to allotment of land by the Collector, a contour plan of the land is furnished by the relevant EHT authority for developing the layout drawings of EHV substation.

## 3.4.2 Transmission Lines

The exact locations of the transmission lines will be decided after site surveys. All houses, including illegal squatters, will be avoided from the ROW. Procedures from site survey to construction of the transmission lines are as follows.

i. MPPTCL conducts survey for the ROW and examine some routes which will not fall on houses, including illegal squatters. (2 – 4 months)
ii. MPPTCL visits all the stakeholders along the proposed routes individually including the head of the village and explains the projects and land use restriction. (during No.1) ← not a meeting style
iii. MPPTCL finalizes the TML routes.
iv. MPPTCL applies for forest clearance if there are any forest areas in the ROW. (Max 1 year)
v. MPPTCL publishes section 164 notification in local papers as per Indian Electricity Act 2003 for the ROW.
vi. People can appeal to MPPTCL within 60 days.
vii. MPPTCL manages the appeals.
viii. MPPTCL starts construction for the Transmission Lines.

### 3.4.2.1 Tower Areas

The exact locations of the transmission towers have not been decided yet, because the transmission routes are not fixed. The average required area for Transmission Towers would be 25.03 $m^2$ to 165.44 $m^2$ per tower (Table 3-4). Estimated number of towers is 3,029 and required total area would be 9.9 ha (see Table 3-5). The transmission towers do not require land acquisitions. Land ownership will be with the Land Owner after construction (Regulation Telegraph Act 1885). Crop compensation will be paid during construction. The land owner can use the land as a vegetable garden after construction but construction building and tree plantation higher than 4 meters is not allowed (Law - Indian Electricity Act-2003). During operation the natural vegetation will be cut by MPPTCL for maintenance.

***Table 3-4 Required Tower Area by Voltage***

| Voltage | Average height of the suspension tower | Average Tower area | Interval (m) |
|---|---|---|---|
| 400 kV | 80 m | 165.44 $m^2$ | 333 m |
| 220 kV | 60 m | 49.25 $m^2$ | 263 m |
| 132 kV | 40 m | 25.03 $m^2$ | 250 m |

***Table 3-5 Estimated Tower Area***

| No. | 400 kV | 220 kV | 132 kV | Total |
|---|---|---|---|---|

| | Length (km) | No. of Towers | Total tower Area (sqm) | Length (km) | No. of Towers | Total tower Area (sqm) | Length (km) | No. of Towers | Total tower Area (sqm) | Length (km) | No. of Towers | Total tower Area (sqm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 15 | 2,482 | - | - | - | - | - | - | 5 | 15 | 2,482 |
| 2 | - | - | - | 50 | 162 | 7,979 | 13 | 56 | 1,402 | 63 | 218 | 9,380 |
| 5 | - | - | - | 110 | 368 | 18,124 | - | - | - | 110 | 368 | 18,124 |
| 6 | - | - | - | 10 | 7 | 345 | - | - | - | 10 | 7 | 345 |
| 7 | - | - | - | 90 | 328 | 16,154 | - | - | - | 90 | 328 | 16,154 |
| 9 | - | - | - | - | - | - | 40 | 140 | 3,504 | 40 | 140 | 3,504 |
| 10 | - | - | - | - | - | - | 3 | 70 | 1,752 | 3 | 70 | 1,752 |
| 11 | - | - | - | - | - | - | 65 | 133 | 3,329 | 65 | 133 | 3,329 |
| 12 | - | - | - | - | - | - | 40 | 123 | 3,079 | 40 | 123 | 3,079 |
| 13 | - | - | - | - | - | - | 10 | 39 | 976 | 10 | 39 | 976 |
| 15 | - | - | - | - | - | - | 50 | 158 | 3,955 | 50 | 158 | 3,955 |
| 16 | - | - | - | - | - | - | 65 | 232 | 5,807 | 65 | 232 | 5,807 |
| 17 | - | - | - | - | - | - | 30 | 105 | 2,628 | 30 | 105 | 2,628 |
| 18 | - | - | - | - | - | - | 35 | 105 | 2,628 | 35 | 105 | 2,628 |
| 19 | - | - | - | - | - | - | 45 | 158 | 3,955 | 45 | 158 | 3,955 |
| 20 | - | - | - | - | - | - | 25 | 92 | 2,303 | 25 | 92 | 2,303 |
| 21 | - | - | - | - | - | - | 50 | 142 | 3,554 | 50 | 142 | 3,554 |
| 22 | - | - | - | - | - | - | 5 | 22 | 551 | 5 | 22 | 551 |
| 23 | - | - | - | - | - | - | 50 | 140 | 3,504 | 50 | 140 | 3,504 |
| 24 | - | - | - | - | - | - | 61 | 189 | 4,731 | 61 | 189 | 4,731 |
| 25 | - | - | - | - | - | - | 80 | 245 | 6,132 | 80 | 245 | 6,132 |
| Total | 5 | 15 | 2,482 | 260 | 865 | 42,601 | 667 | 2,149 | 53,789 | 932 | 3029 | 98,872 |

#### 3.4.2.2 Right of Way

The exact locations of the right of way have not been decided yet. The locations will be finalized in the Detailed Design stage. The average width of ROW would be 27 m to 52 m (see Table 3-6). Estimated required area for ROW would be 2,521 ha (see Table 3-7). Activities during construction will be removal of buildings and vegetation clearance. Activities during operation will be vegetation clearance. Land ownership will not be changed after construction. Therefore, the land owner can keep using the land as agricultural land. But they cannot plant trees higher than 4 m or construct buildings. Habitation is prohibited under

the ROW.

***Table 3-6 Average Width of Right of Way by Voltage***

| Voltage Level | Other than Forest ROW (m) | Forest ROW (m) |
|---|---|---|
| 400 kV | 52 | 46 |
| 220 kV | 35 | 35 |
| 132 kV | 27 | 27 |

Source: Ministry of Environment and Forest, Guidelines for diversion of forest land for non-forest purposes under the Forest Conservation Act, 1980 - guidelines for laying transmission lines through forest areas

***Table 3-7 Estimated ROW Area***

| No. | 400 kV | | 220 kV | | 132 kV | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Length (km) | ROW (ha) | Length (km) | ROW (ha) | Length (km) | ROW (ha) | Length (km) | ROW (ha) |
| 1 | 5.0 | 26.0 | - | - | - | - | 5.0 | 26.0 |
| 2 | - | - | 50.0 | 175.0 | 13.0 | 35.1 | 63.0 | 210.1 |
| 5 | - | - | 110.0 | 385.0 | - | - | 110.0 | 385.0 |
| 6 | - | - | 10.0 | 35.0 | - | - | 10.0 | 35.0 |
| 7 | - | - | 90.0 | 315.0 | - | - | 90.0 | 315.0 |
| 9 | - | - | - | - | 40.0 | 108.0 | 40.0 | 108.0 |
| 10 | - | - | - | - | 3.0 | 8.1 | 3.0 | 8.1 |
| 11 | - | - | - | - | 65.0 | 175.5 | 65.0 | 175.5 |
| 12 | - | - | - | - | 40.0 | 108.0 | 40.0 | 108.0 |
| 13 | - | - | - | - | 10.0 | 27.0 | 10.0 | 27.0 |
| 15 | - | - | - | - | 50.0 | 135.0 | 50.0 | 135.0 |
| 16 | - | - | - | - | 65.0 | 175.5 | 65.0 | 175.5 |
| 17 | - | - | - | - | 30.0 | 81.0 | 30.0 | 81.0 |
| 18 | - | - | - | - | 35.0 | 94.5 | 35.0 | 94.5 |
| 19 | - | - | - | - | 45.0 | 121.5 | 45.0 | 121.5 |
| 20 | - | - | - | - | 25.0 | 67.5 | 25.0 | 67.5 |
| 21 | - | - | - | - | 50.0 | 135.0 | 50.0 | 135.0 |
| 22 | - | - | - | - | 5.0 | 13.5 | 5.0 | 13.5 |
| 23 | - | - | - | - | 50.0 | 135.0 | 50.0 | 135.0 |
| 24 | - | - | - | - | 61.0 | 164.7 | 61.0 | 164.7 |
| 25 | - | - | - | - | 80.0 | 216.0 | 80.0 | 216.0 |
| Total | 5.0 | 26.0 | 260.0 | 910.0 | 667.0 | 1,800.9 | 932.0 | 2,736.9 |

# 4 Scoping

Based on the project information and baseline data, environmental and social issues of concern are scoped. No serious impact is scoped. Some moderate impacts are the leaking out of Sulfur hexafluoride (SF6) from GIS substations during operation, tree cutting under the transmission lines, habitat fragmentation due to transmission lines, resettlement under the transmission lines, land acquisition at the substations, landscape impact caused by the transmission lines, impact on ethnic minorities, and accidents of workers. The scoping table is shown below.

***Table 4-1 Scoping table***

| Item | | Issues of concern* | |
|---|---|---|---|
| | | Construction | Operation |
| Physical | Air pollution | C: Vehicle exhaust | - |
| | Water pollution | C: Turbid water from construction site | C: Human sewage from substation |
| | Waste | C: Cleared vegetation, demolition waste, domestic waste from workers | C: Damaged parts from substation and transmission line |
| | Soil pollution | - | - |
| | Noise and vibrations | C:Construction noise from construction vehicles | C: Machine Noise from substation |
| | Subsidence | - | - |
| | Offensive odors | - | - |
| | Bottom sediment | - | - |
| Natural | Protected area | B: Trees might be cut in some Protected areas | - |
| | Ecosystem | B: Fragmentation of the habitats might change ecosystems | B: Fragmentation of the habitats might change ecosystems |
| | Hydrology | - | - |
| | Topography and geology | C: Slope failures or landslides at the construction site | C: Concurrent slope failure might cause road blocking |
| Social | Resettlement | B: Houses under the TML or Substation | - |
| | Poverty | C: People under the poverty line might affect by the project | C: Land use restriction might prevent new business opportunities |
| | Ethnic Minorities and Indigenous Peoples | B: They might be affected by land acquisition/resettlement | - |
| | Livelihood and local economy | - | C: Project cause positive impact |
| | Land use and natural resource use | B: Land acquisition at the Substation | B: Land use restriction under the TML |
| | Water usage | - | - |
| | Infrastructure and social organizations of decision making | C: | - |
| | Interest opposition in the area | C: The unequal compensation might cause conflicts | - |
| | Local archeological, historical, cultural, and religious heritage | C: They might be damaged by construction work | - |
| | Landscape | B: Landscape near the tourism sites or cultural sites might be affected by TML | B: Landscape near the tourism sites or cultural sites might be affected by TML |
| | Gender | C: Project information might be explained to only gentlemen | C: Working opportunities for the ladies might be limited |
| | Children's right | C: If children is hired as workers, their right will be violated | - |
| | HIV/AIDS and Public Health | C: Infectious diseases brought by workers | - |
| | Working safety | B: Accidents during construction | B: Electrification, falling |
| Others | Accidents | - | C: Tower failure, electrification |
| | Global warming | - | B: Sulfur hexafluoride ($SF_6$) |

*: A: Serious impact B: Moderate impact C: Negligible impact -: No impact

# 5 Survey methods

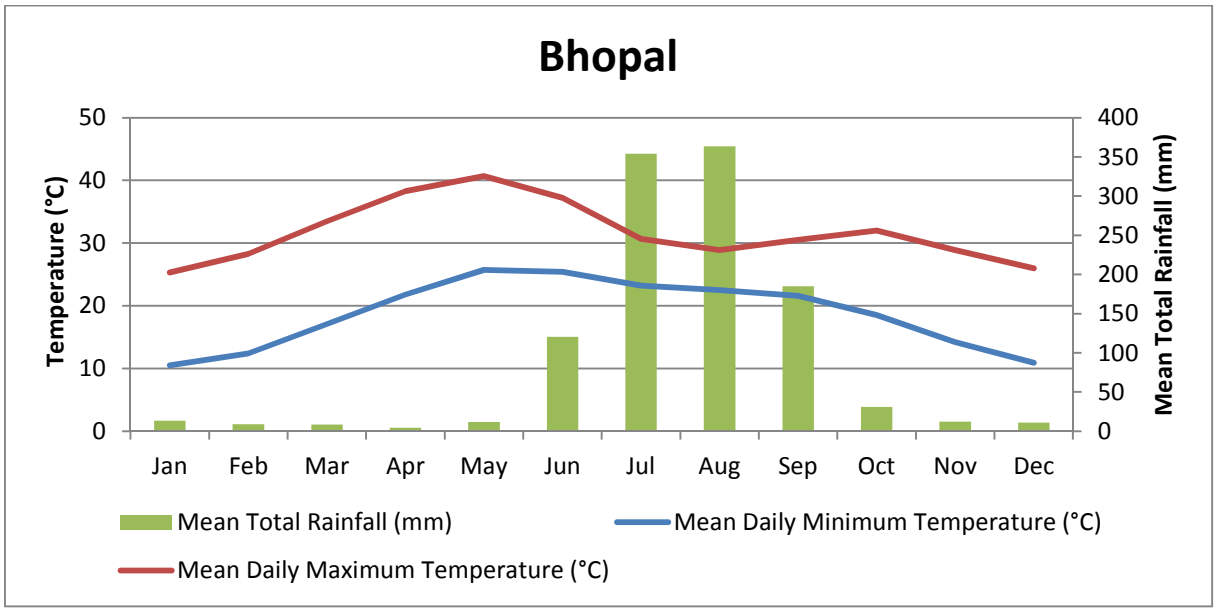
All the survey was conducted by literature survey. No site survey was conducted. Literature survey was conducted by JICA study team. Literature survey items are Climate, Topography, Geology, Forest, Protected area, protected species, Administrative boundaries, Population, Poverty, Ethnic groups, and Land use. All the survey was conducted from 12 July to 18 Sep 2015.

# 6 Survey Result

## 6.1 Physical Environment

### 6.1.1 Climate

The main climate in Madhya Pradesh is Tropical wet and dry or savanna climate (Aw) or Mediterranean climates (Cs). High land areas are Subtropical highland variety (Cw) or Semi-arid climate (Bs). For Bhopal, the dry season is from October to May and the wet season is from June to September. The hottest month is May (25.7 – 40.7 °C) and the coldest month is January (10.5 -25.3 °C).

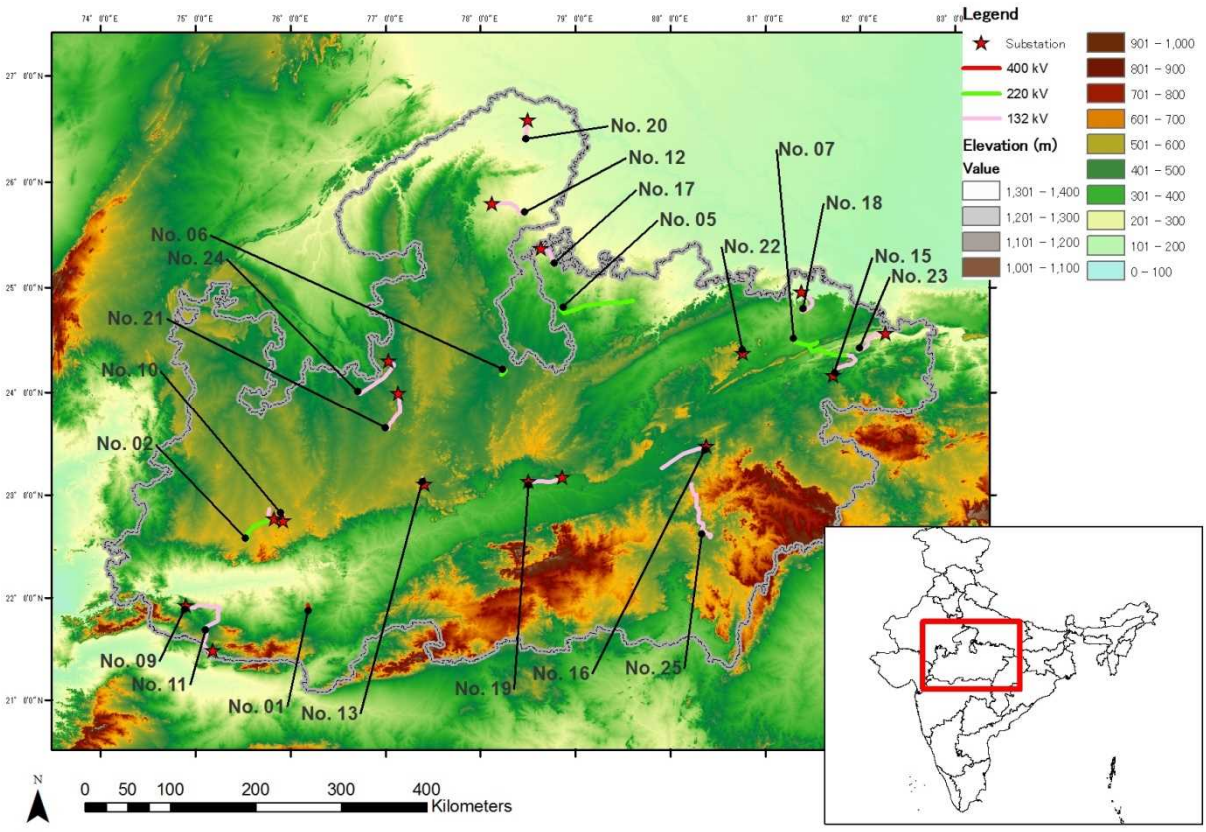



Source: World Meteorological Organization

***Figure 6-1 Climatological Information (Bhopal, 1949-2000)***

### 6.1.2 Topography

The geographical area of Madhya Pradesh is 308,252 sq. km, which constitutes 9.38% of the land area of the country. The topography of Madhya Pradesh is defined by the Narmada Sone Valley. It is a narrow and long valley extending through almost the whole of the state from east to west. The Sone valley forms the upper part; Shahdol and Sidhi districts lie in this valley. The lower part forms the Narmada valley. It has an average elevation of 300 m above MSL and is covered with alluvial soil. Jabalpur, Mandla, Narsinghpur, Hoshangabad, Raisen, Khandwa, Khargone and Barwani districts lie in this region. The Sone valley is narrower than the Narmada valley and alluvial deposit is also comparatively poor and thin; therefore, the Narmada valley is more important than the Sone valley for agricultural activities. To the north of this valley lies the Central Highlands, to the south, the Satpura-Maikal ranges and to the south-east, the eastern plateau. These three form the natural physiographic regions into which the state is divided. The Central Highlands are spread between the Narmada-Sone valley and the Aravali ranges to the west in a triangular form. The highlands slope towards the north and drain into the Yamuna. The highest peak in the state, Dhoopgarh, which rises to 1,360 m above MSL, lies in these ranges. The slope is sharp in the south face and gentle on the northern side. (Source: Government of Madhya Pradesh)



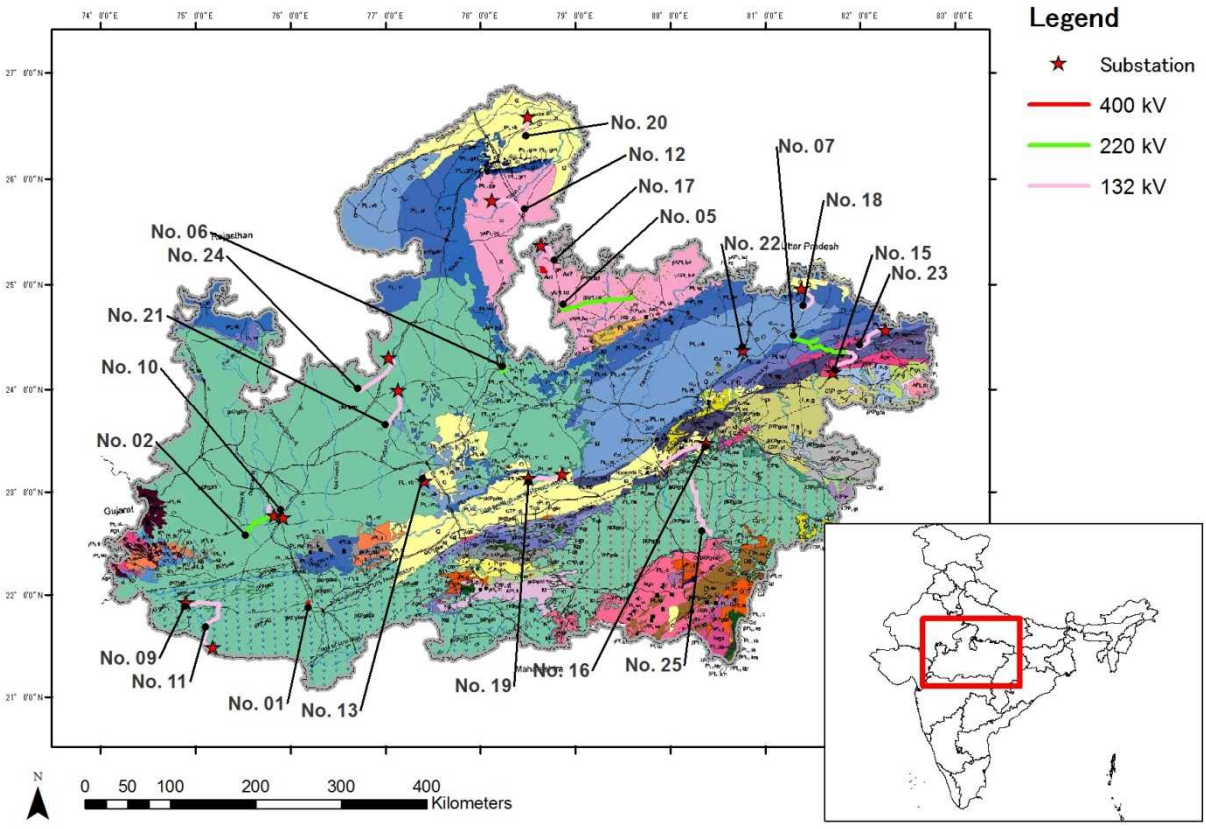

Source: GLASMO (www.iscgm.org/)

***Figure 6-2 Topography Map of Madhya Pradesh***

### 6.1.3 Geology

The oldest group of rocks, comprising Archaeans and Proterozoic formation, constitutes nearly 45% of the State. The next younger formation of Carboniferous to lower Cretaceous, comprising Gondwana Super Group, covers 10% of the area, while the formation of Cretaceous to Paleocene, comprising mostly Deccan Trap basalt, constitutes 38%. (Source: Minerals and Resources Department, Government of Madhya Pradesh)

Figure 3-1 shows a geological map of Madhya Pradesh.


Legend
Substation
400 kV
220 kV
132 kV
No. 20
No. 12
No. 17
No. 07
No. 18
No. 05
No. 22
No. 15
No. 23
No. 06
No. 24
No. 21
No. 10
No. 02
No. 09
No. 11
No. 01
No. 13
No. 19
No. 16
No. 25
Rajasthan
Uttar Pradesh
Gujarat
N
0 50 100 200 300 400
Kilometers


Source: Geological Survey India

***Figure 6-3 Geological Map of Madhya Pradesh***

## 6.2 Natural Environment

### 6.2.1 Forest

According to the Forest Department of Madhya Pradesh the forest area of the state is 94,689.38 sq. km, constituting 30.71% of the geographical area of the state and 12.44% of the forest area of the country. Legally, this area has been classified into Reserved Forest, Protected Forest and Unclassified Forest, which constitute 65.36%, 32.84% and 1.7% of the forest area respectively. Per capita forest area is 0.16 ha., against the national average of 0.07 ha.

The forest cover has been classified into dense forest and open forest. The latest estimates from the Forest Survey of India, published in the State of Forest Report (SFR) 2003, suggest that the total forest cover of M.P. is 76,429 sq. km., which is 24.79% of the land area - dense forest constituting 13.57% and open forest, 11.22%. In addition to these two categories of cover, land having canopy cover of less than 10% is classified as scrub. The area under scrub is not included in the forest cover. Figure 6-4 shows the forest areas in Madhya Pradesh state.

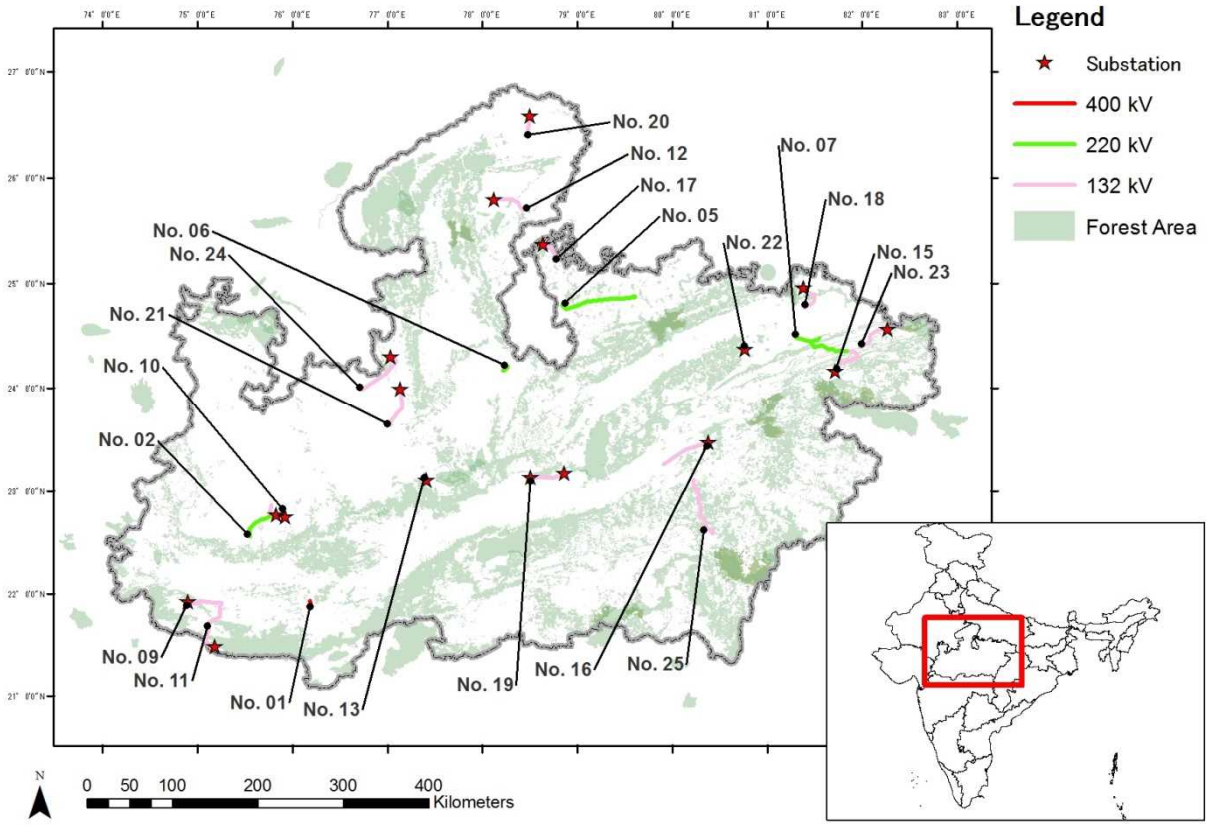



*Figure 6-4 Tree Cover of Madhya Pradesh*

### 6.2.2 Protected Areas

According to the Indian Forest Act 1927 and Environment (Protection) Act 1986, the designated forest areas are categorized as Reserved Forests and Protected Forests. The following table shows the forest types and restricted activities.

*Table 6-1 Restrictions and required actions for TML by Forest Types*

| Class | Type | Restriction | Required permissions for TML/SS | Act and Regulations |
|---|---|---|---|---|
| RESERVED FORESTS | National Park | All activities are prohibited unless permitted. | Permission from supreme court | Environment (Protection) Act 1986, Notification from Ministry of Environment & Forests |
| | Sanctuary | Prohibited activity is taking weapons into a sanctuary.<br>Permitted activities are investigation or study of sanctuary, photography, | Permission from supreme court | Environment (Protection) Act 1986,<br>The wildlife |

| | | | | |
|---|---|---|---|---|
| | | scientific research, tourism and transaction of lawful business.<br>Other activities are considered to regulate, permit or prohibit depending on activities. | | (Protection) Act 1972<br><br>Notification from Ministry of Environment & Forests |
| | Eco-Sensitive zone (10km distance around the National parks and Sanctuaries) | Erection of electrical cables is regulated and underground cabling is recommended. | Permission from the Commissioner of the gov. of MP | Guideline for declaration of Eco-Sensitive zone around national parks and wildlife sanctuaries<br><br>Certificate from Ministry of Environment & Forests,<br>Wildlife Introduction of Ministry of Environment & Forests |
| | Un-designated area around the NP/Sanctuary | - | - | - |
| PROTECTED FORESTS | | Prohibited activities are the quarrying of stone, or the burning of lime or charcoal, or the collection or subjection to any manufacturing process, or removal of, any forest-produce in any such forest, and the breaking up or clearing for cultivation, for building, for herding cattle or for any other purpose, of any land in any such forest. | Forest Clearance | Indian Forest Act 1927 |

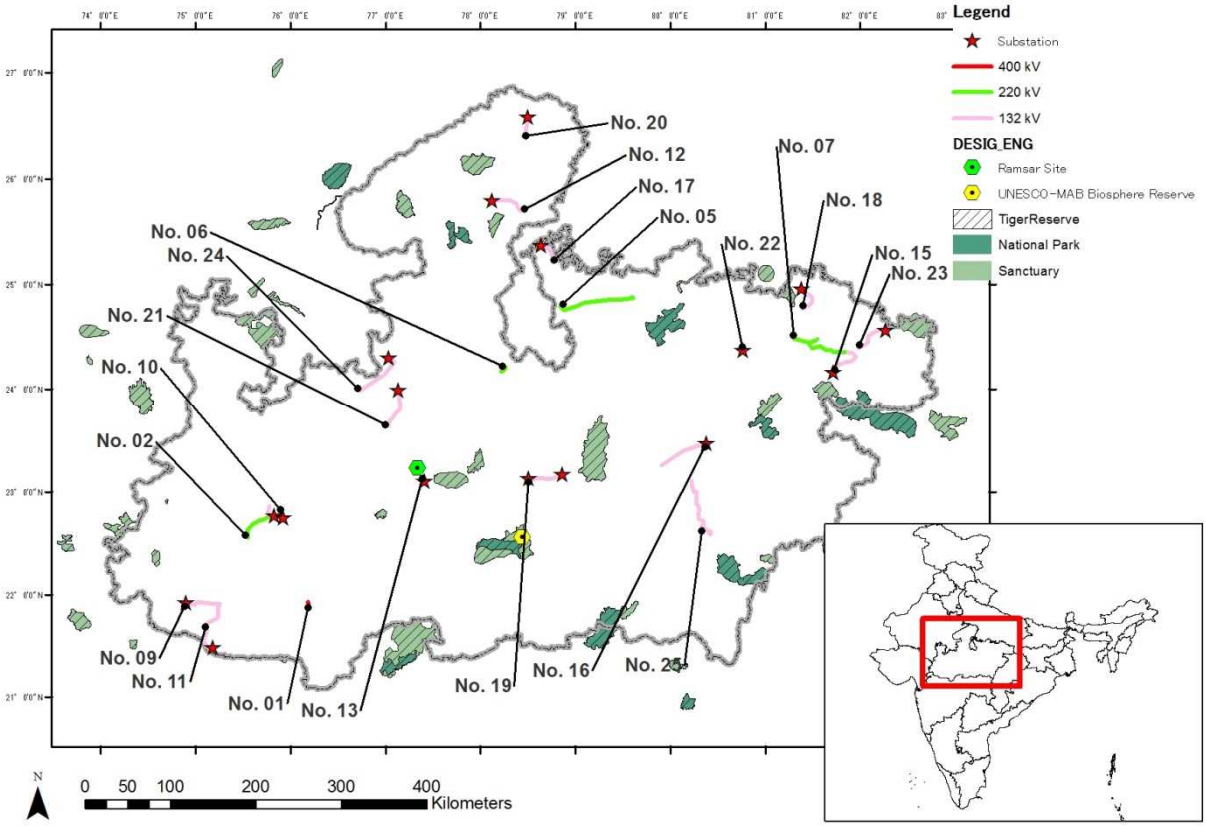
There are 9 National Parks, 25 Sanctuaries, 6 Tiger reserves and two International protected areas (UNESCO-MAB Biosphere Reserve and Ramsar site) in Madhya Pradesh State (see Table 6-2 and Figure 6-5).

***Table 6-2 Protected Areas in Madhya Pradesh State***

| Type | Name | Tiger Reserves | International importance |
|---|---|---|---|
| National Park | 1. Kanha | 1. Kanha | |
| | 2. Bandhavgarh | 2. Bandhavgarh | |
| | 3. Panna | 4. Panna | |
| | 4. Pench | 3. Pench | |
| | 5. Satpura | 5. Satpura | Pachmarhi UNESCO-MAB Biosphere Reserve |
| | 6. Sanjay | 6. Sanjay | |
| | 7. Madhav | | |
| | 8. Vanvihar | | Bhoj Ramsar Wetland |
| | 9. Fossil | | |
| Sanctuary | 1. Bori | 5. Satpura | |
| | 2. Bagdara | | |
| | 3. Phen | | |
| | 4. Ghatigaon | | |
| | 5. Gandhisagar | | |
| | 6. Karera | | |

| | | | |
|---|---|---|---|
| | 7. Ken Ghariyal | | |
| | 8. Kheoni | | |
| | 9. Narsinghgarh | | |
| | 10. N. Chambal | | |
| | 11. Nauradehi | | |
| | 12. Pachmari | 5. Satpura | |
| | 13. Panpatha | 2. Bandhavgarh | |
| | 14. Kuno | | |
| | 15. Pench | 3. Pench | |
| | 16. Ratapani | | |
| | 17. Sanjay Dubri | 6. Sanjay | |
| | 18. Singhori | | |
| | 19. Son Ghariyal | | |
| | 20. Sardarpur | | |
| | 21. Sailana | | |
| | 22. Ralamandal | | |
| | 23. Orchha | | |
| | 24. Gangau | 4. Panna | |
| | 25. V. Durgawati | | |

Source: Protected Planet (www.protectedplanet.net)




Source: Forest Department

***Figure 6-5 Protected Areas***

## 6.2.3 Protected Species

According to IUCN, 1,333 species are tagged as India in the IUCN red list. 136 species are Critically Endangered, 353 species are Endangered, 496 species are Vulnerable and 348 species are Near Threatened (see Table 6-3). Among them, three (3) plants,

fourteen (14) mammals, two (2) reptiles, eight (8) turtles, one (1) Anuras, seventeen (17) fish and one (1) Odonata are known to exist in Madhya Pradesh state (see Table 6-4). The habitats of three (3) species out of forty six (46) protected species are limited in the state as shown in Figure 6-6.

***Table 6-3 Number of IUCN Red list species in India***

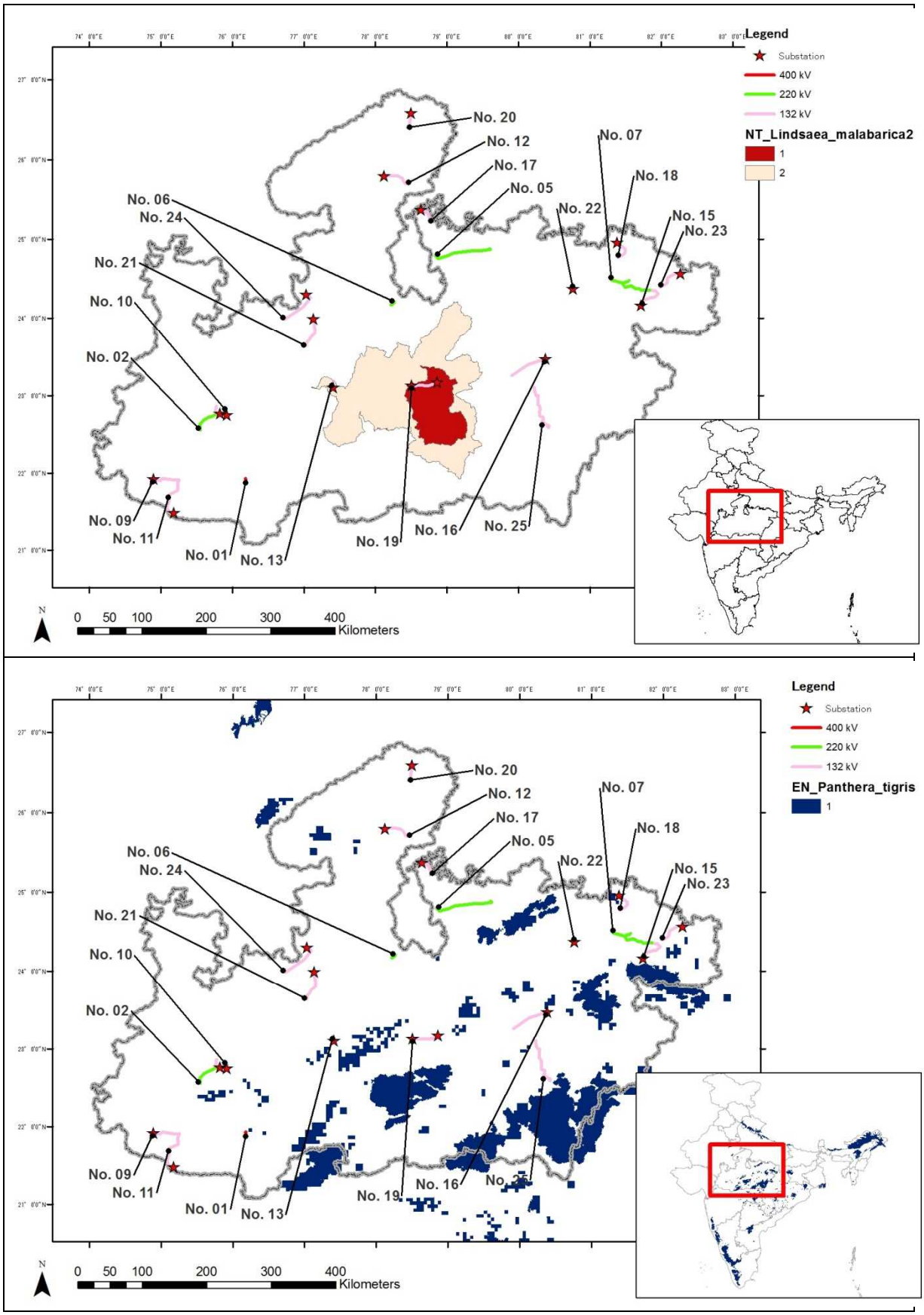
| | Critically Endangered (CR) | Endangered (EN) | Vulnerable (VU) | Near Threatened (NT) | Total* |
|---|---|---|---|---|---|
| ANIMALIA | 75 | 202 | 376 | 326 | 979 |
| ARTHROPODA | 3 | 7 | 31 | 19 | 60 |
| CHORDATA | 71 | 184 | 263 | 199 | 717 |
| ACTINOPTERYGII | 14 | 69 | 88 | 52 | 223 |
| AMPHIBIA | 20 | 32 | 22 | 9 | 83 |
| AVES | 16 | 16 | 50 | 75 | 157 |
| CHONDRICHTHYES | 3 | 9 | 30 | 28 | 70 |
| MAMMALIA | 11 | 40 | 45 | 24 | 120 |
| REPTILIA | 7 | 18 | 28 | 11 | 64 |
| CNIDARIA | 1 | 4 | 73 | 107 | 185 |
| ECHINODERMATA | | 4 | 5 | | 9 |
| MOLLUSCA | | 3 | 4 | 1 | 8 |
| PLANTAE | 61 | 151 | 120 | 22 | 354 |
| BRYOPHYTA | 1 | 1 | 1 | | 3 |
| MARCHANTIOPHYTA | | 3 | 1 | | 4 |
| TRACHEOPHYTA | 60 | 147 | 118 | 22 | 347 |
| Total | 136 | 353 | 496 | 348 | 1333 |

*: Least Concern (LC) and Data Deficient (DD) are excluded.

***Table 6-4 IUCN Red List Species Known in Madhya Pradesh***

| | Scientific Name | Common Name | IUCN Red List category |
|---|---|---|---|
| Plants | Ammannia nagpurensis | | EN |
| | Lindsaea malabarica | | NT |
| | Utricularia praeterita | | NT |
| Mammals | Cuon alpinus | Indian Wild Dog | EN |
| | Hipposideros durgadasi | Durga Das's Leaf-nosed Bat | EN |
| | Manis crassicaudata | Indian Pangolin | EN |
| | Panthera tigris | Tiger | EN |
| | Bos gaurus | Indian Bison | VU |
| | Lutrogale perspicillata | Indian Smooth-coated Otter | VU |
| | Melursus ursinus | Sloth Bear | VU |
| | Prionailurus rubiginosus | Rusty-spotted Cat | VU |
| | Rucervus duvaucelii | Barasingha, Swamp Deer | VU |
| | Rusa unicolor | Sambar Deer | VU |
| | Tetracerus quadricornis | Four-horned Antelope | VU |
| | Antilope cervicapra | Blackbuck | NT |
| | Hyaena hyaena | Striped Hyena | NT |
| | Panthera pardus | Leopard | NT |
| Reptiles | Gavialis gangeticus | Indian Gharial | CR |
| | Crocodylus palustris | Mugger | VU |

| | Scientific Name | Common Name | IUCN Red List category |
|---|---|---|---|
| Turtles | Batagur dhongoka | Three-striped Roofed Turtle | EN |
| | Chitra indica | Indian Narrow-headed Softshell Turtle | EN |
| | Batagur kachuga | Bengal Roof Turtle | CR |
| | Nilssonia gangetica | Indian Softshell Turtle | VU |
| | Hardella thurjii | Crowned River Turtle | VU |
| | Geoclemys hamiltonii | Black Pond Turtle | VU |
| | Nilssonia hurum | Indian Peacock Softshell Turtle | VU |
| | Nilssonia leithii | Leith's Softshell Turtle | VU |
| Anura | Philautus sanctisilvaticus | Sacred Grove Bushfrog | CR |
| Fish | Tor khudree | Black Mahseer | EN |
| | Thynnichthys sandkhol | Sandkhol Carp | EN |
| | Silonia childreni | | EN |
| | Clarias magur | Wagur | EN |
| | Amblyceps arunchalensis | | EN |
| | Ailia coila | Gangetic ailia | NT |
| | Anguilla bengalensis | Indian Mottled Eel | NT |
| | Anguilla bicolor | Shortfin Eel | NT |
| | Bagarius bagarius | | NT |
| | Bagarius yarrelli | | NT |
| | Chitala chitala | | NT |
| | Labeo pangusia | Pangusia labeo | NT |
| | Microphis deocata | | NT |
| | Ompok bimaculatus | | NT |
| | Ompok pabo | | NT |
| | Parambassis lala | Highfin Glassy Perchlet | NT |
| | Wallago attu | | NT |
| Odonata | Indothemis carnatica | | NT |


Legend
Substation
400 kV
220 kV
132 kV
NT_Lindsaea_malabarica2
1
2
No. 20
No. 12
No. 17
No. 05
No. 07
No. 18
No. 22
No. 15
No. 23
No. 06
No. 24
No. 21
No. 10
No. 02
No. 09
No. 11
No. 01
No. 13
No. 19
No. 16
No. 25
N
0 50 100 200 300 400
Kilometers
Legend
Substation
400 kV
220 kV
132 kV
EN_Panthera_tigris
1
No. 20
No. 12
No. 17
No. 05
No. 07
No. 18
No. 22
No. 15
No. 23
No. 06
No. 24
No. 21
No. 10
No. 02
No. 09
No. 11
No. 01
No. 13
No. 19
No. 16
N
0 50 100 200 300 400
Kilometers

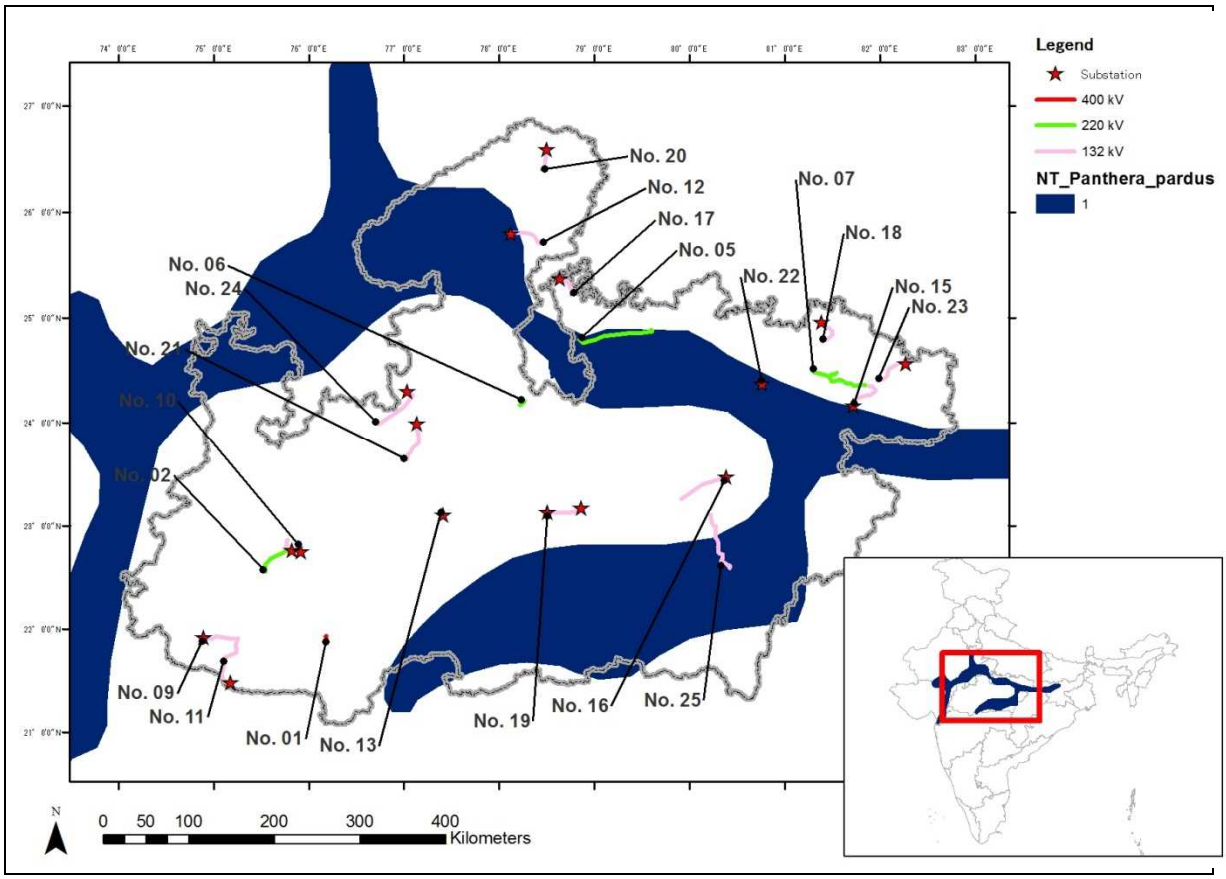



*Figure 6-6 Limited habitat species of protected species*

## 6.3 Social Environment

### 6.3.1 Administrative Boundaries

There are 45 districts in Madhya Pradesh state. The proposed sub-stations and TMLs are located in 26 districts.

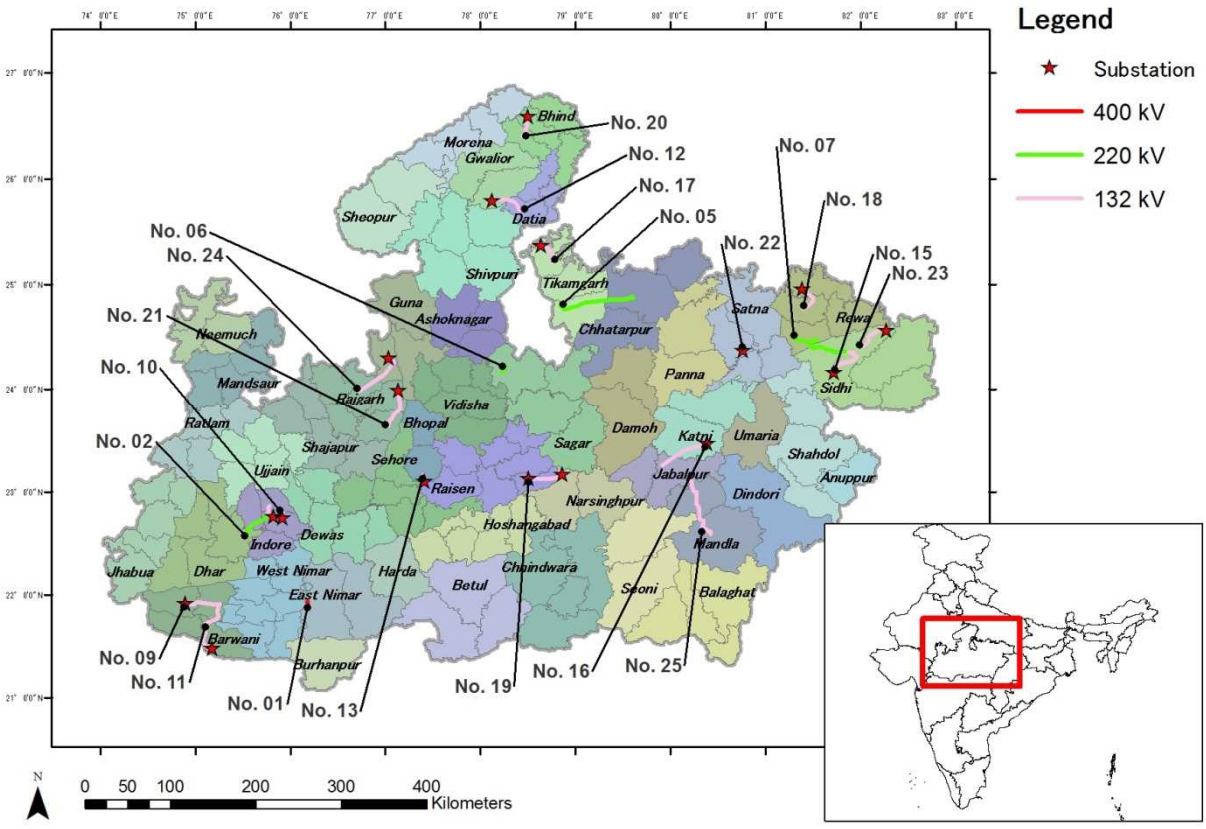



***Figure 6-7 District Map***

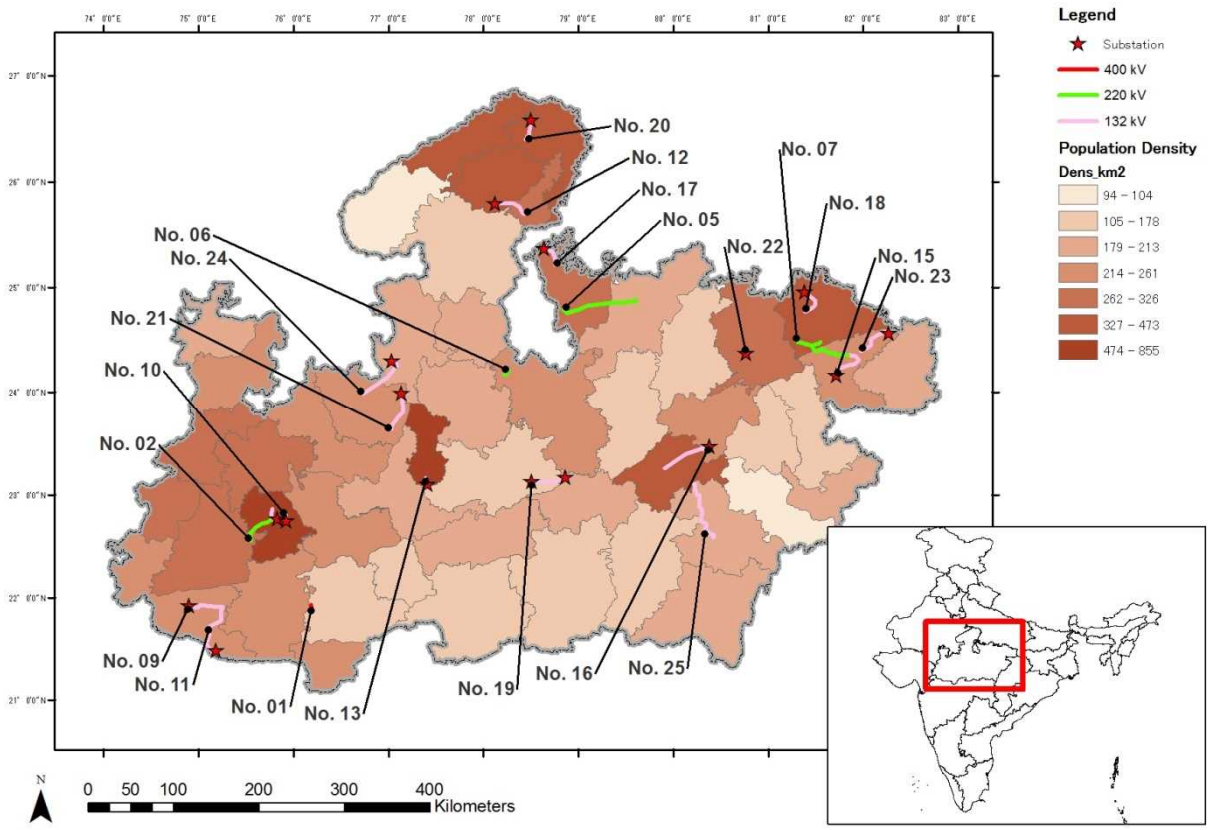
## 6.3.2 Population

According to the 2011 census, around 72.6 million people are living in Madhya Pradesh state. Rural population is 44.4 million (61%) and urban population is 16.0 million (22%). Working population is 25.8 million (36%) including marginal working population. Cultivators are 11.0 million (15%). The highest population district is Indore and the highest population density is Bhopal, which is 855 persons/km2. The highest population growth rate is 32.88 %, Indore district.

***Table 6-5 Population, Growth rate and Population density by District***

| No | District Name | Population (2011) | Population Growth Rate | Area (km2) | Population Density (persons/km2) | Project number |
|---|---|---|---|---|---|---|
| 1 | Indore | 3,276,697 | 32.88% | 3,898 | 841 | 2, 10 |
| 2 | Jabalpur | 2,463,289 | 14.51% | 5,211 | 473 | 16 |
| 3 | Sagar | 2,378,458 | 17.63% | 10,252 | 232 | 6 |
| 4 | Bhopal | 2,371,061 | 28.62% | 2,772 | 855 | 13 |
| 5 | Rewa | 2,365,106 | 19.86% | 6,314 | 375 | 7, 18 |
| 6 | Satna | 2,228,935 | 19.19% | 7,502 | 297 | 22 |
| 7 | Dhar | 2,185,793 | 25.60% | 8,153 | 268 | 2 |
| 8 | Chhindwara | 2,090,922 | 13.07% | 11,815 | 177 | |
| 9 | Gwalior | 2,032,036 | 24.50% | 4,560 | 446 | 12 |
| 10 | Ujjain | 1,986,864 | 16.12% | 6,091 | 326 | |
| 11 | Morena | 1,965,970 | 23.44% | 4,989 | 394 | 3 |
| 12 | West Nimar | 1,873,046 | 22.85% | 8,025 | 233 | 1 |
| 13 | Chhattarpur | 1,762,375 | 19.51% | 8,687 | 203 | 5 |
| 14 | Shivpuri | 1,726,050 | 22.76% | 10,066 | 171 | 12 |
| 15 | Bhind | 1,703,005 | 19.21% | 4,459 | 382 | 20 |
| 16 | Balaghat | 1,701,698 | 13.60% | 9,229 | 184 | |

| No | District Name | Population (2011) | Population Growth Rate | Area (km2) | Population Density (persons/km2) | Project number |
|---|---|---|---|---|---|---|
| 17 | Betul | 1,575,362 | 12.92% | 10,043 | 157 | |
| 18 | Dewas | 1,563,715 | 19.53% | 7,020 | 223 | |
| 19 | Rajgarh | 1,545,814 | 23.26% | 6,153 | 251 | 21, 24 |
| 20 | Shajapur | 1,512,681 | 17.20% | 6,195 | 244 | |
| 21 | Vidisha | 1,458,875 | 20.09% | 7,371 | 198 | 6 |
| 22 | Ratlam | 1,455,069 | 19.72% | 4,861 | 299 | |
| 23 | Tikamgarh | 1,445,166 | 20.13% | 5,048 | 286 | 5, 17 |
| 24 | Barwani | 1,385,881 | 27.57% | 5,427 | 255 | 9, 11 |
| 25 | Seoni | 1,379,131 | 18.22% | 8,758 | 157 | |
| 26 | Mandsaur | 1,340,411 | 13.24% | 5,535 | 242 | |
| 27 | Raisen | 1,331,597 | 18.35% | 8,466 | 157 | 4, 19 |
| 28 | Sehore | 1,311,332 | 21.54% | 6,578 | 199 | |
| 29 | East Nimar | 1,310,061 | 21.50% | 7,352 | 178 | 1 |
| 30 | Katni | 1,292,042 | 21.41% | 4,950 | 261 | 16 |
| 31 | Damoh | 1,264,219 | 16.63% | 7,306 | 173 | |
| 32 | Guna | 1,241,519 | 26.97% | 6,390 | 194 | 24 |
| 33 | Hoshangabad | 1,241,350 | 14.49% | 6,703 | 185 | |
| 34 | Singrauli | 1,178,273 | 28.05% | 5,675 | 208 | |
| 35 | Sidhi | 1,127,033 | 23.72% | 4,851 | 232 | 7, 15, 23 |
| 36 | Narsimhapur | 1,091,854 | 14.01% | 5,133 | 213 | 19 |
| 37 | Shahdol | 1,066,063 | 17.39% | 6,205 | 172 | |
| 38 | Mandla | 1,054,905 | 17.97% | 5,800 | 182 | 25 |
| 39 | Jhabua | 1,025,048 | 30.70% | 3,600 | 285 | |
| 40 | Panna | 1,016,520 | 18.67% | 7,135 | 142 | |
| 41 | Ashoknagar | 845,071 | 22.66% | 4,674 | 181 | |
| 42 | Neemuch | 826,067 | 13.77% | 4,256 | 194 | |
| 43 | Datia | 786,754 | 18.46% | 2,902 | 271 | 12 |
| 44 | Burhanpur | 757,847 | 19.37% | 3,427 | 221 | |
| 45 | Anuppur | 749,237 | 12.30% | 3,747 | 200 | |
| 46 | Alirajpur | 728,999 | 19.45% | 3,182 | 229 | |
| 47 | Dindori | 704,524 | 21.32% | 7,470 | 94 | |
| 48 | Sheopur | 687,861 | 22.94% | 6,606 | 104 | |
| 49 | Umaria | 644,758 | 24.96% | 4,076 | 158 | |
| 50 | Harda | 570,465 | 20.25% | 3,334 | 171 | |




Source: The Office of Registrar General and Census Commissioner of India

***Figure 6-8 Population Density in Madhya Pradesh State***

### 6.3.3 Poverty

According to the 2004 census, the number of people below the poverty line is 25,029,390 and the poverty rate of the state is 38%. The district with the highest poverty rate is Dindori (80.11%); the lowest is Neemuch (7.26%).

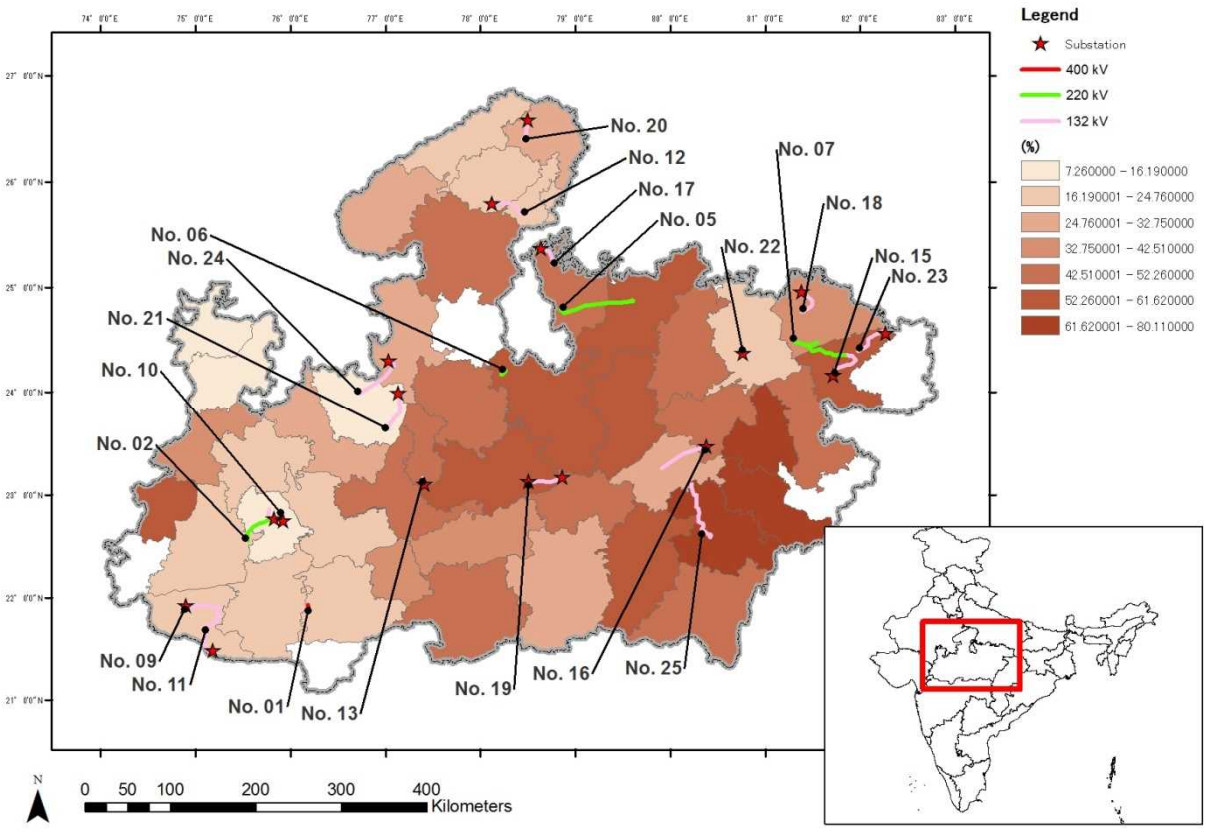



***Figure 6-9 Poverty rate by district***

Source: Census 2004

## 6.3.4 Ethnic Groups

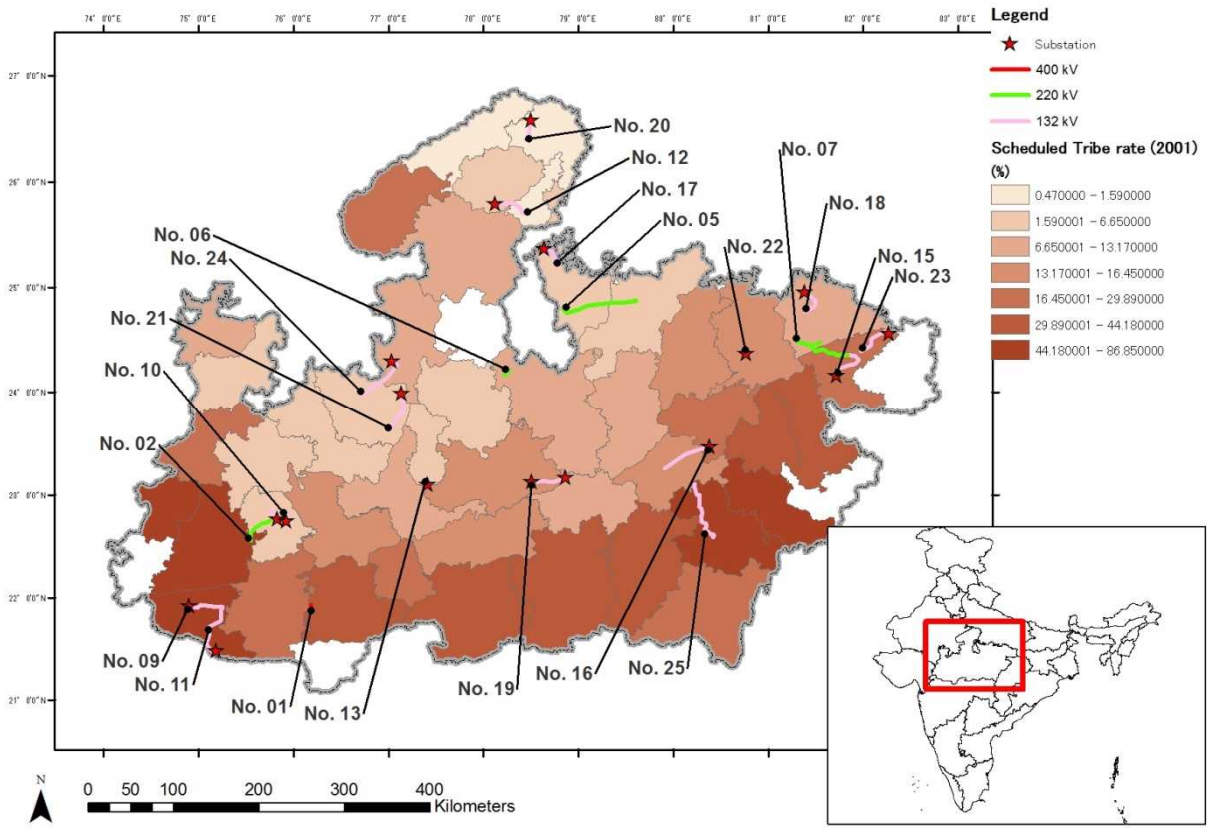
Scheduled Tribes in Madhya Pradesh state are notified as per the Scheduled Castes and Scheduled Tribes Order, 2001 as amended by List of the Scheduled Tribes and Castes in Madhya Pradesh State. According to the list, 46 tribes are in Madhya Pradesh state (see Table 6-6).

***Table 6-6 Scheduled Tribes in Madhya Pradesh State***

| No. | Scheduled Tribes |
|---|---|
| 1. | Agariya |
| 2. | Andh |
| 3. | Baiga |
| 4. | Bhaina |
| 5. | Bharia Bhumia, Bhuinhar Bhumia,Bhumiya, Bharia, Paliha, Pando |
| 6. | Bhattra |
| 7. | Bhil, Bhilala, Barela, Patelia |
| 8. | Bhil Mina |
| 9. | Bhunjia |
| 10. | Biar, Biyar |
| 11. | Binjhwar |
| 12. | Birhul, Birhor |
| 13. | Damor, Damaria |
| 14. | Dhanwar |
| 15. | Gadaba, Gadba |
| 16. | Gond, Arakh, Arrakh, Agaria, Asur, Badi Maria, Bada Maria, Bhatola, Bhimma, Bhuta, |

| No. | Scheduled Tribes |
|---|---|
| | Koilabhuta,Koilabhuti, Bhar, Bisonhom Maria, Chota Maria, Dandami Maria, Dhuru, Dhurwa, Dhoba, Dhulia, Dorla,Gaiki, Gatta, Gatti, Gaita, Gond Gowari, Hill Maria, Kandra, Kalanga, Koitar, Koya, Khirwar, Khirwara, Kucha Maria, Kuchaki Maria, Madia, Maria, Mana, Mannewar, Moghya, Mogia, Monghya, Mudia, Muria, Nagarchi, Nagwanshi, Ojha, Raj, Sonjhari Jhareka, Thatia, Thotya, Wade Maria, Vade Maria, Daroi |
| 17. | Halba,Halbi |
| 18. | Kamar |
| 19. | Karku |
| 20. | Kawar, Kanwar, Kaur, Cherwa, Rathia, Tanwar, Chattri |
| 21. | (Omitted) |
| 22. | Khairwar, Kondar |
| 23. | Kharia |
| 24. | Kondh, Khond, Kandh |
| 25. | Kol |
| 26. | Kolam |
| 27. | Korku, Bopchi, Mouasi, Nihal, Nahul Bondhi, Bondeya |
| 28. | Korwa, Kondaku |
| 29. | Majhi |
| 30. | Majhwar |
| 31. | Mawasi |
| 32. | Omitted |
| 33. | Munda |
| 34. | Nagesia, Nagasia |
| 35. | Oraon, Dhanka, Dhangad |
| 36. | Panika Chhatarpur, Panna, Rewa, Satna, Shahdol, Umaria, Sidhi and Tikamgarh districts, And Sevda and Datia tehsils of Datia district |
| 37. | Pao |
| 38. | Pardhan, Pathari, Saroti |
| 39. | Omitted |
| 40. | Pardhi, Bahelia, Bahellia, Chita Pardhi, Langoli Pardhi, Phans Pardhi, Shikari, Takankar, Takia [In (i) Chhindwara, Mandla, Dindon and Seoni districts, (ii) Baihar Tahsil of Balaghat District, (iii) Betul, Bhainsdehi and Shahpur tahsils of Betul district, (iv) Patan tehsil and Sihora and Majholi blocks of Jabalpur district, (v) Katni (Murwara) and Vijaya Raghogarh tahsils and Bahoriband and Dhemerkheda blocks of Katni district, (vi) Hoshangabad, Babai, Sohagpur, Pipariya and Bankhedi tahsils and Kesla block of Hoshangabad district, (vii) Narsinghpur district, and (viii) Harsud Tahsil of Khandwa district |
| 41. | Parja |
| 42. | Sainariya, Saharia, Seharia, Sehria, Sosia, Sor |
| 43. | Saonta, Saunta |
| 44. | Saur |
| 45. | Sawar, Sawara |
| 46. | Sonr |

Source: ST & SC Development & Welfare Department, Madhya Pradesh Gov.




Source: ST & SC Development & Welfare Department, Madhya Pradesh Gov.

***Figure 6-10 Percentage of Scheduled Tribe Population to Total Population***

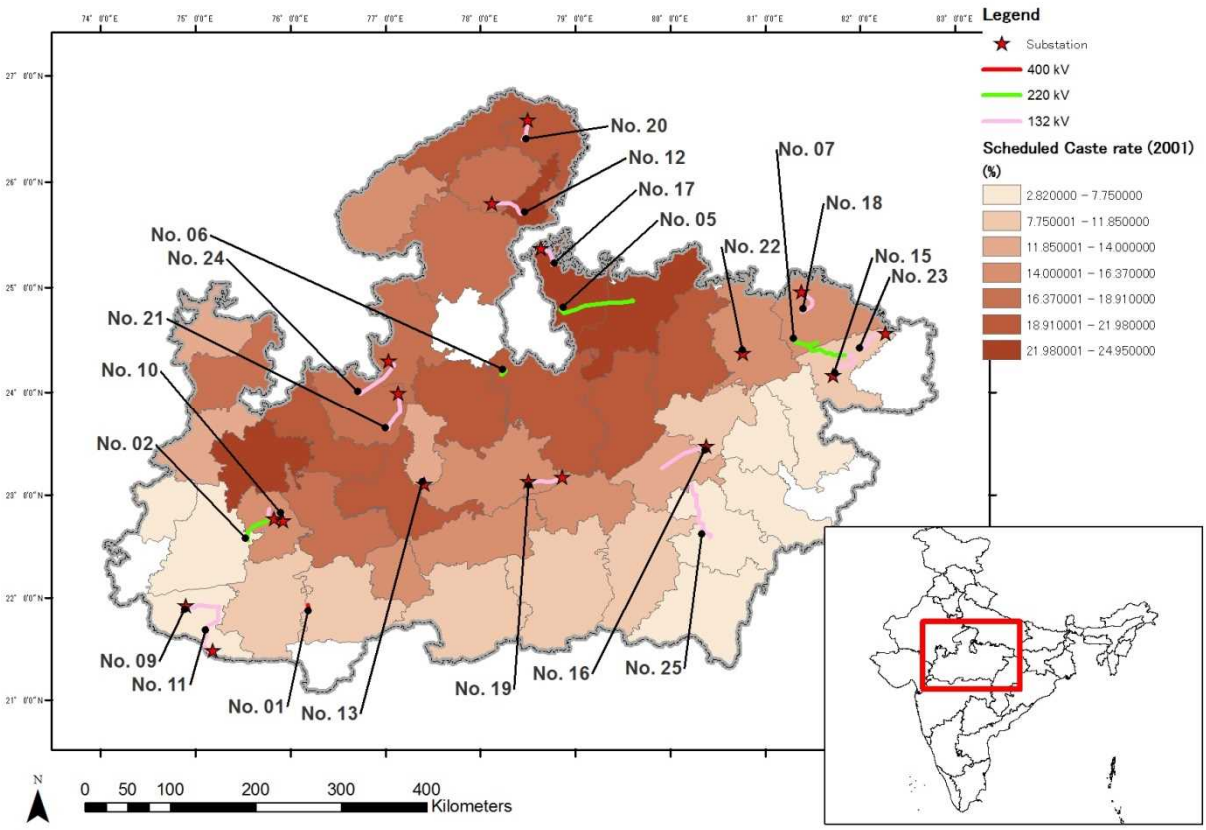
Scheduled Castes in Madhya Pradesh are notified as per the Constitution (Scheduled Castes) Order, 1950, as amended vide Modification Order 1956, Amendment Act, 1976 and the Constitution (Scheduled Castes) Order (Amendment) Act 2002 No. 25 dated 27.5.2002 of the Ministry of Law, Justice and Company Affairs, read with The Constitution (SCs) Order (Second Amendment) Act, 2002 No. 61 of 2002 dated 18.12.2002 of Ministry of Law & Justice republished vide Notification No. 7797-I- Legis-5/2002-L dated 7.6.2003 of Law Dept., Govt. of Orissa and, vide Gazette of India No.381dt.30.8.2007. According to the Order, 95 castes are listed in Madhya Pradesh state (see エラー! 参照元が見つかりません。).

***Table 6-7 Scheduled Castes in Madhya Pradesh State***

| Sl. | Scheduled Castes |
|---|---|
| 1. | Audhelia |
| 2 | Bagri, Bagdi (excluding Rajput, Thakur sub-castes among Bagri, Bagdi) |
| 3. | Bahna, Bahana |
| 4. | Balahi, Balai |
| 5. | Banchada |
| 6. | Barahar Basod |
| 7. | Bargunda |
| 8. | Basor, Burud, Bansor, Bansodi, Bansphor, Basar |
| 9. | Bhanumati |
| 10. | Beldar, Sunkar |
| 11. | Bhangi, Mehtar, Balmiki, Lalbegi, Dharkar |
| 12. | Bhanumati |
| 13. | Chadar |
| 14. | Chamar, Chamari, Bairwa, Bhambhi, Jatav, Mochi, Regar, Nona, Rohidas, Ramnami, Satnami, Surjyabanshi, surjyaramnami, Ahirwar, Chamar, Mangan, Raidas |
| 15. | Chidar |

| Sl. | Scheduled Castes |
|---|---|
| 16. | Chikwa, Chikvi |
| 17. | Chitar |
| 18. | Dahait, Dahayat, Dahat |
| 19. | Dewar |
| 20. | Dhanuh |
| 21. | Dhed, Dher |
| 22. | Dhobi(in Bhopal, Raisen and Sehore distirct) |
| 23. | Dohor |
| 24. | Dom, Dumar, Dome, Domar, Doris |
| 25. | Ganda, Gandi |
| 26. | Ghasi, Ghasia |
| 27. | Holiya |
| 28. | Kanjar |
| 29. | Katia, Patharia |
| 30. | Khatik |
| 31. | Koli, Kori |
| 32. | Kotwal (in Bhind, Dhar, Dewas, Guna, Gwalior, Indore, Jhabua, Khargone, Mandsaur, Morena, Rajgarh, Ratlam, Shajapur, Shivpuri Ujjain and Vidisha Districts) |
| 33. | Khangar, Kanera, Mirdha |
| 34. | Kuchbandhia |
| 35. | Kumar (in Chhatarpur, Datia, Panna, Rewa, Satna, Shahdol, Sidhi and Tikamgarh districts) |
| 36. | Mahar, Mehra, Mehar, Mahara |
| 37. | Mang, Mang Garodi, Mang Garudi, Dankhani Mang, Mang Mahashi, Madari, Garudi, Radhe Mang |
| 38. | Meghwal |
| 39. | Moghia |
| 40. | Muskhan |
| 41. | Nat, Kalbelia, Sapera, Navdigar, Kubutar |
| 42. | Pardhi (in Bhind, Dhar, Dewas, Guna, Gwalior, Indore, Jhabua, Khargone, Mandsaur, Morena, Rajgarh, Ratlam, Shajapur, Shivpuri, Ujjain and Vidisha) |
| 43. | Pasi |
| 44. | Rujjhar |
| 45. | Sansi, Sansia |
| 46. | Silawat |
| 47. | Zamral |
| 48. | Sargara |

Source: ST & SC Development & Welfare Department, Madhya Pradesh Gov.

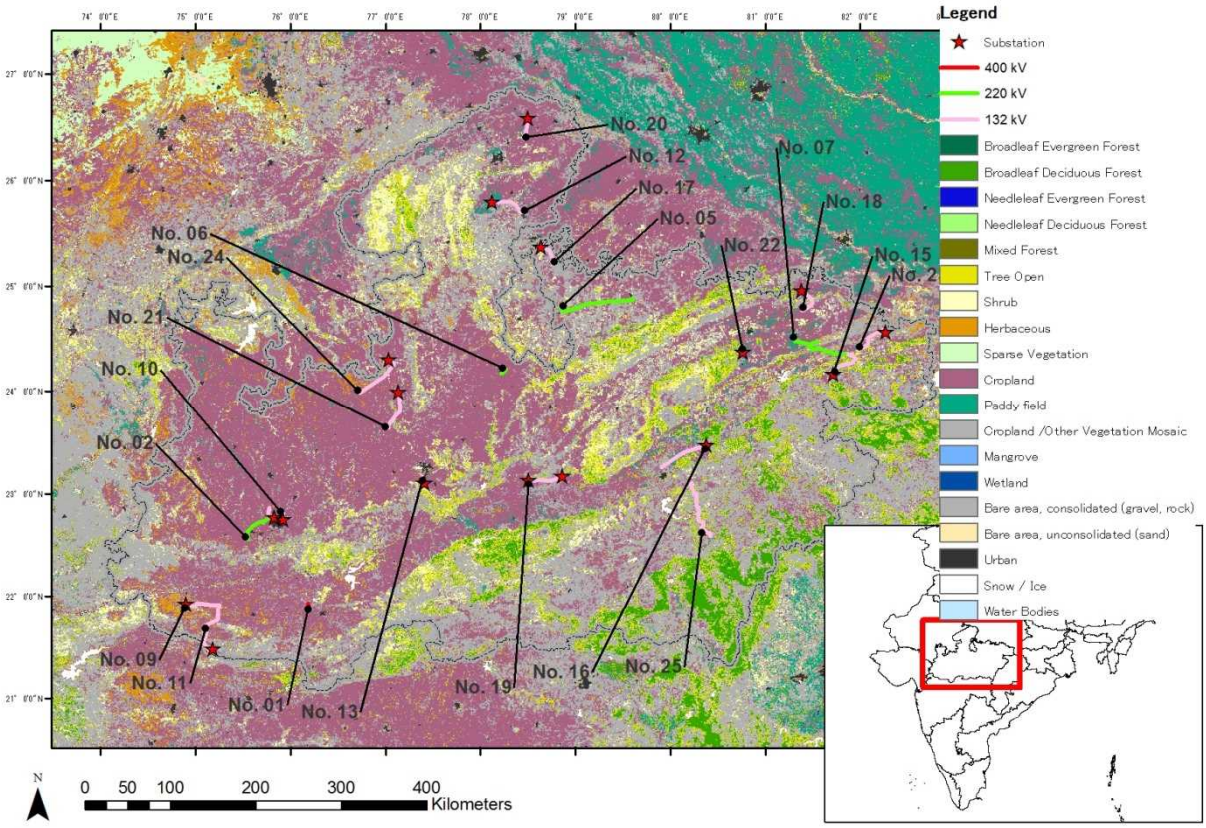



Source: ST & SC Development & Welfare Department, Madhya Pradesh Gov.

***Figure 6-11 Percentage of Scheduled Caste Population to Total Population***

### 6.3.5 Land Use

Land use in Madhya Pradesh state is a mixture of Cropland, Tree open and Needle leaf Deciduous Forest. Forests are located in the southern high mountainous area and most of the lower areas are used for agriculture (see Figure 6-12).




Source: Land use map, International Steering Committee for Global Mapping (ISCGM)

***Figure 6-12 Land use in Madhya Pradesh state***

# 7 Environmental Impacts

## 7.1 Physical Environmental Impact

### 7.1.1 Air Pollution

**Construction Stage:** Vehicle exhaust from construction vehicles might cause air pollution. The dust caused by transportation vehicles might affect the people along the access roads. The affected area would be limited to around the construction area and transportation route. The impact is limited to the construction period. The impact will not be serious because it is confined only to the construction period.

### 7.1.2 Global Warming

**Operation Stage:** Global warming might be an issue of concern when sulfur hexafluoride (SF6)) is accidentally released from the GIS during maintenance. SF6 gas is a non-toxic, odorless and harmless gas.

Four feeders of 220 kV GIS will be installed in the Super Corridor (Indore) 220kV Substation. The average volume of SF6 per GIS would be 13.27m3 (under 0.6 Mpa). Therefore, a total of approximately 53.08 m3 of SF6 shall be used in this Project. Usually the SF6 gas is completely enclosed in the GIS and there is hardly any leakage. However, the probability of leakage of SF6 gas would be slightly higher during the gas treatment work at the time of maintenance. If the gas can be gathered in the specific way recommended by the manufacturer, then the amount of SF6 released into the atmosphere will be very low. The maintenance is performed annually per one GIS.

### 7.1.3 Water Pollution

**Construction Stage:** Water might become turbid at the tower area during construction if towers are located in steep and/or soft soil areas which are not managed adequately. 3,029 towers are planned in the Project, but their exact locations are not fixed yet. Therefore, the exact impact cannot be anticipated.

**Operation Stage:** Human sewage from substations might cause water pollution. All of the domestic waste water from the 16 new substations will be treated by septic tank or sewage system, so it will not cause serious problems.

### 7.1.4 Soil Erosion and Landslides

**Construction Stage:** Slope failures or landslides at the construction site might be caused at the tower points of the transmission lines, if towers are located in unstable steep areas. In the case that the design and construction methods are not suitable for the land, 3,289 tower points which are planned in the Project might be affected. Because the locations are not exactly fixed at this stage, the high risk locations are not clearly known.

### 7.1.5 Waste

**Construction Stage:** Cleared vegetation and domestic waste from workers will be produced at the project sites during construction. The removed plants and domestic waste will be treated by a contractor. The impact will not be serious if proper measures are taken.

**Operation Stage:** Damaged parts from substations and transmission lines might become industrial waste during the operation stage. The main materials would be iron, copper, ceramics, and plastic. None of them are toxic to human health. The volume would be 2kg/year per one substation and 136 kg/km of transmission line per year. This industrial waste will be carried out of the substation following Indian waste management rules (S.O No. 1035 (E), [12/05/2011] - E-waste Management and Handling Rules 2011) for all domestic and industrial waste including hazardous waste.

### 7.1.6 Noise and Vibration

**Construction Stage:** Construction vehicles might cause noise impacts on the people and wildlife around 100m from the construction site. The affected areas are not clear but the impact would not be serious because most of the locations would be in rural areas and these impacts would be temporary. MPPTCL's safety rules stipulated at the construction site will prevent serious impact.

**Operation Stage:** Sometimes, cooling fans and transformers in substations might cause noise impacts on houses around the substations. The impact area of the fans and transformers would be 100m around the facilities. The number of affected houses is not clear. Because locations would be in rural areas, the number of the affected houses would not be high.

### 7.1.7 Electromagnetic Waves

**Operation Stage:** Electromagnetic waves will be released from transformers, beakers and transmission lines. The estimated level of electromagnetic waves under the transmission line would be less than 20μT and electromagnetic waves at the boundary of the substation would be less than 4μT. Therefore, there will be no impact on the persons who are living near the facilities.

### 7.1.8 Radio Interference

**Operation Stage:** Radio interference might happen around the transmission lines and substations. The possible affected area would be 100-300m around the facilities. The number of affected houses cannot be identified at this stage. If mitigation measures are taken, the impact will be compensated for.

## 7.2 Natural Environmental Impact

### 7.2.1 Protected Areas

**Construction Stage:** Indian Forest Act 1927 does not allow any activities in the Reserved Forests (National Park, Sanctuary, and Eco-Sensitive zone) except for the permitted activities. All the sub-projects which affect protected areas are excluded from the proposed project.

### 7.2.2 Protected Species and Ecosystem

Some project locations fall in the known habitats of IUCN red-list species. In terms of Mammals, the habitats of two Endangered species, six Vulnerable species and three Near Threatened species are covered in some project locations. All the sub-projects are located outside of the known Tiger habitats but some of them, such as No.15, 16, 18, and 25, are near the habitats. The sub-projects might not affect the habitat seriously but the ROWs might be used by Tigers. If important corridors are fragmented, the gene level biodiversity will be lowered and the risk of regional extinction will be higher. If the important hunting areas are decreased, the number of individuals will be lowered. If the project cause expansion of the human habitat towered the wildlife habitat, the conflict between people and rare species will be increased. If the ROW make easier for the people to access the habitat, pouching risk will be increased.

***Table 7-1 Protected species and project locations***

| No. | Name | EN | VU | NT |
|---|---|---|---|---|

| | | Cuon alpinus* | Hipposideros durgadasi* | Manis crassicaudata | Panthera tigris* | Bos gaurus | Lutrogale perspicillata | Melursus ursinus | Prionailurus rubiginosus | Rucervus duvaucelii* | Rusa unicolor | Tetracerus quadricornis | Antilope cervicapra | Hyaena hyaena | Panthera pardus* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | LILO of one circuit of 400kV Khandwa - Rajgarh PGCIL line at Chhegaon 400kV Substation (D/C) | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| | 400kV Bus Reactor at Chhegaon 400kV S/S | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| 2 | Pithampur400-Super Corridor 220kV DCDS line | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| | LILO of One ckt of Indore (Jetpura) - Depalpur 132kV DCDS Line at Super Corridor (Indore) 220kV S/s. (D/C) | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| 4 | Charging/Upgradation of Chichli 220 - Udaipura DCDS line on 220kV level | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| 5 | Chhatarpur-Tikamgarh 220kV DCSS line | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | 1 |
| 6 | 400/220kV Additional Transformer at Bina 400kV S/S | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| | LILO of Bina 220 - Ganjbasoda 220kV line at Bina (MPPTCL) 400kV S/s | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| 7 | Rewa 220 - Sidhi 220kV DCDS line through Rewa UMSP | 1 | - | 1 | - | - | 1 | 2 | - | - | 1 | 1 | 1 | 1 | - |
| 9 | Julwania 400 - Pati (Silawad) 132kV DCSS Line | - | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| 10 | Mangliya 220 - Mahalaxmi 132kV DCDS Line | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| 11 | Julwania 400 - Shahpura 132kV DCSS Line | - | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| 12 | Datia220 - Bhitarwar 132kV DCSS Line | - | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | 1 |
| 13 | MugaliaChhap 220 - Mahwadia 132kV DCDS Line | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| 15 | Sidhi 220 - Madwas 132kV DCSS Line | 1 | - | 1 | - | - | 1 | 2 | - | - | 1 | 1 | 1 | 1 | 1 |
| 16 | Panagar 220 - Dheemarkheda 132kV DCSS Line | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| 17 | Prithivipur-Orchha 132kV DCSS Line | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| 18 | Sirmour220 - Atraila 132kV DCSS line | 1 | - | 1 | - | - | 1 | 2 | - | - | 1 | 1 | 1 | 1 | - |
| 19 | Udaipura - Tendukheda 132kV DCSS line | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| 20 | Gohad - Gormi 132kV DCSS line | - | - | 1 | - | - | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | - |
| 21 | Narsinghgarh - Suthaliya 132kV DCSS line | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| 22 | LILO of Satna 220 - Kymore 132kV line at Unchhera 132kV S/s | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | 1 |
| 23 | LILO of one ckt of Sidhi 220 - Deosar 132kV line at Sinhawal 132kV S/s | 1 | - | 1 | - | - | 1 | 2 | - | - | 1 | 1 | 1 | 1 | - |
| 24 | 2nd ckt of Rajgarh (B) - Raghogarh 132kV DCSS line up to Chachoda 132kV S/s | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | - |
| 25 | Maneri - Mandla 132kV DCSS line | 1 | - | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | 1 |

*: The figures show the following conditions

| Code | Origin |
|---|---|
| 1 | Extant |

| | |
|---|---|
| 2 | Probably Extant |
| 3 | Possibly Extant |
| 4 | Possibly Extinct |
| 5 | Extinct (Post 1500) |
| 6 | Presence Uncertain |

Source: IUCN

### 7.2.3 Forest

All the substations are planned outside of forest areas. Total length of TML which passes through forest area is 24.2 km, 67.7 ha in total.

***Table 7-2 Affected forest area by ROW***

| No | Project Name | Transmission line [km] | ROW [ha] |
|---|---|---|---|
| 7 | Rewa220 – Sidhi 220kV DCDS line through Rewa UMSP | 3.0 | 10.5 |
| 9 | Julwania400 – Pati (Silawad) 132kV DCSS Line | 0.5 | 1.4 |
| 11 | Julwania400 – Shahpura 132kV DCSS Line | 6.0 | 16.2 |
| 13 | MugaliaChhap 220 - Mahwadia 132kV DCDS Line | 1.5 | 4.1 |
| 15 | Sidhi 220 - Madwas 132kV DCSS Line | 0.2 | 0.5 |
| 17 | Prithivipur-Orchha 132kV DCSS Line | 2.0 | 5.4 |
| 18 | Sirmour220 - Atraila 132kV DCSS line | 1.0 | 2.7 |
| 23 | Sidhi 220 - Sinhawal 132kV DCSS line | 1.0 | 2.7 |
| 25 | Maneri - Mandla 132kV DCSS line | 9.0 | 24.3 |
| | Total | 24.2 | 67.7 |

## 7.3 Social Environmental Impact

### 7.3.1 Resettlement and Land acquisition

**Construction Stage:** The locations of TML routes and SS will be carefully selected to avoid residential places, including illegal settlements, so there is very little possibility of resettlements. But it has not been completely confirmed that all the squatters are avoided, because the routes are still tentative and no site surveys are conducted. MPPTCL has no experience of resettlement over 20 years. MPPTCL doesn't need to acquire the land under the ROW. The land for the SSs will not require expropriation of private land, because all the areas will be allocated by the government.

### 7.3.2 Land use restriction

**Construction Stage:** Some agricultural activities under the ROW will be stopped during construction.

**Operation Stage:** In order to keep clearance between land and transmission lines, land use in the ROW will be restricted. Construction of houses, structures more than 4 m, and tree planting higher than 4 m will not be allowed. But as long as the clearance is kept the area can be used as agricultural land and grazing ground. Natural tree sprouts should be cleared by MPPTCL on a regular basis to keep clearance between ground and lines. The number of affected land owners and peasants has not been cleared yet.

### 7.3.3 Local Heritage

**Construction Stage:** Local heritage, including buried cultural property, in the project site will not be allowed by the Site Selection Committee, so there is very little possibility of their being affected by the project.

### 7.3.4 Landscape

**Construction Stage:** Most of the sub-projects are more than 10 km from National parks and sanctuaries. Sub-project No.13 (MugaliaChhap 220 - Mahwadia 132kV DCDS Line) is located less than 10 km away but it is 6.5km away from the Vanvihar National Park. Therefore, no serious landscape impact is predicted.

### 7.3.5 Ethnic Minorities and Indigenous People

**Construction Stage:** Ethnic minorities and indigenous people might be affected by land acquisition/resettlement. Exact locations and numbers are not clear at this stage.

### 7.3.6 Public Health

**Construction Stage:** Infectious diseases such as HIV/AIDS might be brought in by workers during the construction stage. The number of workers during the construction period would be 10 persons for 14 days per TML tower and 15 persons for 180 days per SS. Total man-days would be 45,059. The risk is not so high because they are not staying in one location for a long time like with hydropower plant construction, highway construction or mining activities. MPPTCL has never experienced HIV/AIDS problems so far.

### 7.3.7 Accidents

**Operation Stage:** Tower failures and electrification might happen when too strong wind comes or people touch high voltage facilities. The risk would be lower if adequate mitigation measures are taken. According to past MPPTCL experience, 3 fatal accidents and 4 non-fatal accidents have been recorded in two years. Therefore, one or two accidents per year is estimated.

***Table 7-3 Accidents in the MPPTCL areas (2013-2015)***

| Date of accident | Fatal/Non-Fatal | Name of the lines |
|---|---|---|
| 13-May-2013 | - | 132kV Southzone-Satyasai |
| 25-Feb-2014 | Fatal | 132kV Southzone-Chambal line |
| 14-Feb-2014 | Fatal | 132kV Southzone-Mangaliya line |
| 4-Oct-2014 | - | 132kV Chambal-Satyasai line |

### 7.3.8 Working Safety

**Construction Stage:** Worker accidents such as car accidents, falling etc. might happen during construction. MPPTCL has experienced some accidents so far. An average of two fatal accidents happened per 1,000 km of TML construction. Therefore, one accident is estimated for 932 km of TML construction.

**Operation Stage:** Workers' accidents such as electrification, falling etc. might happen during operation. MPPTCL has had no experience of worker injury at substations so far. Therefore, the possibility of workers' accidents would be very low.

***Table 7-4 Accidents in the MPPTCL areas (2013-2015)***

| Date of accident | Fatal/Non-Fatal | Name of the lines |
|---|---|---|
| 16-Jun-2014 | - | 220kV S/s Nayagaon-Jabalpur line |
| 20-Jun-2014 | Fatal | 220kV Bhopal-Sukhisevaniya line |
| 21-May-2015 | - | 220kV Satna-SGTPS Birsinghpur line |

# 8 Analysis of Alternatives

The main alternative designs have been examined before project proposal. Some of the projects were excluded because of impacts on forest or protected areas. Other alternative routes will be selected to minimize resettlements and the impact on forest during the detailed design stage too. For example first design was designed without consideration the protected areas and forests but after checking the locations of the protected areas and forest area, the routes are changed and cancelled to minimize the forest area. Then the affected forest length was reduced from 86.6 km to 24.2 km.

***Table 8-1 Changed and cancelled routes***

| Project No | Voltage | Previous Plan | | | Revised Plan | | | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | Protected Area | Forest | Total | Protected Area | Forest | Total | |

| | | (km) | (km) | (km) | (km) | (km) | (km) | |
|---|---|---|---|---|---|---|---|---|
| 3 | 220 | 0.0 | 55.0 | 55.0 | 0.0 | 0.0 | 0.0 | Cancelled |
| | 132 | 2.5 | 10.0 | 12.5 | 0.0 | 0.0 | 0.0 | Cancelled |
| 7 | 220 | 0.0 | 1.0 | 1.0 | 0.0 | 3.0 | 3.0 | |
| 8 | 132 | 7.0 | 0.0 | 7.0 | 0.0 | 0.0 | 0.0 | Cancelled |
| 9 | 132 | 0.0 | | 0.0 | 0.0 | 0.5 | 0.5 | |
| 11 | 132 | 0.0 | 6.0 | 6.0 | 0.0 | 6.0 | 6.0 | |
| 13 | 132 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 | 1.5 | |
| 14 | 132 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | Cancelled |
| 15 | 132 | 0.0 | 1.0 | 1.0 | 0.0 | 0.2 | 0.2 | |
| 17 | 132 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 2.0 | |
| 18 | 132 | 0.0 | 1.5 | 1.5 | 0.0 | 1.0 | 1.0 | |
| 23 | 132 | 0.0 | | 0.0 | 0.0 | 1.0 | 1.0 | |
| 25 | 132 | 0.0 | 12.0 | 12.0 | 0.0 | 9.0 | 9.0 | |
| Total | | 9.5 | 86.5 | 96.0 | 0.0 | 24.2 | 24.2 | |

# 9 Environmental Management Plan

## 9.1 Mitigation Plan

### 9.1.1 Physical Environment

#### 9.1.1.1 Global Warming

**Operation Stage:** GIS is a very hermetically-sealed system, so less than 0.5 % of the sealed SF6 gas per year might be released. In order to check the GIS, all the SF6 gas should be removed and the GIS opened every 12 years. More than 80% of the SF6 gas will be collected and it will be reused after maintenance. The maintenance cost would be 148,688 Rs. per one GIS. Therefore, a total of 594,751 Rs./year is required for the mitigation. This will be covered by operation costs.

#### 9.1.1.2 Water Pollution

**Construction Stage:** MPPTCL will strictly follow the construction rules to minimize turbid water. The rules are as follows.

- Slope areas of more than 10 degrees should not be selected as locations of TML towers.
- Sedimentation ponds should be settled if turbid water is anticipated.

#### 9.1.1.3 Soil Erosion and Landslides

**Construction Stage:** MPPTCL will strictly follow the construction rules to minimize erosion and landslides. The rules are as follows. By adhering to them, the risk of landslides and slope failures will be avoided.

- Slope areas of more than 10 degrees should not be selected as locations of TML towers.
- Geological boring exploration should be done before detailed design.
- High risk landslide areas should be avoided for TML towers.
- Erosion prevention techniques should be adopted for slope areas.
- After construction, bare ground should be covered by vegetation.

#### 9.1.1.4 Waste

**Construction Stage:** MPPTCL will manage construction waste properly. The following rules will be adopted for all the subprojects.

- Cleared trees and vegetation should be given to the land owners.
- Demolition waste should be taken to an industrial waste dumping site.
- Portable toilets and separated garbage boxes should be installed at the project site.
- No domestic garbage is allowed to be thrown out at the construction site.

The cost for the mitigation will be included in the construction cost.

**Operation Stage:** MPPTCL has the following waste management rules and they will be adopted at all the substations. Therefore, the impact will be totally minimized.

- Damaged parts should be divided by type (metal, glass, plastic, and flammable) and collected in a waste storage place.
- The waste should be sold to a registered waste collection company.

- Produced waste should be recorded by date, type, volume, and price.

#### 9.1.1.5 Noise and Vibration

**Construction Stage:** In order to minimize the noise and vibration impact, the following measures will be taken.

- Noise source in the substation should be located more than 30m from residential areas.
- The substation should be designed to reduce the noise at the boundary of the compound to adhere to the noise standards of India (Noise Pollution (Regulation and Control) Rules, 2000).
- If residents around the substation complain about the noise, soundproof covers or sound insulation walls should be examined.

Mitigation cost will be managed by operation costs.

#### 9.1.1.6 Radio Interference

**Construction Stage:** Radio interference will be completely mitigated by the following compensation rules.

- MPPTCL will inform neighboring communities about the project.
- MPPTCL will establish a special client liaison.
- If MPPTCL receives any complaints about radio interference, it will check the conditions and install community reception antennae.

The mitigation cost would be managed by operation costs.

### 9.1.2 Natural Environment

#### 9.1.2.1 Protected Species and Ecosystem

**Construction Stage:** MPPTCL has already selected the routes to avoid the forest areas. But there are some sub-projects which locations are near to the Tiger reserve (No.15, 16, 18, and 25) and distribution areas of leopard. Sub-project No.19 and No. 4 is in the area of *Lindsaea malabarica*. In order to avoid fragmentation of the corridors or extinction by invasive species, careful considerations are required. Then before the routes would be finalized, MPPTCL will discuss with Wildlife Department and Forest Department about the routes and vegetation management under the ROW. Possible mitigation measures are as follows.

During planning

- Based on the biological survey result, change the TML route
- Change the height of the towers to keep higher the vegetation
- Planning compensation planting to protect the habitat

During construction

- Consider construction time schedule to keep corridor to the affected species

**Operation Stage:** If the Wildlife Department gives any instructions, MPPTCL should follow them adequately. The possible mitigation might be vegetation control under the right of way, installation of the access rules, conducting poaching patrol and so on.

#### 9.1.2.2 Forest

**Construction Stage:** Forest areas affected by substations and the ROW must be compensated for based on the Forest (Conservation) Act, 1980, amended 1988. Trees cut by the project should be planted at a 1:10 rate. Compensation for plantation will be charged by the Forest Department after site survey. The estimated compensation cost would be 216 million Rs (see Table 9-1). Forest department will plant trees in order to mitigate the cleared forest.

***Table 9-1 Forest compensation cost***

| No. | Name | Forest [km] | ROW [ha] | Cost As per Estimate [INR] |
|---|---|---|---|---|
| 7 | Rewa (UMSP) - Sidhi 220 DCDS line | 3.0 | 10.5 | 33,495,000 |
| 9 | Julwania 400 - Pati (Silawad) 132kV DCSS Line | 0.5 | 1.4 | 4,466,000 |
| 11 | Julwania 400 - Shahpura 132kV DCSS Line | 6.0 | 16.2 | 51,678,000 |
| 13 | MugaliaChhap 220 - Mahwadia 132kV DCDS Line | 1.4 | 4.1 | 13,079,000 |
| 15 | Sidhi 220 - Madwas 132kV DCSS Line | 0.2 | 0.6 | 1,914,000 |
| 17 | Prithivipur-Orchha 132kV DCSS Line | 2.0 | 5.4 | 17,226,000 |
| 18 | Sirmour 220 - Atraila 132kV DCSS line | 1.0 | 2.7 | 8,613,000 |
| 23 | Sidhi 220 - Sinhawal 132kV DCSS line | 1.0 | 2.7 | 8,613,000 |
| 25 | Maneri - Mandla 132kV DCSS line | 9.0 | 24.3 | 77,517,000 |

| | | | |
|---|---|---|---|
| Total | 24.1 | 67.9 | 216,601,000 |

Source: MPPTCL

## 9.1.3 Social Environment

#### 9.1.3.1 Resettlement

**Construction Stage:** Most resettlement will be avoided during the design stage. But if any resettlement issues happen, MPPTCL will follow the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013.

#### 9.1.3.2 Land Use

**Construction Stage:** In terms of Sub-stations MPPTCL does not need to purchase private land because all of the lands will be government land, directly from the land owner. In terms of ROW, MPPTCL will not need to purchase the land but MPPTCL has to pay compensation for the agricultural crops during construction. Estimated affected crop lands would be 2,736.9 ha and the compensation cost would be 183 million Rs.

***Table 9-2 Land compensation cost***

| No. | Name | Length [km] | ROW [ha] | Unit Cost*1 [INR/ha] | Cost As per Estimate [INR] |
|---|---|---|---|---|---|
| 1 | LILO of one circuit of 400kV Khandwa - Rajgarh PGCIL line at Chhegaon 400kV Substation (D/C) 400kV Bus Reactor at Chhegaon 400kV S/S | 5.0 | 26.0 | 40,192 | 1,045,000 |
| 2 | Pithampur 400-Super Corridor 220kV DCDS line LILO of One ckt of Indore (Jetpura) - Depalpur 132kV DCDS Line at Super Corridor (Indore) 220kV S/s. (D/C) | 63.0 | 210.1 | 60,995 | 12,815,000 |
| 5 | Chhatarpur-Tikamgarh 220kV DCSS line | 110.0 | 385.0 | 56,000 | 21,560,000 |
| 6 | 400/220kV Additional Transformer at Bina 400kV S/S LILO of Bina 220 - Ganjbasoda 220kV line at Bina (MPPTCL) 400kV S/s | 10.0 | 35.0 | 64,429 | 2,255,000 |
| 7 | Rewa 220 - Sidhi 220kV DCDS line through Rewa UMSP | 90.0 | 315.0 | 58,342 | 18,378,000 |
| 9 | Julwania 400 - Pati (Silawad) 132kV DCSS Line | 40.0 | 108.0 | 72,199 | 7,798,000 |
| 10 | LILO of Mangliya 220 –Indore 132kV Line at Mahalaxmi | 3.0 | 8.1 | 74,691 | 605,000 |
| 11 | Julwania 400 - Shahpura 132kV DCSS Line | 65.0 | 175.5 | 78,374 | 13,755,000 |
| 12 | Datia 220 - Bhitarwar 132kV DCSS Line | 40.0 | 108.0 | 72,315 | 7,810,000 |
| 13 | MugaliaChhap 220 - Mahwadia 132kV DCDS Line | 10.0 | 27.0 | 83,878 | 2,265,000 |
| 15 | Sidhi 220 - Madwas 132kV DCSS Line | 50.0 | 135.0 | 73,219 | 9,885,000 |
| 16 | Panagar 220 - Dheemarkheda | 65.0 | 175.5 | 72,707 | 12,760,000 |

| | | | | | |
|---|---|---|---|---|---|
| | 132kV DCSS Line | | | | |
| 17 | Prithivipur-Orchha 132kV DCSS Line | 30.0 | 81.0 | 83,664 | 6,777,000 |
| 18 | Sirmour 220 - Atraila 132kV DCSS line | 35.0 | 94.5 | 74,292 | 7,021,000 |
| 19 | Udaipura - Tendukheda 132kV DCSS line | 45.0 | 121.5 | 71,523 | 8,690,000 |
| 20 | Gohad - Gormi 132kV DCSS line | 25.0 | 67.5 | 74,963 | 5,060,000 |
| 21 | Narsinghgarh - Suthaliya 132kV DCSS line | 50.0 | 135.0 | 72,111 | 9,735,000 |
| 22 | LILO of Satna 220 - Kymore 132kV line at Unchhera 132kV S/s | 5.0 | 13.5 | 89,630 | 1,210,000 |
| 23 | Sidhi 220 - Sinhawal 132kV DCSS line 132kV | 50.0 | 135.0 | 74,414 | 10,046,000 |
| 24 | 2nd ckt of Rajgarh (B) - Raghogarh 132kV DCSS line up to Chachoda 132kV S/s | 61.0 | 164.7 | 40,540 | 6,677,000 |
| 25 | Maneri - Mandla 132kV DCSS line | 80.0 | 216.0 | 80,334 | 17,353,000 |
| total | | 932.0 | 2,736.9 | 1,468,810 | 183,497,000 |

Note *1: Unit Cost is calculated based on Cost as per estimate from MPPTCL.

Source: MPPTCL

**Operation Stage:** The land use will be restricted for building construction and tree or crop planting over 4 m. There will be no compensation for this impact based on .

***Table 9-3 Entitlement Matrix of Land Use compensation***

| Item No. | Type of loss | Entitled Persons (Beneficiaries) | Entitlement (Compensation Package) | Implementation issues/Guidelines | Responsible Organization |
|---|---|---|---|---|---|
| 1. | Stop cropping (during construction) | The land owners and peasants under the right of way | Crop compensations | Values estimated by Revenue Department | Revenue Department |
| 2. | Restrict construction buildings (during operation) | The land owners under the right of way | Nothing | Nothing/ Indian Electricity Act-2003 | MPPTCL |
| 3. | Restrict planting (During operation) | The land owners and peasants under the right of way | Nothing | Nothing/ Indian Electricity Act-2003 | MPPTCL |

#### 9.1.3.3 Local Heritage

**Construction Stage:** Impacts on local heritage, including temples, holy trees, historical rocks, or local cemeteries, might be revealed at the site survey by the Revenue Department. If any serious impacts are expected, MPPTCL should follow the instructions from the Revenue Department.

#### 9.1.3.4 Ethnic Minorities and Indigenous People

**Construction Stage:** If impacts on ethnic minorities and indigenous people are identified during the detailed design stage, compensation must be provided based on the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013.

#### 9.1.3.5 Public Health

**Construction Stage:** Even if the risk of infectious diseases is not high, MPPTCL will provide a public health program for all the workers before construction. The program includes:

- Education on the propagation mechanisms of infectious diseases including HIV/AIDS
- Instruction on precautions for infectious diseases
- Instruction on examination for infectious diseases, and
- Instruction on handling methods for infectious diseases.

The program preparation cost would be around USD 3,000. The training will be provided at the same time as the safety program.

#### 9.1.3.6 Accidents

**Operation Stage:** As long as towers are accessible by the public, the risk of accidents cannot be avoided. In order to lower the risk, danger plates shall be applied to all the transmission towers. The plates should be of durable material and should be well illustrated so that even children who cannot read can understand them. The plates cost would be 3,029,000 Rs. (1,000 Rs. x 3,029 towers).

#### 9.1.3.7 Working Safety

**Construction Stage:** The Safety Department will prepare a safety training program for construction, and educate the workers before construction. The training cost will be managed by the operation costs of the Safety Department.

**Operation Stage:** The Safety Department will prepare a safety training program for operation and educate the workers periodically. The training cost will be managed by the operation costs of the Safety Department.

***Table 9-4 Mitigation cost***

| No. | Impacts | Proposed mitigation | Implementing Organization | Responsible Organization | Cost |
|---|---|---|---|---|---|
| Construction | | | | | |
| 1 | Water pollution | • Slope areas of more than 10 degrees should not be selected as locations of TML towers.<br>• Sedimentation ponds should be settled if turbid water is anticipated. | MPPTCL | MPPTCL | Unknown (Included in construction cost) |
| 2 | Soil erosion and landslides | • Slope areas of more than 10 degrees should not be selected as locations of TML towers.<br>• Geological boring exploration should be done before detailed design.<br>• High risk landslide areas should be avoided for TML towers.<br>• Erosion prevention techniques should be adopted for slope areas.<br>• After construction, bare ground should be covered by vegetation. | MPPTCL | MPPTCL | Unknown (Included in construction cost) |
| 3 | Waste | • Cleared trees and vegetation should be given to the land owners.<br>• Demolition waste should be taken to an industrial waste dumping site.<br>• Portable toilets and separated garbage boxes should be installed at the project site.<br>• No domestic garbage is allowed to be thrown out at the construction site. | MPPTCL | MPPTCL | Unknown (Included in construction cost) |
| 4 | Noise | • Noise source in the substation should be located more than 30m from residential areas.<br>• The substation should be designed to reduce the noise at the boundary of the compound to adhere to the noise standards of India (Noise Pollution (Regulation and Control) Rules, 2000).<br>• If residents around the substation complain about the noise, soundproof covers or sound insulation walls should be examined. | MPPTCL | MPPTCL | Unknown (Included in construction cost) |
| 5 | Radio Interference | • MPPTCL will inform neighboring communities about the project.<br>• MPPTCL will establish a special client liaison.<br>• If MPPTCL receives | MPPTCL | MPPTCL | Unknown (Included in construction cost) |

| | | | | | |
|---|---|---|---|---|---|
| 6 | Protected Species and Ecosystem | Before the routes would be finalized, MPPTCL will discuss with Wildlife Department and Forest Department about the routes and vegetation management under the ROW. | MPPTCL | MPPTCL | Unknown (Included in construction cost) |
| 7 | Forest | Tree plantation | Department of Forest | Department of Forest | 216,601,000 INR |
| 8 | Resettlement | MPPTCL will follow the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 | MPPTCL | Revenue Department | Unknown |
| 9 | Land use | MPPTCL has to pay compensation for the agricultural crops during construction | MPPTCL | Revenue Department | 183 million Rs. |
| 10 | Local Heritage | If any serious impacts are expected, MPPTCL should follow the instructions from the Revenue Department. | MPPTCL | Revenue Department | Unknown |
| 11 | Ethnic Minorities and Indigenous People | If impacts on ethnic minorities and indigenous people are identified during the detailed design stage, compensation must be provided based on the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013. | MPPTCL | Revenue Department | Unknown |
| 12 | Public Health | The program includes:<br>• Education on the propagation mechanisms of infectious diseases including HIV/AIDS<br>• Instruction on precautions for infectious diseases<br>• Instruction on examination for infectious diseases, and<br>• Instruction on handling methods for infectious diseases. | MPPTCL | MPPTCL | USD 3,000 |
| 13 | Working Safety | The Safety Department will prepare a safety training program for construction, and educate the workers before construction. | MPPTCL | MPPTCL | Unknown (operation cost of the Safety Department) |
| Operation | | | | | |
| 1 | Global warming | Careful maintenance to collect 80% of thesealed SF6 in every 12 years | MPPTCL | MPPTCL | 594,751 Rs./year (Included in operation cost) |
| 2 | Waste | • Damaged parts should be divided by type (metal, glass, plastic, and flammable) and collected in a waste storage place.<br>• The waste should be sold to a registered waste collection company.<br>• Produced waste should be recorded by date, type, volume, and price. | MPPTCL | MPPTCL | Unknown (Included in operation cost) |
| 3 | Protected species and Ecosystem | If the Wildlife Department gives any instructions, MPPTCL should follow them adequately. | MPPTCL | MPPTCL | Unknown (Included in operation cost) |
| 4 | Accidents | In order to lower the risk, danger plates shall be applied to all the transmission towers. The plates should be of durable material and should be well illustrated so that even children who cannot read can understand them. | MPPTCL | MPPTCL | 3,029,000 Rs |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Working Safety | The Safety Department will prepare a safety training program for operation and educate the workers periodically | MPPTCL | MPPTCL | Unknown (Included in operation cost) |
| Total cost | | | | | Unknown |

## 9.2 Monitoring Plan

### 9.2.1 Impact Monitoring

Impact monitoring will be done based on the order by Forest Department. If Forest Department will not order any monitoring, no monitoring will be conducted. Possible items are as follows.

***Table 9-5 Impact Monitoring***

| Items | Sub items | Location | Frequency | Responsible organizations |
|---|---|---|---|---|
| During construction | | | | |
| Plant | Flora, Vegetation | 33 subprojects | 2 times a year | MPPTCL |
| Mammal | Fauna, protected species | 33 subprojects | 2 times a year | MPPTCL |
| Bird | Fauna, protected species | 33 subprojects | 2 times a year | |
| Reptile/ Amphibian | Fauna, protected species | 33 subprojects | 2 times a year | MPPTCL |
| Fish | Fauna, protected species | 33 subprojects | 2 times a year | MPPTCL |
| Operation | | | | |
| Plant | Flora, Vegetation | 33 subprojects | 2 times a year | MPPTCL |
| Mammal | Fauna, protected species | 33 subprojects | 2 times a year | MPPTCL |
| Bird | Fauna, protected species | 33 subprojects | 2 times a year | MPPTCL |
| Reptile/ Amphibian | Fauna, protected species | 33 subprojects | 2 times a year | MPPTCL |
| Fish | Fauna, protected species | 33 subprojects | 2 times a year | MPPTCL |

### 9.2.2 Compliance monitoring

The compliance monitoring should be conducted once a month by subprojects during detailed design and construction. If the mitigation does not work as planned, adequate mitigation measures should be planned. Impact monitoring will be considered based on the suggestions from the Forest Department and complaints from the people.

***Table 9-6 Compliance Monitoring***

| Items | Sub items | Location | Frequency | Responsible organizations |
|---|---|---|---|---|
| During construction | | | | |
| General | Institutional arrangement, Reporting and feedback | 33 subprojects | Once a month | MPPTCL |
| Physical Environment | Water pollution, Soil erosion and landslides, Waste, Noise and vibration, Radio interference | 33 subprojects | Once a month | MPPTCL |
| Natural Environment | Protected species and ecosystem, Forest | 33 subprojects | Once a month | MPPTCL |
| Social Environment | Information disclosure, Land use, Local heritage, Ethnic | 33 subprojects | Once a month | MPPTCL |

| | | | | |
|---|---|---|---|---|
| | minorities and Indigenous people, Public Health, Accidents, Working safety, Resettlement | | | |
| During Operation | | | | |
| General | Institutional arrangement, Reporting and feedback | 33 subprojects | Once a month | MPPTCL |
| Physical Environment | Water pollution, Global warming, Soil erosion and landslides, Waste, Noise and vibration, Radio interference | 33 subprojects | Once a month | MPPTCL |
| Natural Environment | Protected species and ecosystem | 33 subprojects | Once a month | MPPTCL |
| Social Environment | Information disclosure, Land use, Ethnic minorities and Indigenous people, Accidents, Working safety, Resettlement | 33 subprojects | Once a month | MPPTCL |

***Table 9-7 Compliance Monitoring check sheet for design and construction period***

| Compliance Monitoring check sheet | | |
|---|---|---|
| Date: _____ | Subproject Name: _____ | Person: _____ |
| Location: _____ | | |

| General | | | | |
|---|---|---|---|---|
| Institutional arrangement | • MPPTCL should assign a person in charge of compliance monitoring. | | □ Satisfied | □ Unsatisfied |
| | • MPPTCL should hire or assign a person who has enough knowledge about the environment for monitoring. | | □ Satisfied | □ Unsatisfied |
| Reporting and feedback | • MPPTCL should have submitted the monitoring check sheet to JICA last month. | | □ Satisfied | □ Unsatisfied |
| | • MPPTCL should take action on the suggestions from previous monitoring. | | □ Satisfied | □ Unsatisfied |

| Physical Environment | | | | |
|---|---|---|---|---|
| Water pollution | • Slope areas of more than 10 degrees should not be selected as locations of TML towers. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| | • Sedimentation ponds should be settled if turbid water is anticipated. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| Soil erosion and landslides | • Slope areas of more than 10 degrees should not be selected as locations of TML towers. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| | • Geological boring exploration should be done before detailed design. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| | • High risk landslide areas should be avoided for TML towers. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| | • Erosion prevention techniques should be adopted for slope areas. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| | • After construction, bare ground should be covered by vegetation. | | □ Satisfied | □ Unsatisfied |
| Waste | • Cleared trees and vegetation should be given to the land owners. | | □ Satisfied | □ Unsatisfied |
| | • Demolition waste should be taken to an industrial waste dumping site. | | □ Satisfied | □ Unsatisfied |
| | • Portable toilets and separated garbage boxes should be installed at the project site. | | □ Satisfied | □ Unsatisfied |
| | • No domestic garbage is allowed to be thrown out at the construction site. | | □ Satisfied | □ Unsatisfied |
| Noise and vibration | • Noise source in the substation should be located more than 30m from residential areas. | | □ Satisfied | □ Unsatisfied |

| | | | | |
|---|---|---|---|---|
| | • The substation should be designed to reduce the noise at the boundary of the compound to adhere to the noise standards of India (Noise Pollution (Regulation and Control) Rules, 2000). | | □ Satisfied | □ Unsatisfied |
| | • If residents around the substation complain about the noise, soundproof covers or sound insulation walls should be examined. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| | • Construction noise should be lower than the national standard noise level at the residential area and it should be during the designated time. | | □ Satisfied | □ Unsatisfied |
| Radio interference | • MPPTCL should inform the neighboring communities about the project's radio interference risk. | | □ Satisfied | □ Unsatisfied |

| Natural Environment | | | | |
|---|---|---|---|---|
| Protected Species and ecosystem | • Before finalizing the locations, MPPTCL should discuss with the Wildlife Department about important habitats for protected species such as Tiger and Leopard. | | □ Satisfied | □ Unsatisfied |
| | • MPPTCL should strictly follow the instructions from the Wildlife Department, if any instructions are given. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| Forest | • MPPTCL should get Forest clearance if there are any forest areas in the planned route. | □ Not applicable | □ Satisfied | □ Unsatisfied |

| Social Environment | | | | |
|---|---|---|---|---|
| Information disclosure | The project design, possible impact, compensation plans, and grievance mechanism are fully explained to all the affected people before the designs are fixed. The design should not be fixed before communication with the people. | | □ Satisfied | □ Unsatisfied |
| | The project is announced in newspapers before construction. | | □ Satisfied | □ Unsatisfied |
| | When MPPTCL receives opinions or suggestions from the affected people, MPPTCL should take them into account for designs or compensation. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| Land use | MPPTCL should follow crop compensation procedures and pay compensation costs to the Revenue Department. | | □ Satisfied | □ Unsatisfied |
| Local heritage | If any sites of cultural importance, such as temples, holy trees, historical rocks, or local cemeteries are found by the site survey, MPPTCL should follow the instructions from the Revenue Department. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| Ethnic minorities and Indigenous people | If impacts on ethnic minorities and indigenous people are identified during detailed design, compensation must be provided to them. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| Public Health | MPPTCL should conduct a public health program for all the workers before construction. | | □ Satisfied | □ Unsatisfied |
| Accidents | MPPTCL should explain the risk of electrification to the local people and install warning sign on all the | | □ Satisfied | □ Unsatisfied |

| | | | | |
|---|---|---|---|---|
| | towers. | | | |
| Working safety | The Safety Department will prepare a safety training program for construction and educate the workers before construction. | | □ Satisfied | □ Unsatisfied |
| Resettlement | All resettlement is avoided, including illegal squatters. | | □ Satisfied | □ Unsatisfied |
| | If some resettlements are not avoided, they should be compensated for based on "Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013". | □ Not applicable | □ Satisfied | □ Unsatisfied |

| Problems and the reasons (with the name of responsible party) |
|---|
| |

| Suggestions for minimizing the impact |
|---|
| |

***Table 9-8 Compliance Monitoring check sheet for Operation period***

| Compliance Monitoring check sheet | | |
|---|---|---|
| Date: _____ | Subproject Name: _____ | Person: _____ |
| Location: _____ | | |

| General |
|---|

| | | | | |
|---|---|---|---|---|
| Institutional arrangement | • MPPTCL should assign a person in charge of compliance monitoring. | | □ Satisfied | □ Unsatisfied |
| | • MPPTCL should hire or assign a person who has enough knowledge about the environment for monitoring. | | □ Satisfied | □ Unsatisfied |
| Reporting and feedback | • MPPTCL should have submitted the monitoring check sheet to JICA last month. | | □ Satisfied | □ Unsatisfied |
| | • MPPTCL should take action on the suggestions from previous monitoring. | | □ Satisfied | □ Unsatisfied |

| Physical Environment | | | | |
|---|---|---|---|---|
| Water pollution | • Domestic waste water is treated properly and does not cause any river/underground water pollution. | | □ Satisfied | □ Unsatisfied |
| | • Industrial waste water is treated properly and does not cause any river/underground water pollution. | | □ Satisfied | □ Unsatisfied |
| Global warming | SF6 gas should be collected properly during maintenance. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| Soil erosion and landslides | • Slopes after construction do not cause landslides or erosion. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| | • Planted vegetation is growing as planned. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| Waste | • Domestic waste is properly collected and treated. No garbages are thrown out around the project site. | | □ Satisfied | □ Unsatisfied |
| | • Industrial waste is properly collected and treated. It is not thrown out around the project site. | | □ Satisfied | □ Unsatisfied |
| | • Sub-station areas are cleaned well and free from waste. | | □ Satisfied | □ Unsatisfied |
| Noise and vibration | • Noise level at the nearest settlement is under the environmental standard (Noise Pollution (Regulation and Control) Rules, 2000). Residents are not complaining about the noise caused by the project. | | □ Satisfied | □ Unsatisfied |
| | • If residents around the substation complain about the noise, soundproof covers or sound insulation walls should be examined. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| Radio interference | • If MPPTCL receives any complaints about radio interference, take mitigation measures such as installing community reception antennae. | □ Not applicable | □ Satisfied | □ Unsatisfied |

| Natural Environment | | | | |
|---|---|---|---|---|
| Protected Species and ecosystem | • If the Wildlife Department gives instructions for vegetation management etc., MPPTCL should follow the instructions. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| | • If any important animals are found, MPPTCL should inform the Wildlife Department immediately. | □ Not applicable | □ Satisfied | □ Unsatisfied |

| Social Environment |
|---|

| | | | | |
|---|---|---|---|---|
| Information disclosure | If MPPTCL gets any complaints about the project, MPPTCL should follow the grievance mechanism under the Indian Laws. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| Land use | If any kind of damage to people's property is caused by the project, MPPTCL has to compensate for it. The living standards of the affected people should not be lowered by the project. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| Ethnic minorities and Indigenous people | The living standards of the affected people should not be lowered by the project. If their living standards are lowered by the project, additional compensation should be considered. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| Accidents | MPPTCL should replace the warning signs on the towers if they are broken. | □ Not applicable | □ Satisfied | □ Unsatisfied |
| Working safety | The Safety Department should implement a safety training program for the workers periodically. | | □ Satisfied | □ Unsatisfied |
| Resettlement | If any resettlements happen, MPPTCL has to keep supporting the affected people so as not to lower their living standard or to upgrade them to higher than the poverty line. | □ Not applicable | □ Satisfied | □ Unsatisfied |

| Problems and the reasons (with the name of responsible party) |
|---|
| |

| Suggestions for minimizing the impact |
|---|
| |

## 9.3 Implementation Arrangement

There is no Environmental Department in MPPTCL but the Construction Department and Land Department etc. will manage all the environmental and social issues. The PMU will manage all the Environmental and Social issues, cooperating with the following departments.

***Table 9-9 Environmental Items and Department Responsible***

| Items | Department Responsible | Mitigation planning | Mitigation implementation | Impact Monitoring | Compliance Monitoring | Evaluation |
|---|---|---|---|---|---|---|
| Air, Noise | Construction Department, MPPTCL | Contractor | Contractor | - | Env. Consultant | JICA |
| Waste water | Construction Department, MPPTCL/Contractor | Contractor | Contractor | - | Env. Consultant | JICA |
| Soil Erosion | Construction Department, MPPTCL/Construction Contractor | Contractor | Contractor | - | Env. Consultant | JICA |
| Industrial waste | Operation & Maintenance Department, MPPTCL | Contractor | Contractor | - | Env. Consultant | JICA |
| Electromagnetic waves | Construction Department/Gov. of MP | Construction Department of MPPTCL | Construction Department of MPPTCL | - | Env. Consultant | JICA |
| Forest impact | Project Management Unit, MPPTCL | Forest Department | Forest Department | Env. Consultant | Env. Consultant | JICA |
| Protected species | Project Management Unit, MPPTCL | Wildlife Department | Wildlife Department | Env. Consultant | Env. Consultant | JICA |
| Land and resettlement | Land Department, MPPTCL | Revenue Department | Revenue Department | - | Env. Consultant | JICA |
| Ethnic Minorities | Land Department, MPPTCL | Revenue Department | Revenue Department | - | Env. Consultant | JICA |
| Cultural assets | Land Department, MPPTCL | Revenue Department | Revenue Department | - | Env. Consultant | JICA |
| Landscape | Construction Department, MPPTCL/Construction contractor | Revenue Department | Revenue Department | - | Env. Consultant | JICA |
| Public health | Health Department, MPPTCL | Health Department of MPPTCL | Health Department of MPPTCL | - | Env. Consultant | JICA |
| Accidents | Safety Department, MPPTCL | Safety Department of MPPTCL | Safety Department of MPPTCL | - | Env. Consultant | JICA |
| Work safety | Safety Department, MPPTCL | Safety Department of MPPTCL | Safety Department of MPPTCL | - | Env. Consultant | JICA |

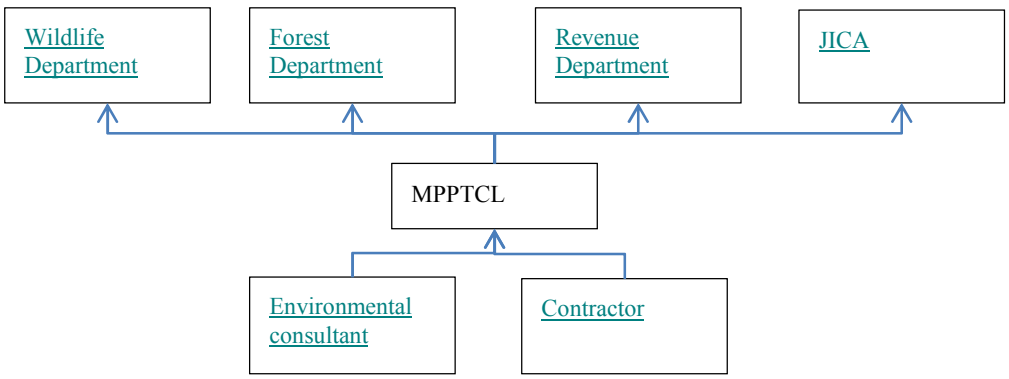



***Figure 9-1 Implementation Arrangement of Mitigation and Monitoring***

## 9.4 Reporting and Audit

To monitor and manage the environmental issues effectively, a monthly monitoring report must be prepared by MPPTCL. Based on the monthly reports, MPPTCL will summarize and submit a quarterly monitoring report during construction and semiannually monitoring report during operation to JICA. If Forest department or Wildlife Department order any report submission, MPPTCL will submit the monitoring report to them.

# 10 Public Consultation and Information Disclosure

The Project does not require an EIA or SIA. Therefore, public consultations and information disclosure related to EIA and SIA are not planned. But the project plan will be reported on in local newspapers before construction as per the Indian Electricity Act 2003. People can appeal to MPPTCL within 60 days and MPPTCL will manage the appeal.

# 11 Grievance Mechanism

MPPTCL and the Revenue Department of the Government of Madhya Pradesh ensure that all grievances and complaints regarding environmental and social impacts will be addressed in a timely and satisfactory manner. The Aps can make complaints or air their grievances regarding the project implementation in areas related to compensation, entitlement, compensation policy, rates, land acquisition, resettlement, allowance, income restoration and so on. The complaining APs will not be charged any fee during the resolution of their grievances and complaints. There are four (4) stages in the resolution of grievances and complaints under the Project. MPPTCL and the Revenue Department must explain the Grievance Mechanism to all the APs.

(i) First Stage: The APs can make a claim to the project complaints officers of MPPTCL and the Revenue Department.

(ii) Second Stage: Nyaya Panchayat - If the AP is not satisfied with the compensation suggested by the Revenue Department, the AP may submit the complaint to the Nyaya Panchayat, in written or verbal form. The cost of the consultation should be charged to MPPTCL and the Revenue Department. The Nyaya Panchayat will examine the complaint referring to the compensation rules, such as compensation unit cost, resettlement allowance etc., and seek a solution. The suggested solution should be recorded and opened to the public with its reasons.

(iii) Third Stage: District Legal Service Authority - If the AP does not accept the suggestions by Nyaya Panchayat, the AP may submit the complaint to the District Legal Service Authority in written form. The cost of the lawsuit should be charged to MPPTCL and the Revenue Department. The District Legal Service Authority should examine the case and give the decision of the court.

(iv) Fourth Stage: Madhya Pradesh Legal Service Authority – If the AP does not accept the decision of the court, the AP can appeal it to the Madhya Pradesh Legal Service Authority. The cost of the lawsuit should be charged to MPPTCL and the Revenue Department.

# Environmental Screening Format

Name of Proposed Project: ***Transmission System Strengthening Works in Madhya Pradesh***
Project Executing Organization, Project Proponent or Investment Company: ***Madhya Pradesh Power Transmission Corporation Limited (MPPTCL)***
Name, Address, Organization, and Contact Point of a Responsible Officer:

Name: ***S.P. Gupta***
Address: ***Chief Engineer (Procurement)***
Organization: ***MPPTCL***
Tel: ***0761-2702134***
Fax***: 0761-2665593***
E-Mail:
Date***:*** _____

Signature***:*** _____

**Check Items**

Please write "to be advised (TBA)" when the details of a project are yet to be determined.

**Question 1**:
Address of project site

***35 projects are located in various districts (See table 1). 12 of them are just installing equipment into existing Substations. Excepting these upgrading projects other projects locates in 26 districts in Madhya Pradesh.***

***Table 1 Names of the district by Substations***

| *No.* | *Project description* | *District* |
|---|---|---|
| *1* | *LILO of one circuit of 400kV Khandwa - Rajgarh PGCIL line at Chhegaon 400kV Substation (D/C)*<br>*400kV Bus Reactor at Chhegaon 400kV S/S* | *East Nimar* |
| *2* | *Pithampur400-Super Corridor 220kV DCDS line*<br>*LILO of One ckt of Indore(Jetpura) - Depalpur 132kV DCDS Line at Super Corridor (Indore) 220kV S/s.(D/C)* | *Indore, Dhar* |
| *4* | *Charging/Upgradation of Chichli220 - Udaipura DCDS line on 220kV level* | *Raisen* |
| *5* | *Chhatarpur-Tikamgarh 220kV DCSS line* | *Chhattarpur, Tikamgarh* |
| *6* | *400/220kV Additional Transformer at Bina 400kV S/S*<br>*LILO of Bina220 - Ganjbasoda 220kV line at Bina(MPPTCL) 400kV S/s* | *Sagar* |
| *7* | *Rewa220 - Sidhi 220kV DCDS line through Rewa UMSP* | *Rewa, Sidhi* |
| *9* | *Julwania400 - Pati(Silawad) 132kV DCSS Line* | *Barwani* |
| *10* | *LILO of Mangliya220 –Indore 132kV Line at Mahalaxmi* | *Indore* |
| *11* | *Julwania400 - Shahpura 132kV DCSS Line* | *Barwani* |
| *12* | *Datia220 - Bhitarwar 132kV DCSS Line* | *Gwalior, Datia* |
| *13* | *MugaliaChhap220 - Mahwadia 132kV DCDS Line* | *Bhopal* |

| No. | Project description | District |
|---|---|---|
| 15 | Sidhi220 - Madwas 132kV DCSS Line | Sidhi |
| 16 | Panagar220 - Dheemarkheda 132kV DCSS Line | Jabalpur, Katni |
| 17 | Prithivipur-Orchha 132kV DCSS Line | Tikamgarh |
| 18 | Sirmour220 - Atraila 132kV DCSS line | Rewa |
| 19 | Udaipura - Tendukheda 132kV DCSS line | Raisen, Narsimhapur |
| 20 | Gohad - Gormi 132kV DCSS line | Bhind |
| 21 | Narsinghgarh - Suthaliya 132kV DCSS line | Rajgarh |
| 22 | LILO of Satna220 - Kymore 132kV line at Unchhera 132kV S/s | Satna |
| 23 | Sidhi220 - Sinhawal 132kV DCSS line 132kV | Sidhi |
| 24 | 2nd ckt of Rajgarh(B) - Raghogarh 132kV DCSS line up to Chachoda 132kV S/s | Rajgarh, Guna |
| 25 | Maneri - Mandla 132kV DCSS line | Mandla |
| 26 | Sukha (Jabalpur) | Jabalpur |
| 27 | Hoshangabad 220kV (2nd) | Hoshangabad |
| 28 | Barwaha 220kV (3rd) | West Nimar |
| 29 | Betma 132kV | Indore |
| 30 | Khirkiya 132kV | Harda |
| 31 | Amla 132kV | Betul |
| 32 | Tejgarh 132kV | Damoh |
| 33 | Satwas 132kV | Harda |
| 34 | Sitamau 132kV | Mandsaur |
| 35 | Baroda 132kV | Shajapur |
| 36 | Amrawadkhurd 132kV | Bhopal |

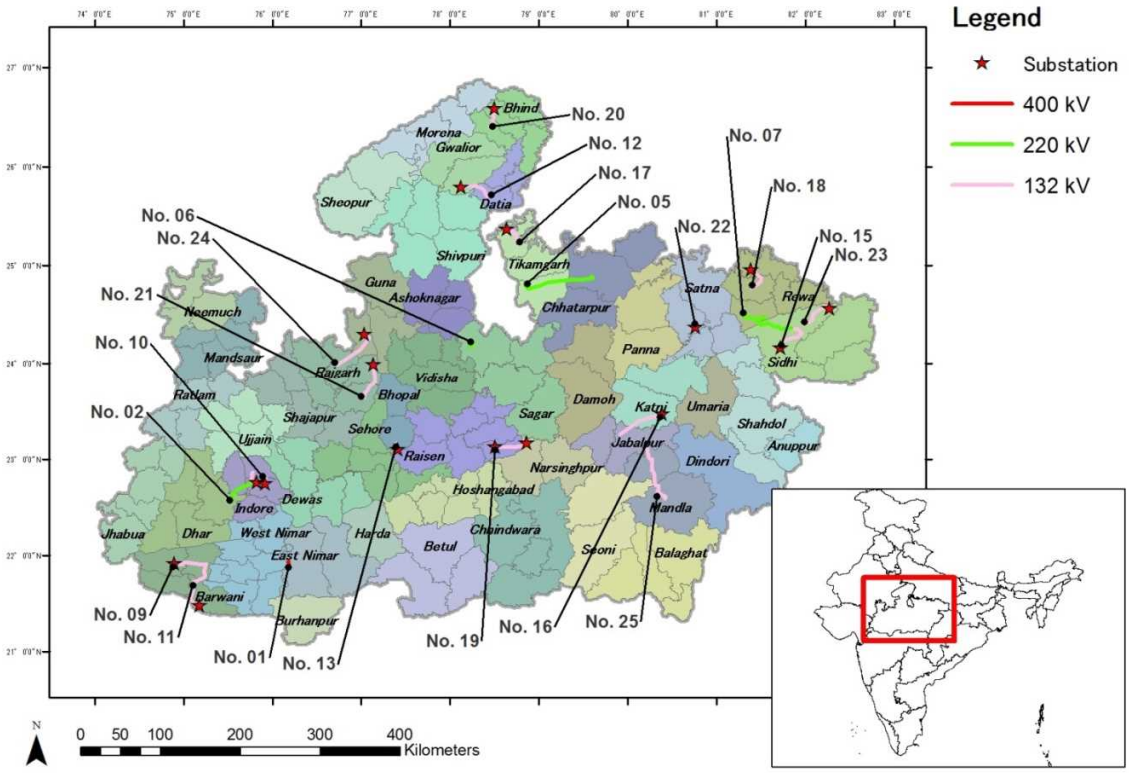



*Figure 1 Location of the subprojects*

**Question 2**:

Scale and contents of the project (approximate area, facilities area, production, electricity generated, etc.)

2-1. Project profile (scale and contents)

***21 TML, 15 new Substations, and 13 Additional Transformers are planned in 33 sub-projects.***

***Table 2 Project profile***

| *No.* | *Project description* | *TML (km)* | | | *Substation* | | *Additional Transformer* |
|---|---|---|---|---|---|---|---|
| | | *400 kV* | *220 kV* | *132 kV* | *Name* | *Required Area (ha)* | |
| *1* | *LILO of one circuit of 400kV Khandwa - Rajgarh PGCIL line at Chhegaon 400kV Substation (D/C) 400kV Bus Reactor at Chhegaon 400kV S/S* | *5* | *-* | *-* | *-* | *-* | *1x125 MVAR* |
| *2* | *Pithampur400-Super Corridor 220kV DCDS line LILO of One ckt of Indore(Jetpura) - Depalpur 132kV DCDS Line at Super Corridor (Indore) 220kV S/s.(D/C)* | *-* | *50* | *13* | *Super Corridor (Indore)* | *3.27* | |
| *4* | *Charging/Upgradation of Chichli220 - Udaipura DCDS line on 220kV level* | *-* | *-* | *-* | *Udaipura* | *-* | |
| *5* | *Chhatarpur-Tikamgarh 220kV DCSS line* | *-* | *110* | *-* | *-* | *-* | |
| *6* | *400/220kV Additional Transformer at Bina 400kV S/S LILO of Bina220 - Ganjbasoda 220kV line at Bina(MPPTCL) 400kV S/s* | *-* | *10* | *-* | *-* | *-* | *1x315 MVA* |
| *7* | *Rewa220 - Sidhi 220kV DCDS line through Rewa UMSP* | *-* | *90* | *-* | *-* | *-* | |
| *9* | *Julwania400 - Pati(Silawad) 132kV DCSS Line* | *-* | *-* | *40* | *Pati(Silawad)* | *4.00* | |
| *10* | *LILO of Mangliya220 –Indore 132kV Line at Mahalaxmi* | *-* | *-* | *3* | *Mahalaxmi* | *unknown* | |
| *11* | *Julwania400 - Shahpura 132kV DCSS Line* | *-* | *-* | *65* | *Shahpura* | *2.25* | |
| *12* | *Datia220 - Bhitarwar 132kV DCSS Line* | *-* | *-* | *40* | *Bhitarwar* | *2.25* | |
| *13* | *MugaliaChhap220 - Mahwadia 132kV DCDS Line* | *-* | *-* | *10* | *Mahwadia* | *5.00* | |
| *15* | *Sidhi220 - Madwas 132kV DCSS Line* | *-* | *-* | *50* | *Madwas* | *3.30* | |
| *16* | *Panagar220 - Dheemarkheda 132kV DCSS Line* | *-* | *-* | *65* | *Dheemarkheda* | *2.25* | |
| *17* | *Prithivipur-Orchha 132kV DCSS Line* | *-* | *-* | *30* | *Orchha* | *3.00* | |
| *18* | *Sirmour220 - Atraila 132kV DCSS line* | *-* | *-* | *35* | *Atraila* | *4.00* | |
| *19* | *Udaipura - Tendukheda 132kV DCSS line* | *-* | *-* | *45* | *Tendukheda* | *3.82* | |
| *20* | *Gohad - Gormi 132kV DCSS line* | *-* | *-* | *25* | *Gormi* | *2.25* | |
| *21* | *Narsinghgarh - Suthaliya 132kV DCSS line* | *-* | *-* | *50* | *Suthaliya* | *3.28* | |
| *22* | *LILO of Satna220 - Kymore 132kV line at Unchhera 132kV S/s* | *-* | *-* | *5* | *Unchhera* | *6.25* | |
| *23* | *Sidhi220 - Sinhawal 132kV DCSS line 132kV* | *-* | *-* | *50* | *Sinhawal* | *unknown* | |

| *No.* | *Project description* | *TML (km)* | | | *Substation* | | *Additional Transformer* |
|---|---|---|---|---|---|---|---|
| | | *400 kV* | *220 kV* | *132 kV* | *Name* | *Required Area (ha)* | |
| *24* | *2nd ckt of Rajgarh(B) - Raghogarh 132kV DCSS line up to Chachoda 132kV S/s* | *-* | *-* | *61* | *Chachoda* | *unknown* | |
| *25* | *Maneri - Mandla 132kV DCSS line* | *-* | *-* | *80* | *-* | *-* | |
| *26* | *Sukha (Jabalpur)* | *-* | *-* | *-* | *-* | *-* | *+ 2x50 MVA* |
| *27* | *Hoshangabad 220kV (2nd)* | *-* | *-* | *-* | *-* | *-* | *+ 1x160 MVA* |
| *28* | *Barwaha 220kV (3rd)* | *-* | *-* | *-* | *-* | *-* | *+ 1x160 MVA* |
| *29* | *Betma 132kV* | *-* | *-* | *-* | *-* | *-* | *+ 50 MVA* |
| *30* | *Khirkiya 132kV* | *-* | *-* | *-* | *-* | *-* | *+ 50 MVA* |
| *31* | *Amla 132kV* | *-* | *-* | *-* | *-* | *-* | *+ 50 MVA* |
| *32* | *Tejgarh 132kV* | *-* | *-* | *-* | *-* | *-* | *+ 50 MVA* |
| *33* | *Satwas 132kV* | *-* | *-* | *-* | *-* | *-* | *+ 50 MVA* |
| *34* | *Sitamau 132kV* | *-* | *-* | *-* | *-* | *-* | *+ 50 MVA* |
| *35* | *Baroda 132kV* | *-* | *-* | *-* | *-* | *-* | *+ 50 MVA* |
| *36* | *Amrawadkhurd 132kV* | *-* | *-* | *-* | *-* | *-* | *+ 50 MVA* |

2-2. How was the necessity of the project confirmed?
Is the project consistent with the higher program/policy?
☑YES: Please describe the higher program/policy.
（*13th Five year Plan (2018-2023)* ）
□NO

2-3. Did the proponent consider alternatives before this request?
☑YES: Please describe outline of the alternatives
（***Many alternative TML routes of first design were changed to avoid protected area, forest area, and residential area.***）
□NO

2-4. Did the proponent implement meetings with the related stakeholders before this request?
□Implemented ☑Not implemented
If implemented, please mark the following stakeholders.
□Administrative body
□Local residents
□NGO
□Others（ ）

**Question 3:**

Is the project a new one or an ongoing one? In the case of an ongoing project, have you received strong complaints or other comments from local residents?

☑New ☐Ongoing (with complaints) ☐Ongoing (without complaints)
☐Other (  )

**Question 4**:

Is an Environmental Impact Assessment (EIA), including an Initial Environmental Examination (IEE) Is, required for the project according to a law or guidelines of a host country? If yes, is EIA implemented or planned? If necessary, please fill in the reason why EIA is required.

☐Necessity (☐Implemented ☐Ongoing/planning)
(Reason why EIA is required: )
☑Not necessary
☐Other (please explain)

**Question 5**:

In the case that steps were taken for an EIA, was the EIA approved by the relevant laws of the host country? If yes, please note the date of approval and the competent authority.

| ☐Approved without a supplementary condition | ☐Approved with a supplementary condition | ☐Under appraisal |
|---|---|---|

(Date of approval: Competent authority: )
☐Under implementation
☐Appraisal process not yet started
☐Other ( )

**Question 6**:

If the project requires a certificate regarding the environment and society other than an EIA, please indicate the title of said certificate. Was it approved?

☐Already certified
Title of the certificate: ( )
☑Requires a certificate but not yet approved
***(Forest Clearances are required for 67.7 ha for 9 sub-projects. They will be taken in a year.)***

☐Not required

☐Other (  )

**Question 7**:

Are any of the following areas present either inside or surrounding the project site?
☑Yes ☐No

If yes, please mark the corresponding items.

☐National parks, protection areas designated by the government (coastline, wetlands, reserved area for

ethnic or indigenous people, cultural heritage)

☐Primeval forests, tropical natural forests

☐Ecologically important habitats (coral reefs, mangrove wetlands, tidal flats, etc.)

☑Habitats of endangered species for which protection is required under local laws and/or international treaties

***(All the Tiger reserves and known tiger habitat are avoided. Some sub-projects (No. 15, 16, 18, 25) are near the habitat of Tiger (See Figure 2). MPPTCL will strictly follow all the instructions of Forest Department. )***

☐Areas that run the risk of a large scale increase in soil salinity or soil erosion

☐Remarkable desertification areas

☐Areas with special values from an archaeological, historical, and/or cultural points of view

☑Habitats of minorities, indigenous people, or nomadic people with a traditional lifestyle, or areas with special social value

***(Some of the lands of scheduled tribe and scheduled caste might be affected by ROW. They will be compensated based on government rules. )***

**Question 8**:

Does the project include any of the following items?

☑Yes ☐No

If yes, please mark the appropriate items.

☑Involuntary resettlement (It might happen involuntary resettlement but the scale is not clear now. )

☐Groundwater pumping (scale: m3/year)

☑Land reclamation, land development, and/or land-clearing

***(scale: Around 44.92 + x hectors of government land will be developed for the new Sub-stations. No private land will be affected by Sub-stations (See table 3). In terms of TML 2,669 hectors of crop land or wood land might come under the ROW (See table 4). The land under the ROW/Tower is not need expropriation and land owners can use the land up to 4.5m for agricultural purposes. )***

***Table 3 Required Government Areas for the new Sub-stations***

| *No.* | *SS Name* | *Required Area (ha)* |
|---|---|---|
| *2* | *Super Corridor (Indore)* | *3.27* |
| *9* | *Pati(Silawad)* | *4.00* |
| *10* | *Mahalaxmi* | *unknown* |
| *11* | *Shahpura* | *2.25* |
| *12* | *Bhitarwar* | *2.25* |
| *13* | *Mahwadia* | *5.00* |
| *15* | *Madwas* | *3.30* |
| *16* | *Dheemarkheda* | *2.25* |
| *17* | *Orchha* | *3.00* |
| *18* | *Atraila* | *4.00* |
| *19* | *Tendukheda* | *3.82* |
| *20* | *Gormi* | *2.25* |
| *21* | *Suthaliya* | *3.28* |

| | | |
|---|---|---|
| ***22*** | ***Unchhera*** | ***6.25*** |
| ***23*** | ***Sinhawal*** | ***unknown*** |
| ***24*** | ***Chachoda*** | ***unknown*** |
| ***Total*** | | ***44.92+ x*** |

***Table 4 Estimated affected crop/tree areas for compensation***

| No. | 400 kV | | | | 220 kV | | | |
|---|---|---|---|---|---|---|---|---|
| | Length (km) | ROW (ha) | Length (km) | ROW (ha) | Length (km) | ROW (ha) | Length (km) | ROW (ha) |
| 1 | 5.0 | 26.0 | - | - | - | - | 5.0 | 26.0 |
| 2 | - | - | 50.0 | 175.0 | 13.0 | 35.1 | 63.0 | 210.1 |
| 5 | - | - | 110.0 | 385.0 | - | - | 110.0 | 385.0 |
| 6 | - | - | 10.0 | 35.0 | - | - | 10.0 | 35.0 |
| 7 | - | - | 90.0 | 315.0 | - | - | 90.0 | 315.0 |
| 9 | - | - | - | - | 40.0 | 108.0 | 40.0 | 108.0 |
| 10 | - | - | - | - | 3.0 | 8.1 | 3.0 | 8.1 |
| 11 | - | - | - | - | 65.0 | 175.5 | 65.0 | 175.5 |
| 12 | - | - | - | - | 40.0 | 108.0 | 40.0 | 108.0 |
| 13 | - | - | - | - | 10.0 | 27.0 | 10.0 | 27.0 |
| 15 | - | - | - | - | 50.0 | 135.0 | 50.0 | 135.0 |
| 16 | - | - | - | - | 65.0 | 175.5 | 65.0 | 175.5 |
| 17 | - | - | - | - | 30.0 | 81.0 | 30.0 | 81.0 |
| 18 | - | - | - | - | 35.0 | 94.5 | 35.0 | 94.5 |
| 19 | - | - | - | - | 45.0 | 121.5 | 45.0 | 121.5 |
| 20 | - | - | - | - | 25.0 | 67.5 | 25.0 | 67.5 |
| 21 | - | - | - | - | 50.0 | 135.0 | 50.0 | 135.0 |
| 22 | - | - | - | - | 5.0 | 13.5 | 5.0 | 13.5 |
| 23 | - | - | - | - | 50.0 | 135.0 | 50.0 | 135.0 |
| 24 | - | - | - | - | 61.0 | 164.7 | 61.0 | 164.7 |
| 25 | - | - | - | - | 80.0 | 216.0 | 80.0 | 216.0 |
| Total | 5.0 | 26.0 | 260.0 | 910.0 | 667.0 | 1,800.9 | 932.0 | 2,736.9 |

☑Logging (scale: ***67.7 hectors of forest land should be claimed for Forest Clearance***)

***Table 5 Affected forest areas***

| ***No*** | ***Project Name*** | ***Voltage*** | ***Forest (km)*** | |
|---|---|---|---|---|
| | | | ***Length (km)*** | ***RoW (ha)*** |
| ***7*** | ***Rewa220 - Sidhi 220kV DCDS line through Rewa UMSP*** | ***220*** | ***3.0*** | ***10.5*** |
| ***9*** | ***Julwania400 - Pati(Silawad) 132kV DCSS Line*** | ***132*** | ***0.5*** | ***1.4*** |
| ***10*** | ***Mangliya220 - Mahalaxmi 132kV DCDS Line*** | ***132*** | ***-*** | ***-*** |
| ***11*** | ***Julwania400 - Shahpura 132kV DCSS Line*** | ***132*** | ***6.0*** | ***16.2*** |
| ***12*** | ***Datia220 - Bhitarwar 132kV DCSS Line*** | ***132*** | ***-*** | ***-*** |
| ***13*** | ***MugaliaChhap220 - Mahwadia 132kV DCDS Line*** | ***132*** | ***1.5*** | ***4.1*** |
| ***15*** | ***Sidhi220 - Madwas 132kV DCSS Line*** | ***132*** | ***0.2*** | ***0.5*** |
| ***17*** | ***Prithivipur-Orchha 132kV DCSS Line*** | ***132*** | ***2.0*** | ***5.4*** |

| | | | | |
|---|---|---|---|---|
| *18* | *Sirmour220 - Atraila 132kV DCSS line* | *132* | *1.0* | *2.7* |
| *23* | *LILO of one ckt of Sidhi220 - Deosar 132kV line at Sinhawal 132kV S/s* | *132* | *1.0* | *2.7* |
| *25* | *Maneri - Mandla 132kV DCSS line* | *132* | *9.0* | *24.3* |
| *Total* | | | *24.2* | *67.7* |

**Question 9**:

Please mark related adverse environmental and social impacts, and describe their outlines.

☐Air pollution
☐Water pollution
☐Soil pollution
☐Waste
☐Noise and vibrations
☐Ground subsidence
☐Offensive odors
☐Geographical features
☐Bottom sediment
☑Biota and ecosystems
☐Water usage
☑Accidents
☐Global warming

☑Involuntary resettlement
☐Local economies, such as employment, livelihood, etc.
☑Land use and utilization of local resources
☐Social institutions such as social infrastructure and local decision-making institutions
☐Existing social infrastructures and services
☑Poor, indigenous, or ethnic people
☐Misdistribution of benefits and damages
☐Local conflicts of interest
☐Gender
☐Children's rights
☐Cultural heritage
☐Infectious diseases such as HIV/AIDS
☐Other ( )

Outline of related impact:

Tige habitat might be affected by some sob-projects. It might cause habitat fragmentation and make the risk of regional extinction higher. And some activities might cause poarching.

**Question 10**:

In the case of a loan project such as a two-step loan or a sector loan, can sub-projects be specified at the present time?

☑Yes ☐No

**Question 11**:

Regarding information disclosure and meetings with stakeholders, if JICA's environmental and social considerations are required, does the proponent agree to information disclosure and meetings with stakeholders through these guidelines?

☐Yes ☑No

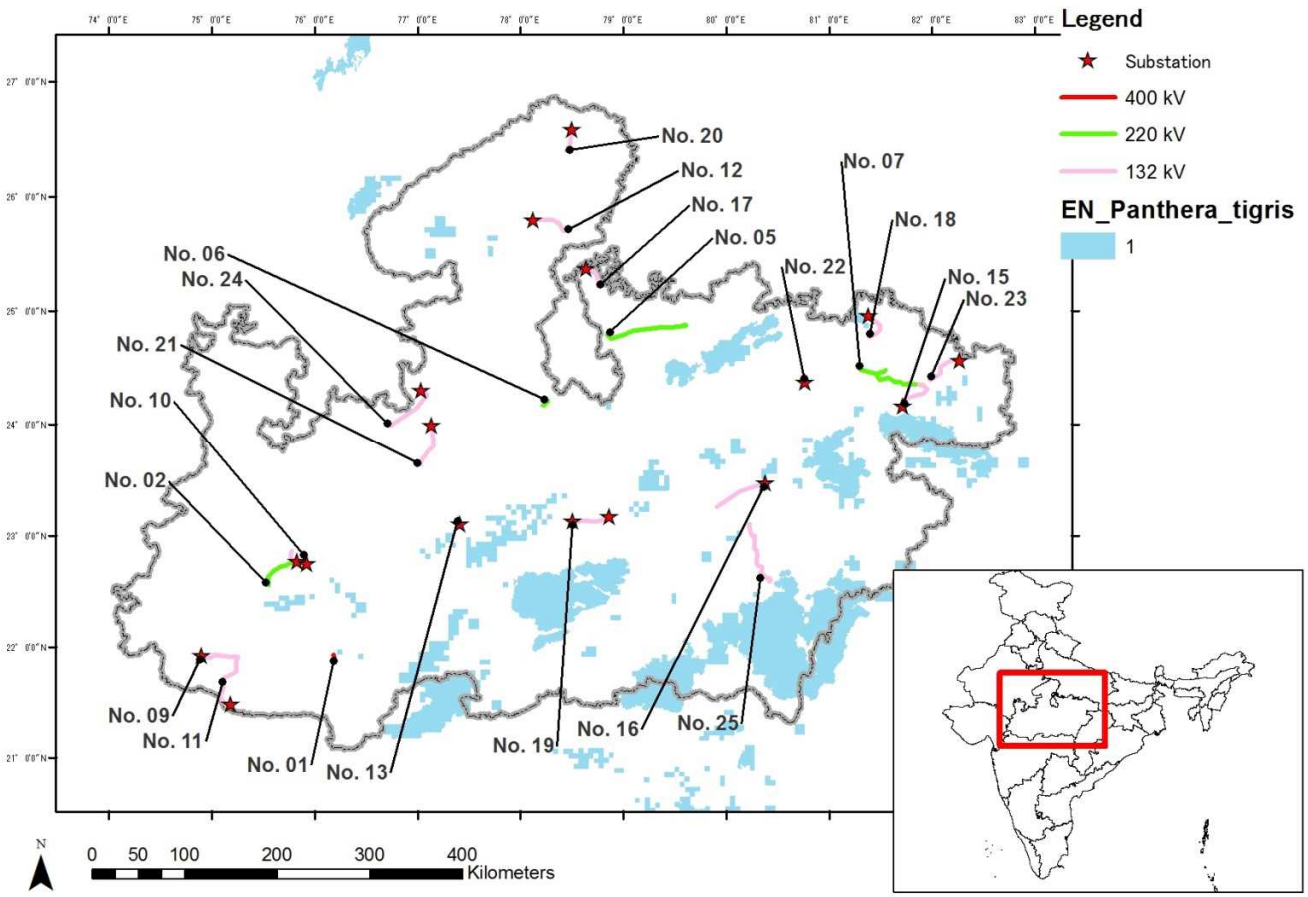



*Figure 2: Habitat of Tiger (IUCN: EN)*

## Environmental Checklist

| Category | Environmental Item | Main Check Items | Yes: Y<br>No: N | Confirmation of Environmental Considerations (Reasons, Mitigation Measures) |
|---|---|---|---|---|
| 1 Permits and Explanation | (1) EIA and Environmental Permits | (a) Have EIA reports already been prepared in official process?<br>(b) Have EIA reports been approved by authorities of the host country's government?<br>(c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?<br>(d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government? | (a) N/A<br>(b) N/A<br>(c) N/A<br>(d) N | (a) EIA reports are not required.<br>(b) EIA reports are not required.<br>(c) EIA reports are not required.<br>(d) Forest clearances are required for 9 subprojects. One of them has already been acquired. |
| | (2) Explanation to the Local Stakeholders | (a) Have the contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Has understanding been obtained from the Local stakeholders?<br>(b) Have the comments from the stakeholders (such as local residents) been reflected in the project design? | (a) N<br>(b) N | (a) No information has been given to the local stakeholders. It will be given before construction.<br>(b) No comments have been taken. |
| | (3) Examination of Alternatives | (a) Have alternative plans for the project been examined taking into account social and environmental considerations? | (a) Y | (a) Many alternative routes have been considered so far. Two sub-projects are cancelled due to impact on protected areas and the length of passing through the forest was reduced from 86.5 km to 24.2 km by changing the routes. |
| 2 Pollution Control | (1) Water Quality | (a) Is there any possibility that soil runoff from the bare lands resulting from earthmoving activities, such as cutting and filling, will cause water quality degradation in downstream water areas? If water quality degradation is anticipated, have adequate measures been considered? | (a) ? | (a) There might be some possibility of runoff if the towers are located in mountainous areas. EMP provides some precautions for runoff (See 9.1.1.3 of IEE) such as “Erosion prevention techniques should be adopted for slope areas” and “After construction, bare ground should be covered by vegetation”. |
| 3 Natural Environment | (1) Protected Areas | (a) Is the project site located in protected areas designated by the country’s laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas? | (a) N | (a) All the sub-projects are located outside of the National parks and Sanctuaries designated by the Indian Government. |
| | (2) Ecosystem | (a) Does the project site encompass primeval forests, tropical rain forests, or ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)?<br>(b) Does the project site encompass the protected habitats of endangered species designated by the country’s laws or international treaties and conventions?<br>(c) If significant ecological impacts are anticipated, have adequate protection measures been taken to reduce the impacts on the ecosystem?<br>(d) Have adequate measures been taken to prevent disruption of migration routes and habitat fragmentation of wildlife or livestock?<br>(e) Is there any possibility that the project will cause negative impacts, such as destruction of forest, poaching, desertification, reduction in wetland areas, or disturbance of ecosystem due to introduction of exotic (non-native invasive) species or pests? Have adequate measures for preventing such impacts been considered? | (a) N<br>(b) N<br>(c) Y<br>(d) ?<br>(e) Y<br>(f) N | (a) Most of the primeval forest in the protected areas has been avoided, but it is not clear whether it has all been completely avoided or not because of the lack of a site survey.<br>(b) All the designated Tiger reserves are outside of the project location.<br>(c) It is not clear whether there will be significant ecological impact or not because of the lack of a biological site survey. Some sub-projects might be located in undesignated Tiger corridors. The possible impact would be increasing regional extinction risk of Tiger by habitat fragmentation, decreasing number of individuals by shrinking habitats, and increasing |

| Category | Environmental Item | Main Check Items | Yes: Y<br>No: N | Confirmation of Environmental Considerations (Reasons, Mitigation Measures) |
|---|---|---|---|---|
| | | (f) In cases where the project site is located in undeveloped areas, is there any possibility that the new development will result in extensive loss of natural environments? | | human conflict caused by human habitat expansion. EMP mentioned that MPPTCL will discuss with the Wildlife Department and follow all the instructions.<br>(d) It is not clear which kind of instructions will be given by the Wildlife Department to maintain migration routes. Possible instruction would be detail survey during detail design, increasing the tower height to preserve vegetation under the ROW, installation of access rules to the habitat and so on.<br>(e) There is a small possibility that the project causes negative impacts. Clearing vegetation under the ROW might make access to the forest easier. It might cause illegal logging and introduction of exotic species. EMP mentioned that MPPTCL will discuss with the Wildlife Department and follow all the instructions.<br>(f) There is no possibility that the project will result in extensive loss of natural environments. The loss of forest has been carefully avoided during route identification and minimized up to 67.7 ha, which is only 2.7 % of the total ROW. |
| 3 Natural Environment | (3) Topography and Geology | (a) Is there any soft ground on the route of power transmission and distribution lines that may cause slope failures or landslides? Have adequate measures been considered to prevent slope failures or landslides, where needed?<br>(b) Is there any possibility that civil works, such as cutting and filling will cause slope failures or landslides? Have adequate measures been considered to prevent slope failures or landslides?<br>(c) Is there a possibility that soil runoff will result from cut and fill areas, waste soil disposal sites, or borrow sites? Have adequate measures been taken to prevent soil runoff? | (a) ?<br>(b) ?<br>(c) ? | (a) It is not clear because no detailed surveys have been done yet. EMP states that “Slope areas of more than 10 degrees should not be selected as locations of TML towers”, “Geological boring exploration should be done before detailed design” and “High risk landslide areas should be avoided for TML" towers” (See 9.1.1.3 of IEE).<br>(b) It is not clear whether there is any possibility of slope failures or landslides because it is before the detailed survey.<br>(c) It is not clear whether there is any possibility of slope failures or landslides because it is before the detailed survey. |

| Category | Environmental Item | Main Check Items | Yes: Y<br>No: N | Confirmation of Environmental Considerations (Reasons, Mitigation Measures) |
|---|---|---|---|---|
| 4 Social Environment | (1) Resettlement | (a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, have efforts been made to minimize the impacts caused by the resettlement?<br>(b) Is adequate explanation on compensation and resettlement assistance to be given to affected people prior to resettlement?<br>(c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?<br>(d) Is the compensation going to be paid prior to the resettlement?<br>(e) Are the compensation policies prepared in a document?<br>(f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples?<br>(g) Are agreements with the affected people to be obtained prior to resettlement?<br>(h) Is an organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?<br>(i) Have any plans been developed to monitor the impacts of resettlement?<br>(j) Is the grievance redress mechanism established? | (a) Y<br>(b) Y<br>(c) N/A<br>(d) N/A<br>(e) N/A<br>(f) N/A<br>(g) N/A<br>(h) N/A<br>(i) Y<br>(j) Y | (a) It is not clear whether involuntary resettlement will be completely avoided or not because the designs are not fixed, but a large number of involuntary resettlements will not happen because MPPTCL has no experience of resettlement over 20 years.<br>(b) EMP states that MPPTCL will follow the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (See 9.1.3.1 of IEE).<br>(c) Resettlement is not confirmed at this stage.<br>(d) Resettlement is not confirmed at this stage.<br>(e) Resettlement is not confirmed at this stage.<br>(f) Resettlement is not confirmed at this stage.<br>(g) Resettlement is not confirmed at this stage.<br>(h) Resettlement is not confirmed at this stage.<br>(i) Compliance Monitoring check list in the EMP confirms resettlement issues (See 9.2 of IEE).<br>(j) Grievance redress mechanism is mentioned in Section 9 of IEE. |
| | (2) Living and Livelihood | (a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Have adequate measures been considered to reduce the impacts, if necessary?<br>(b) Is there a possibility that diseases, including infectious diseases, such as HIV will be brought in due to immigration of workers associated with the project? Have adequate considerations been given to public health, if necessary?<br>(c) Is there any possibility that installation of structures, such as power line towers, will cause radio interference? If any significant radio interference is anticipated, have adequate measures been considered?<br>(d) Is the compensation for transmission wires given in accordance with the domestic law? | (a) Y<br>(b) Y<br>(c) Y<br>(d) Y | (a) The project will reduce agricultural production in land which falls in the ROW during construction. Crop compensation will be paid to the farmers (See 9.1.3.2 of IEE).<br>(b) There is a possibility that some diseases might be brought in by workers. A public health program is planned in EMP (See 9.1.3.5 of IEE).<br>(c) It is not clear whether radio interference will happen or not, but MPPTCL will explain the risk to the local people and take precautionary measures if required (See 9.1.1.6 of IEE).<br>(d) Crop compensation will be paid to the land owners based on the survey by the Revenue Department. |
| 4 Social Environment | (3) Heritage | (a) Is there a possibility that the project will damage the local archeological, historical, cultural, or religious heritage? Have adequate measures been considered to protect these sites in accordance with the country's laws? | (a) ? | (a) It is not clear whether damage to cultural assets will be completely avoided or not. It will be minimized during the site survey by the Revenue Department or discussion with the local people. If any serious impacts are expected, MPPTCL will follow |

| Category | Environmental Item | Main Check Items | Yes: Y<br>No: N | Confirmation of Environmental Considerations (Reasons, Mitigation Measures) |
|---|---|---|---|---|
| | | | | the instructions from the Revenue Department (See 9.1.3.3 of IEE). |
| | (4) Landscape | (a) Is there a possibility that the project will adversely affect the local landscape? Have necessary measures been taken? | (a) ? | (a) It is not clear whether there is any possibility or not because no site survey has been conducted. |
| | (5) Ethnic Minorities and Indigenous Peoples | (a) Are considerations given to reducing impacts on the culture and lifestyle of ethnic minorities and indigenous peoples?<br>(b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected? | (a) Y<br>(b) Y | (a) Settlements of Ethnic Minorities are also avoided by the TML routes. Crop compensation will be given when crop lands of Ethnic Minorities are affected.<br>(b) The rights of Scheduled Tribes and Scheduled Castes will be respected based on the Scheduled Caste and Scheduled Tribe (Prevention of Atrocities) Act, 1989 by MPPTCL. |
| | (6) Working Conditions | (a) Is the project proponent not violating any laws or ordinances associated with the working conditions of the country which the project proponent should observe in the project?<br>(b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials?<br>(c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.?<br>(d) Have appropriate measures been taken to ensure that security guards involved in the project do not violate the safety of other individuals involved, or local residents? | (a) N<br>(b) Y<br>(c) Y<br>(d) N/A | (a) Project proponent will not be violating any laws. Safety Department of MPPTCL will implement safety training program for workers during both construction and operation (See 9.1.3.7 of IEE).<br>(b) Safety equipment is present in existing Sub-stations. The same equipment will be installed in the planned Sub-stations too.<br>(c) Safety Department of MPPTCL has implemented various precautions and conducting training for the workers so far. These activities will be implemented in this project too.<br>(d) Such kinds of issues are not expected. MPPTCL has no experience of security guards violating the safety of individuals. |
| 5 Others | (1) Impacts during Construction | (a) Have adequate measures been considered to reduce impacts during construction (e.g. noise, vibrations, turbid water, dust, exhaust gases, and waste)?<br>(b) If construction activities adversely affect the natural environment (ecosystem), have adequate measures been considered to reduce the impacts?<br>(c) If construction activities adversely affect the social environment, have adequate measures been considered to reduce the impacts? | (a) Y<br>(b) Y<br>(c) Y | (a) Water pollution, noise, and waste issues will be monitored by compliance monitoring (See 9.2 of IEE).<br>(b) If any instructions are issued by the Wildlife Department, MPPTCL will follow the instructions.<br>(c) If any instructions are issued by the Revenue Department, MPPTCL will follow the instructions. |
| | (2) Monitoring | (a) Does the proponent develop and implement a monitoring program for the environmental items that are considered to have potential impacts?<br>(b) What are the items, methods and frequencies of the monitoring program?<br>(c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget) to sustain the monitoring framework?<br>(d) Have any regulatory requirements pertaining to the monitoring report system been identified, such as the format and frequency of reports from the proponent to the regulatory authorities? | (a) Y<br>(b) Y<br>(c) ?<br>(d) Y | (a) MPPTCL developed compliance monitoring. If impact monitoring is suggested by other agencies MPPTCL will follow the instructions.<br>(b) The items cover Physical, Natural and Social environment. Checklist system is used. The frequency is once a month (See 9.2 of IEE).<br>(c) There is no Environmental Department in MPPTCL. The related Department would be changed |

| Category | Environmental Item | Main Check Items | Yes: Y<br>No: N | Confirmation of Environmental Considerations (Reasons, Mitigation Measures) |
|---|---|---|---|---|
| | | | | depend on the issues (9.3 of IEE), but MPPTCL will assign a person who is in charge of Environment for this project. But the institutional and budget frameworks are not fixed yet.<br>(d) The monitoring style is checklist. The results of the checklist will be combined and submitted to JICA annually. |
| 6 Note | Reference to Checklist of Other Sectors | (a) Where necessary, pertinent items described in the Road checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities). | (a) N/A | (a) Most of the project location is near existing roads. There might be a few sub-projects which require construction of access roads but this is not clear at present. |
| | Note on Using Environmental Checklist | (a) If necessary, the impacts on transboundary or global issues should be confirmed, (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming). | (a) Y | (a) One of the global warming gases, FX6, will be used for the GIS system. It will be carefully treated and collected during maintenance, which would be once in 20 years. |

1) Regarding the term “Country’s Standards” mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made. In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).

2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and area in which it is located.