STUDY ON RENOVATION AND MODERNISATION (R&M) OF SOLAR POWER PLANT

By

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A DISSERTATION REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

MBA in POWER MANAGEMENT

OF

CENTRE FOR CONTINUING EDUCATION

UNIVERSITY OF PETROLEUM & ENERGY STUDIES, DEHRADUN

Acknowledgement

This is to acknowledge with thanks the help, guidance and support that I have received during the Dissertation.

I have no words to express a deep sense of gratitude to the management of Greenko Group for giving me an opportunity to pursue my Dissertation, and in particular Mr. ***N. Ramprasad*** for his able guidance and support.

I must also thank Mr. ***Santosh J.V.N*** and Mr. ***Kasi Viswanadh. P*** for their valuable support.

I also place on record my appreciation of the support provided by Mr. ***Venugopal .VL*** and Mr. ***Krishna Chaitanya .M*** for valuable inputs from current project.

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Declaration by the Guide

This is to certify that the Mr. ***VALLURU RAVEENDRA***, a student of MBA in Power Management, SAP ID: ***500059955*** of UPES has successfully completed this dissertation report on "***Study on Renovation and Modernisation (R&M) of solar power plant***" under my supervision.

Further, I certify that the work is based on the investigation made, data collected and analysed by him and it has not been submitted in any other University or Institution for award of any degree. In my opinion it is fully adequate, in scope and utility, as a dissertation towards partial fulfilment for the award of degree of MBA.

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Chapter 1
INTRODUCTION

1.1 Introduction and background:

There are many old and inefficient power plants still contributing to the grid and due to tear and wear their performance has dropped. Environmental requirements also change over a period. These plants could be upgraded at minimum cost and time than the construction of a new plant with an increase in capacity from improved efficiency and reliability, causing no additional burden on already existing infrastructure. There is unanimity that R&M (Renovation & Modernisation) is one of the most cost-effective ways of bridging the gap between demand and supply in the short-term. The R&M program has a special significance for developing countries like India.

To cope up with growing demand for power, Construction of new power plants, transmission lines and substations are always a difficult proposition due to various factors. R&M of existing projects is one of the cost-effective alternatives to setup new power plants. R&M is not only cost-effective solution but also acquires major advantages such as increase the power transmission capabilities, reduce losses of transmission system and increase the grid availability to generate more power.

1.2 Renovation and Modernization:

The objective of Renovation & Modernization (R&M) of solar power plants is to equip or modify the existing plant with latest modified & augmented technology equipment/systems with a view to improve their performance in terms of output, reliability, efficiency and availability, reduction in maintenance requirements, ease of maintenance and minimizing inefficiencies. Here R&M Programme is primarily aimed at Transmission line and overcoming problems such as increase in copper Losses and down time etc.

The need of doing R & M technique is to Implement the fresh capacity additions to cope up with the demand supply gap involves huge investments and long gestation periods. primarily due to the process of land acquisition and getting the required fuel and water allocations, permits & clearances, particularly, the environmental clearance.

R&M activity of existing old power plants which requires less investment and can be completed in shorter duration has been recognized as a techno-economically viable option to supplement the fresh capacity addition for maximizing the energy generation

1.3 Statement of Problem:

Most of the power plants are designed for an economical and stable life span of 25 years, after which, the level of performance of the plants starts deteriorating because of degradation of its equipment, components and materials.

Renovations & Modernization (R&M) of Power plants is an activity of carrying out repairs, refurbishments and replacement of defective equipment & components and to restore the performance parameters to equal or better than the original design parameters.

1.4 Need for research:

Implementation of fresh capacity additions to cope up with the demand supply gap involves huge investments and long gestation periods. primarily due to the process of land acquisition and getting the required fuel and water allocations, permits & clearances, particularly, the environmental clearance.

R&M activity of existing old power plants which requires less investment and can be completed in shorter duration has been recognized as a techno-economically viable option to supplement the fresh capacity addition for maximizing the energy generation.

1.5 Objectives of the study:

- To restore rated capacity and design parameters.
- To make the operating units well equipped with modified/ augmented latest technology.
- To improve the performance parameters in terms of Plant Load Factor, Efficiency, Forced Outages, Availability and Reliability.
- To reduce maintenance requirements and enhance the ease in maintenance.
- Compliance of stringent environmental norms, safety and other statutory requirements.

1.6 Dissertation outline:

Chapter-1 deals with introduction and project outline

Chapter-2 deals with Literature review

Chapter-3 deals with Research Methodology and plan.

Chapter-4 deals with findings, Analysis

Chapter-5 deals with Interpretations and results

Chapter-6 deals with conclusions and scope for future work.

Chapter 2
LITERATURE REVIEW

2.1 Literature Survey

- Lahmeyer international (India) pvt. Ltd. (LII-GETS12021-G-00100-002) prepared the feasibility report for renovation & modernisation of fossil fuel-based power plants in India and discusses the salient features and operational history of the power plant and the specific problems being faced from the operation of various plant equipment & systems. The report describes the residual life of critical components of the plant, Cost estimation etc.,
- WAPCOS Limited under technical assistance to CEA prepared the report on review of R&M Implementation Experience from Pilot R&M Interventions in Thermal Power Stations in India.
- Https://powermin.nic.in/en/content/policy-renovation-and-modernisation-existing-stations describes the policy for renovation and modernisation of existing stations
- An overview on renovation and modernization of existing substations published in 2017 International Conference on Nascent Technologies in Engineering (ICNTE), IEEE, 10.1109/ICNTE.2017.7947925 gives overview on combined features of all upgraded technology, related to achieve optimum results, space management and its effects on system. It also focused on cost reduction in long term usage while maintaining the performance of entire system.
- Feasibility of the Modernization and Upgrade of the Electrical High Voltage Substations published in 2006 IEEE/PES Transmission & Distribution Conference and Exposition: Latin America, IEEE, 10.1109/TDCLA.2006.311404 deals with the techno-economical solution for replacement of high voltage equipment, Life cycle cost (LCC) of substations and comparison among the different technology alternatives.

Chapter 3

RENOVATION AND MODERNISATION

3.1 Renovation and Modernisation:

Renovation, Modernization and Upgradation of old power stations is extremely cost effective, environment friendly and meets sustainability requirements. Further it requires less time for implementation. Capacity addition through RM&U of old power stations is an attractive proposition in the present scenario, when most of the Power Utilities on account of their financial conditions are not able to invest in creation of new generating capacity. The economy in cost and time, essentially results from the fact that apart from the availability of the existing infrastructure, only selective replacement of critical can lead to increase in efficiency, peak power and energy availability apart from giving a new lease of life to the power plant/ equipment.

Modernization is a continuous process and can be a part of the renovation programme. For techno-economic feasibility, it is desirable to consider the uprating along with Renovation & Modernization / Life extension.

The ever-increasing demand–supply gap in the power sector and the sectoral imbalances are the major concerns, which needs to be addressed, in the Indian power market. There are many new projects, which have been allotted to different private developers and only a few have achieved their targets and rest of the developers are still in the hunt. Its best solution for old power plants to implement Renovation, Modernization & Upgradation due to its following benefits:

3.1.1 No / Minimum clearances required:

For development of any new Solar project following statutory clearances are required:

- Techno-economic clearance of the project
- Site Clearances by MOEF after feasibility studies
- Environmental Clearances based on EIA (Environmental Impact Assessment) and EMP (Environment Management Plan)
- Forest Clearances
- Land acquisition etc.
- R&R Issues

These clearances are the major risk to the development of the project as they take considerable time and effort. In case of RM&U of the old projects, these stages are already taken care of during its initial construction. Any clearances required only if any land is to be used other than the project land, which may be meagre in quantum and can be accommodated as a parallel activity. Moreover, Rehabilitation & Resettlement issues are either nil or very less for the RM&U projects.

3.1.2 Less Gestation Period:

Each project needs to start afresh since its inception. The geological conditions are different at different sites, which make it a very uncertain venue to invest. These uncertainties and enormous civil works could extend the gestation period of a new project, resulting in cost overruns and less return on investments. RMU of old power station is having very less gestation period in comparison to an equivalent new project. Proper scheduling of the works can reduce the implementation period of any RMU project.

3.1.3 Less Risks:

New Projects are high-risk investments with geographical terrain playing major role in their successful completion. There are various major risks associated with the development of any new project such as clearance risks, geographical risk, construction risk, regulatory risk, resettlement & rehabilitation risk, social risk etc. These risks not only increase the gestation period of the project but also delay the return on the investments. However, these risks are not at all associated with the RMU of old power stations. The return on investments would be far earlier as compared to any new project.

3.1.4 Less investment as against equivalent new project:

Cost of development of any new solar electric project may range from ₹5 to 6 Crore per MW, whereas, depending on the scope of RMU, the cost of development of RMU of old solar electrical projects may range from ₹0.05 – 1.5 Crore per MW. Arrangement of finance for development of any project is a major hurdle for any management. Lesser the cost and lessen the risk easier would be the arrangement of finance and since the risk associated with the RMU projects are very less, financial institutions would readily make available the required finance.

3.1.5 Technological Advancement:

Technology is ever changing, and solar sector is not untouched of it. For example, there is improvement in technology in Solar modules and inverters. The efficiency of the latest solar module got increased to 18% and the ratings, voltage levels and efficiency of inverters has increased. Currently, all the solar panels are of poly crystalline type rather than thin films.

3.1.6 Safety Margins and Overload Margins in the Old design:

Most of the old solar electric power stations are very pessimistically designed. At times the safety margins of the civil structure are to the tune of 200% to 400%. Also overload margins of old solar stations are on higher side, which can be usefully exploited to get about 10 -15 % additional capacities. These margins can be optimized by enhancing the parameters responsible for the generation of energy.

3.1.7 Life Extension of Existing Facilities:

RMU of old power stations will not only be beneficial in enhancing the capacity of the plant but also help in the life extension of the plant by another 25 -35 years depending on the degree of RMU.

3.2 Stages of R&M Cycle:

The various stages involved in R&M of a solar power station are described below:

3.2.1 Early R&M Planning:

The plant/units for implementation of R&M works are identified after analysis of the performance of the units. Key parameters such as Heat Rate, PLF, Auxiliary Power Consumption, Specific Coal Consumption, Specific Oil Consumption, Environmental Emissions etc. are regularly monitored. Identification at this stage is primarily based on historical data of various performance parameters.

3.2.2 R&M Project Assessment:

During this stage, R&M project scope is defined keeping in view available data, results specialized testing and analysis, RLA/LE studies and cost-benefit analysis. Apart from this, there may be early failures due to deviations in operation practices. As such, before undertaking any preparation of R&M project, assessment of the extent of equipment ageing/deterioration/residual life etc. needs to be made for which following studies/tests are required to be conducted for identification of the scope of R&M works:

a) Residual Life Assessment (RLA)

b) Energy Audit

c) Condition Assessment

3.2.3 Development of Procurement Strategy:

After defining the scope of R&M project, design specifications and different packages are decided. The procurement strategy covers Tendering, Pre-bid meetings, Evaluation of Technical and Commercial bids, Negotiation proceedings and finally award of work to suppliers/manufacturers in case of competitive bidding. In some cases, R&M works are awarded to the Original Equipment Manufacturers.

3.2.4 R&M Project Implementation:

The following activities are involved in implementation of R&M Projects:

a) Ordering of material required for R&M works and issue of work order for execution

b) Inspection of material

c) Receipt of material at site

3.3 Approach and Methodology:

The relevant data/information for review and analysis relating implementation of R&M works in solar power plant is taken from site authorities/officials. The following procedure was adopted for execution of the assignment. The following flow chart briefly describes the procedure for execution of Renovation and modernisation:

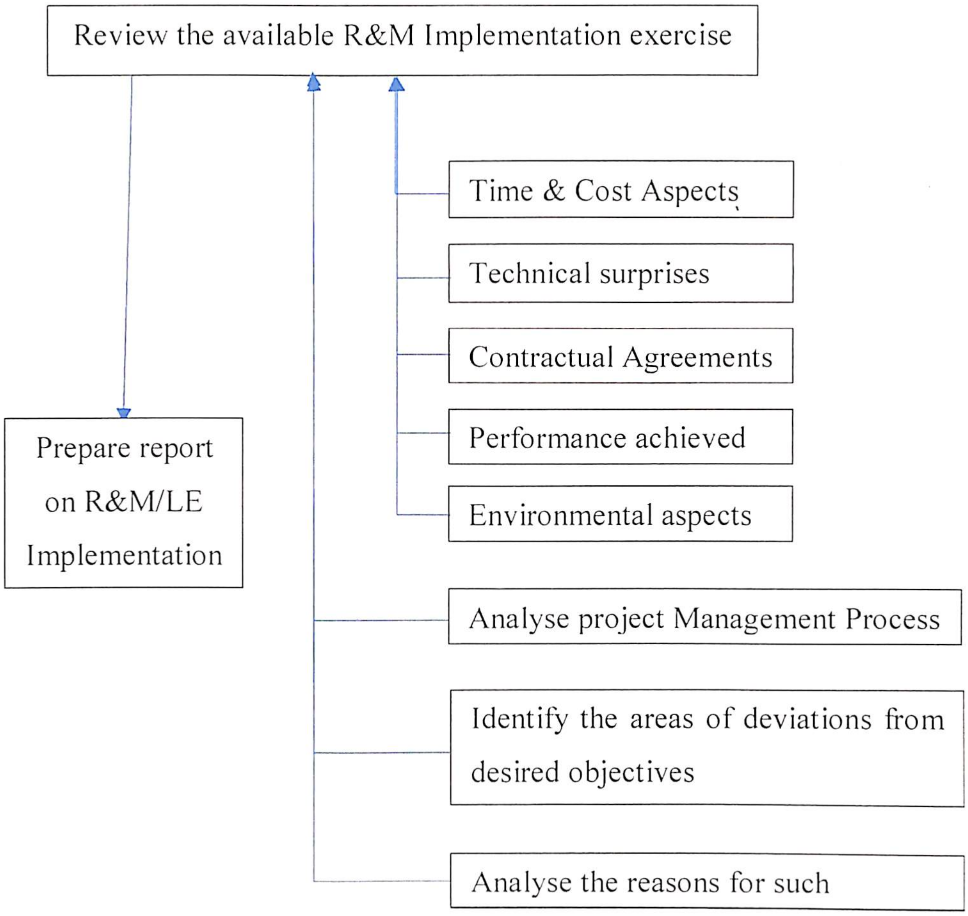

Figure 3.1: Flow chart of R&M exercise approach and methodology

- Review of R&M Implementation Experience:

The review also covered time and cost aspects, technical surprises, contractual arrangements and the performance achieved. It also covered the R&M implementation experience available at the thermal power stations listed under the study. The review includes the analysis of project management process and identify the areas where the actual project implementation deviated from desired objectives and analyse the reasons for such deviations.

A questionnaire was circulated to the concerned power utilities and the solar power covering the following aspects for collection of data/information:

3.3.1 Time & Cost Aspects.

- Scope of works.
- Stipulated time in the contract for completion of various R&M works/activities.

- Actual time taken for completion of various R&M works/activities.
- Whether there was any delay in executing the job. If yes, then for how much time it got delayed. Reasons for delay to be brought out.
- Total cost of R&M works along with Package wise /Item wise cost and analysis of Cost Over-run.
- Quantum of Penalty imposed on the Contractor if any.

3.3.2 Technical Surprises:

- The type of technical problems encountered.
- Steps taken to address the problems.
- Whether help of any outside Agency/Expert taken to solve such problems.

3.3.3 Contractual Arrangement

- Whether it was a Turnkey job or the contract was divided into various packages.
- For awarding the contract, what practice was followed i.e. through press Tender or Limited Tender Enquiry or ICB.
- Names of various Tenderers who executed the jobs.
- Whether credentials of various contractors were checked before issue of Tender documents and whether they fulfilled the Tender condition etc.
- Whether work was executed under the supervision of Project authorities or contract supervision was taken from outside agency.
- What was the penalty clause & if any, whether the same was imposed on the contractor for any delay or not
- Whether all the contractors executed the work as per condition laid in Work Order or any breach of contract was there.
- Whether PG tests were conducted. If yes, what is the status.
- Whether any work was got done at the risk & cost of contractor or not
- Any disputes with the contractors
- After R&M works, what was the performance of each Unit in respect of important parameters such as PLF, Oil Consumption, Coal Consumption, DM Water Consumption, Auxiliary Consumption, Heat Rate, Reduction in no. of tripping, environment aspect etc. In case Guaranteed Performance not achieved, then what penalty was imposed/realized.
- From Management view, what was the organization chart, Bar Chart, PERT etc. Whether the works were done according to that or slippage was there, Whether

Supervisory services of outside Agency were taken. What was the Schedule of Review Meetings i.e. whether it was held weekly, fortnightly, monthly to assess the work progress.

- Whether various works were executed as per the contract or not. If not, the reasons for deviations to be examined. What were the barriers causing such deviations?

3.4 R & M Implementation exercise:

R&M Implementation Experience study was carried out by visiting, collecting and interacting with the Solar Power Plant authorities The analysis and review to be conducted on various aspects of implementation R&M project which broadly covered the time & cost aspects, technical surprises, contractual arrangements, performance achieved, analysis of project management process and identifying the areas where the actual project implementation deviated from desired objectives and analyse the reasons for such deviations. The questionnaire broadly covered Zero date of R&M project; Project schedule planned as well as actual achievement of the same. Data related to RLA study its findings and suggestions, brief scope of work, status of the project. Time and Cost aspects of the projects is covered in detail in the following chapters. Technical surprises encountered during R&M implementation in all the areas covered and the remedial measures taken. It also covers the project management process, the authorities involved in the project execution, key milestones achieved. It also covers problems faced due to contractor/sub-contractor, labour issues etc.

R&M implementation experience at three power stations of Pilot R&M Projects listed was reviewed. A Check List/Questionnaire prepared at the initial stage was supplied to the Project Authorities for collecting the available data/information as shown in the table 3.1.

3.5 (2x120 MW) Ukai Thermal Power Station, GSECL, Gujarat

3.5.1 Background

The Ukai Thermal Power Station (UTPS) is owned and operated by Gujarat State Electricity Corporation Ltd. (GSECL). The station has total installed capacity of 850MW which is comprised of 2x120MW units each (unit#1&2), 2x200MW units each (unit#3&4) and 1x210MW (unit#5) and it is located near Ukai Dam on Tapi River in Tapi District of Gujarat. Ukai TPS unit no. 1 & 2 (2x120MW) were commissioned during the year 1976.

Both the units had completed their useful life of 20 years and were not operating at rated capacity. The units had low PLF and low efficiency. Both the units were in need of performance improvement and life extension of the plant particularly considering deterioration in coal quality, turbine problems like bending of HP rotor, HP & IP high eccentricity, poor turbine efficiency, boiler problems like frequent economizer tube failure, ID fan overloading, air ingress in the furnace, lower collection efficiency of ESP. the control system supplied by Instrumentation Limited was based on Russian technology, which was obsolete, and spares were not available in market and also with ILK, the original supplier. Most of auto control loops were not working. The machines were operating at low PLF of 56.5% and with higher station heat rate.

The contract was awarded to BHEL for carrying out comprehensive Residual Life Assessment (RLA), Condition Assessment (CA), and Performance Evaluation Test (PET) of 2x120MW units. RLA/CA of unit 1&2 was completed by BHEL during forced outage from 01.08.2003 to 30.04.2004 for unit-1 and during capital overhauling from 27.02.2003 to 17.06.2003 for unit-2. Final report of RLA/LE study was submitted by BHEL for both the units.

Proposed R&M works based on RLA/CA & PET recommendations and the scope of work had been concluded through protracted discussions/interaction with GSECL Engineers/Officers of P&P Department, Generation Department and site engineers by BHEL. Based on RLA study recommendations, discussions and negotiations, R&M and LE activities were finalized for achieving rated capacity of 120MW, life extension post R&M by 15-20 years and modernization of C&I by state-of-art Distributed Digital Control and Management Information System (DDCMIS). To operate the plant optimally and improve the PLF and availability, it was recommended to change the existing instrumentations to modern microprocessor based and Distributed Digital Control System (DDCS) along with field instruments, SWAS, UPS, emission monitoring system and instrument cables.

3.5.2 Scope of R&M/LE Works:

The broad scope of supply covered design, engineering, manufacturing, inspection, factory testing, packing and forwarding and supply of O&M spares for boiler & auxiliaries, turbine-generator & auxiliaries, C&I, BoP and Electrical systems. The scope of services included unloading, storage, material handling at site, insurance, dismantling, erection, testing and commissioning of system/equipment. Performance Guarantee Test of boiler, turbine, C&I and BoP packages were also included in the scope of M/s. BHEL after the final commissioning of the units. The scope of work for carrying out renovation and modernization of major packages were as under.

3.5.2.1 Boiler & auxiliaries: Replacement of water wall tubes, economizer coils/tubes, super heater tubes etc. included in this package was done.

3.5.2.2 Turbine & auxiliaries: Replacement of turbine bearing numbers 1 through 7, replacement of inner and outer casing of HP turbine, replacement of rotor of IP and LP turbines, replacement of cartridges of BFP and replacement of CEP pump was done.

3.5.2.3 Generator: Stator coil were rewound with Class F insulation and slip ring assembly was replaced.

3.5.2.4 Balance of Plant: Fire Detection System with up gradation by installing new pumps in fuel oil station, replacement of air compressors, installation of new HVAC system, up gradation of ash handling system, water system, water treatment plant, make up water system and coal handling plant were included for R&M.

3.5.2.5 Electrical: Replacement of 6.6kV VCB (Vacuum Circuit Breaker) circuit breakers used for operation of HT motors.

3.5.2.6 Control & Instrumentation: Replacement of old control system with new Max DNA Distributed Control System (DCS) supplied by BHEL. Max DNA is a type of DCS developed by BHEL.

S. No.	Parameter	Target Values
1	Boiler Efficiency	85.5%
2	Heat Rate	2122+0.9% kCal/kWh
3	ESP outlet dust emission level	125 mg/Nm^3
4	Plant Availability	85% for first year

Table 3.1: Target Values after R&M for Ukai TPS

3.5.3 Time and Cost Aspects

The time aspects of the R&M works carried out at Unit#1&2 of Ukai Power Station was as follows.

S. No.	Milestones	Target Date/ Month	Actual Date/Month
1	Date of RLA Study	Not Available	October 2003
2	Zero Date of R&M Project	29.03.2005	29.03.2005
3	Date of Shutdown for R&M	06.09.2005	06.09.2006
4	Date for completion of R&M works	28.11.2006	24.05.2008
5	Hydro Test	Not Available	01.09.2007
6	Boiler Light Up	Not Available	04.09.2007
7	Synchronization	28.11.2006	24.05.2008

Table 3.2: R&M Implementation Schedule for Unit# 1 of Ukai TPS

S. No.	Milestones	Target Date/ Month	Actual Date/Month
1	Date of RLA Study	Not Available	March 2003
2	Zero Date of R&M Project	29.03.2005	29.03.2005
3	Date of Shutdown for R&M	Not Available	12.08.2008
4	Date for completion of R&M works	28.06.2007	24.02.2010
5	Hydro Test	Not Available	February 2010
6	Boiler Light Up	Not Available	February 2010
7	Synchronization	28.06.2007	24.02.2010

Table 3.3: R&M Implementation Schedule for Unit# 2 of Ukai TPS

As per contract the original duration of project for both the units was planned for 27 months for both the units from zero date out of which the 7 months was allocated for each unit shutdown i.e. for Unit-1 it was scheduled from 14th month to 20th month and for Unit-2, shutdown was scheduled from 21st month to 27th month but actual time taken to complete overall project was 59 months. The actual R&M implementation period of unit-1 was 38 months and that of unit-2 was 59 months. The Lead Period unit-1 was scheduled as 14 months and for unit-2 it was 20 months. Unit-1 was kept under shutdown for 20.5 months and unit-2 was under shutdown for 18 months. The project of both the units was mainly delayed due to delay in supply of critical materials by M/s. BHEL, performance of some of the sub-contractors were not up to the mark and some sub-contractors left the site without completing the works assigned to them and their replacement with new ones took long time.

3.5.4 Cost Aspect:

Competent authority had accorded an administrative approval for implementing major R&M and LE works and accepted BHEL's negotiated offer of ₹260/- crores (₹1.08/- crore per MW) for awarding R&M and LE works contract to M/s. BHEL being OEM on negotiable offer manner without inviting any tender as per Ministry of Power guidelines.

S. No.	Item	Estimated Cost (₹ Crores)
1	Supply of Material	210.05
2	Service	46.95
3	Civil Work	3.0
	Total	**260.00**

Table 3.4: Cost of R&M for Both the units of Ukai TPS

The contract was awarded to M/s. BHEL for supply, erection, testing and commissioning of both the units, i.e. Unit# 1&2 as shown below: - 70% of the fund for R&M/LE works was allocated by Power Finance Corporation, New Delhi at the prevailing norms of the PFC and balance funds were allocated from annual plan of the Gujarat Electricity Board. There was no cost overrun for this project.

3.5.5 Project Management Process

The project management process included description about the project execution team and in-charges of the concerned areas including that of the contractors also, package-wise subcontractors, coordination between project authorities and sub-contractors and any issues related during execution of the project like labour unrest etc. Drawings were approved before various works of R&M. The contractor submitted L1, L2 and L3 schedule prior to the project start-up. Supply management was looked after by dedicated R&M team of the project.

General information	Unit-1	Unit-2
R&M Team for implementation of R&M Project.	A.C.E. (R&M), S.E.(R&M), E.E. (R&M), D.E & J.E (R&M)	
R&M Team of Contractor.	Every work package handled by supervisors and assisted by suitable engineering team	
Names of Sub-contractors- below	Package wise as per Table 4.6	
Project Monitoring Process being followed Through Consultant:	Monitoring was carried out by authorized consultant M/s. Lahmeyer International, Gurgaon	
Issues related to Decision making, if any	Project authority jointly with consultant	
Whether all Contractors executed the work as per conditions laid in Work Orders or there was any breach of contracts	Yes, as per work order. No breach of contract	

Table 3.5: General Information

Unit-1	Unit-2
a) **Boiler & Auxiliary** For Acid Cleaning Work M/s Aruchem, Chennai For Fabrication Work Panjab Engg. Sonagadh K. Ismil, Ukai b) **Turbine & Auxiliary** For Insulation Work M/s Om Insulation, Vadodara For Insitu. Machining Work M/s Stimex Engineers, Indore (MP) For Reaming Works M/s Sing Tools, Gajiabad (UP)	a) **6.6 kV Switchgear** • M/s Shraddha Factories, Sonagadh b) **Electrical Overhauling** • M/s Masion Electricals, Delhi • M/s Shrddha Factories, Sonagadh • M/s Shanu Enterprise, Vyara c) **Ash Handling System Erection Work** • K. Ismile, Ukai • M/s Engineering India Ltd., Sonagadh d) **Civil Work** M/s AB Engineers, Gandhi Nagar e) **Cable Tray Work** Roshni Engg. Ukai f) **For Water Treatment System** • M/s IST, Sonagadh • Raj Engineering Surat g) **Coal Handling System** • M/s Spectrum Engg. Vadodara • M/s Engineering India LTD.., Sonagadh M/s Chandra Construction, Bhopal

Table 3.6: List of Sub-Contractors

To execute the project properly and to coordinate between authorities and sub-contractors, regular meetings were held for project monitoring. Following table depicts the coordination.

S. No.	Description	Unit-1	Unit-2
i)	Scheduled of meeting held for monitoring the progress of work	Internal meetings were held almost daily	
ii)	Coordination among the utility and contractor	Meeting of project authority, main contractor & subcontractors were held	
iii)	Coordination among sub-teams of the contractor	Meetings done by main contractor M/s. BHEL	
Issues & Problems faced			
i)	Any Labour Unrest during execution of work	No labour unrest	
ii)	Any other Issues	No other issues	

Table 3.7: Coordination

3.5.6 Technical Surprises

No major technical surprises occurred as per the plant authorities.

3.5.7 Problems/Challenges faced After R&M

Unit # 1

- Temperature of Turbine bearing number 3 was constantly high during commissioning.
- Up to 114MW load, two BFPs were running and thereafter to increase the load up to 120MW, three BFPs were required to run, even though the third BFP is standby equipment which is not run in normal times.
- One CEP (Condensate Extraction Pump) was not able to maintain the De-Aerator level, therefore both CEPs were kept in running condition
- Due to running of all three Boiler Feed Pumps and both the Condensate Extraction Pumps, the Auxiliary Power Consumption of the Unit has gone up.
- High horizontal and vertical vibrations observed in Generator bearing numbers 6 and 7.
- CBD (Continuous Blow Down) was kept continuously opened due to higher value of Silica content in steam.

Unit# 2

- Eccentricity of HP Turbine was high
- Bearing metal temperature of Turbine bearing numbers 3, 6 and 7 was high.
- Two BFPs are not able to maintain the Boiler drum level at 120MW load therefore all three of them were kept in running condition.
- One CEP was not able to maintain the De-Aerator level; therefore, both CEPs were kept in running condition.
- Due to running of all three Boiler Feed Pumps and both the Condensate Extraction Pumps, the Auxiliary Power Consumption of the Unit was high.

3.5.8 Contractual Arrangements

The R&M contract was awarded to BHEL as they were the OEM of the plant. The liquidated damage was fixed as performance LD. There was the provision for performance guarantee tests in the contract as described below:

3.5.9 Liquidated Damage (LD)

Delay in supply of material beyond contractual schedule was subjected to liquidated damage (LD) at the rate of 0.25% of the order value of the respective unit of delayed material per week or part there of subject to maximum ceiling of 7.5% of total order value comprises of supply of materials, services and civil works for respective unit including BoP and Electrical. In case of failure of guaranteed performance parameters, LD charges were fixed at following rates.

S. No.	Parameter Name	Parameter Value	LD in ₹
1	Output Power	120MW	₹26285/- for every kW shortfall in output power
2	Turbine Heat Rate	2122+0.9% kCal/kWh	₹53200/- for every kCal/kWh increase in guaranteed turbine heat rate
3	Boiler efficiency	85.5%	₹273000/- for drop of every 0.1% in efficiency
4	Collection efficiency of ESP	99.764%	₹273000/- for drop of every 0.1% in efficiency

Table 3.8: Liquidated Damage for Failure of Guaranteed Parameters

The actual amount of LD recovered was ₹ 3.23 Crores/-.

3.5.10 Performance Guarantee (PG) Test

PG test on both units were to be conducted as per contract to prove the performance parameters within one month of commissioning based on mutually agreed PG test procedures, comprising of following points. However, the PG test has not yet been conducted since the unit failed to achieve the full load of 120MW and there is still some dispute going on between GSECL and BHEL officials.

(a) ESP Dust concentration of 125 mg/Nm^3 at outlet with 99.76% collection efficiency at 100% MCR with 12 fields in service.

(b) Gas distribution test inside ESP

(c) Gas flow measurement for / through the ESP

(d) Clean airflow test for Mills

(e) Performance test for auto control loops including ramp and step tests

(f) Condenser vacuum test

3.5.11 Performance Achieved

(a) Benefits anticipated after implementation of R&M works After implementation of R&M/LE works the generation was anticipated to increase by 30 MW per unit and station heat rate was anticipated to decrease from 2881.52 to 2481.87 kCal/kWh i.e. decrease in heat rate by 399.65 kCal/kWh and life of the units would be extended by further 15-20 years. This would also improve the plant load factor (PLF) from 56.5% to 80%. The payback period worked out to be 4 years & 4 months.

(b) Performance Achieved Unit-1 R&M was done from 06/09/2006 to 24/05/2008. The performance of Unit-1 before and after R&M is stated below. The Pant Load Factor (PLF) of 80% was to be obtained as planned after R&M works. The performance of 120 MW Unit # 1 & 2 before and after R&M Implementation, is shown in table 3.9.

Pre-R&M						
Parameter	**Gross Generation**	**PLF**	**APC**	**SOC**	**SCC**	**Heat Rate**
Period	**MU**	**%**	**%**	**ml/ kWh**	**kg/kWh**	**kCal/ kWh**
2004-05	285.35	27.15	10.85	6.4	0.67	2765
2005-06	573.23	54.53	8.91	1.02	0.69	2879
2006-07	219.78	20.91	12.87	3.03	0.71	2978
Post R&M						
2008-09	157.886	24.53	14.46	66.81	0.54	2793
2009-10	532.732	50.68	10.85	12.83	0.88	2813
2010-11	694.32	66.05	11.46	8.088	0.76	2995
2011-12	626.29	59.41	10.81	1.46	0.74	2835
2012-13	493.99	46.99	10.69	4.44	0.733	2835.03
2013-14	222.44	21.16	12.38	2.12	0.735	2821.51

Table 3.9: Unit-1 performance Pre and Post R&M of Ukai TPS

From the above Tables it can be observed that only PLF has improved, but no significance improvement in other parameters. The Specific Oil Consumption (SOC) value just after R&M is seen very high at 66.81 ml/kWh. The reason was due to frequent tripping of the Unit, as many as 62 times, during the year 2008-09 and Unit start up thereafter.

Pre-R&M						
Parameter	**Gross Generation**	**PLF**	**APC**	**SOC**	**SCC**	**Heat Rate**
Period	**MU**	**%**	**%**	**ml/kWh**	**kg/ kWh**	**kCal/ kWh**
2004-05	517.57	49.24	10.49	3.4	0.66	2723
2005-06	569.59	54.18	9.38	3.28	0.68	2876
2006-07	477.02	45.38	10.94	3.43	0.71	2990
Post R&M						
2010-11	694.32	66.05	11.46	8.088	0.74	2995
2011-12	739.06	70.11	10.27	1.032	0.734	2809.7
2012-13	607.71	57.81	10.87	1.406	0.734	2827.6
2013-14	128.95	12.26	13.19	1.145	0.75	2854.5

Table 3.10: Unit-2 performance Pre and Post R&M of Ukai TPS

The above Table shows that only Gross Generation, PLF and Specific Oil Consumption (SOC) improved after R&M Implementation but other parameters remained same.

3.5.12 Overall Remarks

It was suggested by the utility that major R&M of 120MW units needed to be dropped and were to be phased out and Sub-Critical units of adequate capacity could be contemplated. Based on the bad experiences of 120MW sets of Ukai TPS, major R&M of 120MW sets of GTPS have been dropped by GSECL. Critical materials were not supplied by BHEL as per the order schedule. Performance of some of the sub-contractors was not satisfactory. Some sub-contractors left site without completing the work assigned to them and their replacement with new ones took longer time.

Similarly, in our project we are implementing R&M Exercise for 10MW solar power plant in the next chapter.

Chapter 4

ANALYSIS

4.1 Overview on 10MW Solar Plant

10MW Solar Plant Comprises of 5 no. of 2MW Inverter blocks and the power from each 2MW block is pooled to 33kV outdoor substation through 33kV double/single circuit lines and further total 10MW is pooled to State utility through 33kV Double circuit transmission lines.

4.1.1 Module level:

The Module capacity is of 300 Wp and 20 no. of Modules get connected in series and form one string. Similarly, total 24 no. of strings connected to String combiner box (SCB). Hence the String combiner box capacity is of 144Kwp.Further, 4 no. of SCB are connected to 500KVA Inverter. Module connectivity, SCB and connection to Inverter as shown in the figure – 4.1.

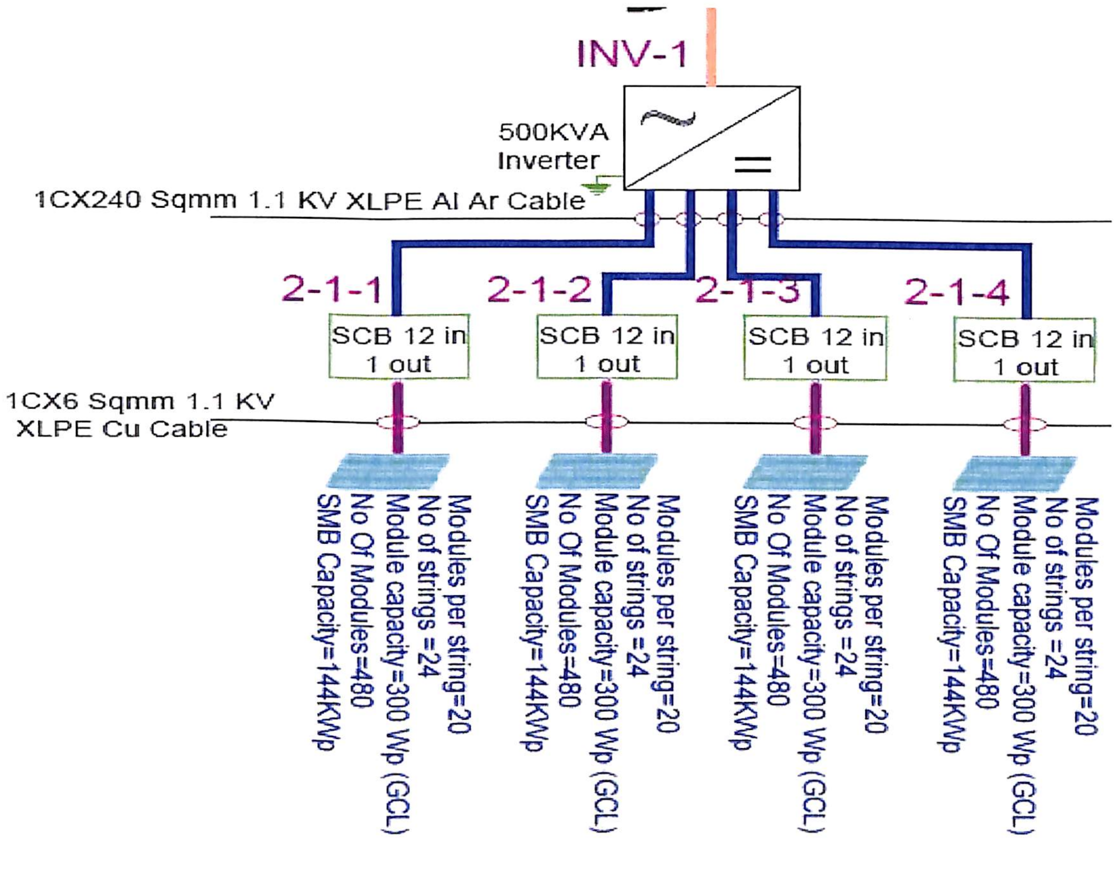

Figure 4.1- SCB to Inverter connectivity drawing

Salient features of Solar Module evacuation up to Inverter:

1.	Capacity of Solar Module	300 Wp
2	No. of modules per string	20 Nos.
3	No. of Strings	24 Nos.
4	Cable connectivity from Modules to SMB	1C X 6Sq.mm, 1.1kV, XLPE, cu cable
5	SCB Capacity	12 in 1 out, 144KWp.
6	Cable connectivity from SCB to Inverter	1C X 240Sq.mm 1.1kV, XLPE Al. Ar. cable

Table 4.1: Salient features of Solar Module evacuation up to Inverter

4.1.2 Inverter Block:

The Inverters related to 2MW block with 2000KVA Inverter duty transformer and associated Switchgear with cables interconnected as shown in figure- 4.2. The cable connectivity between Inverter and Inverter Duty transformer is 1C X 12R X 400Sq.mm,1.1kV, XLPE Al. Cable.

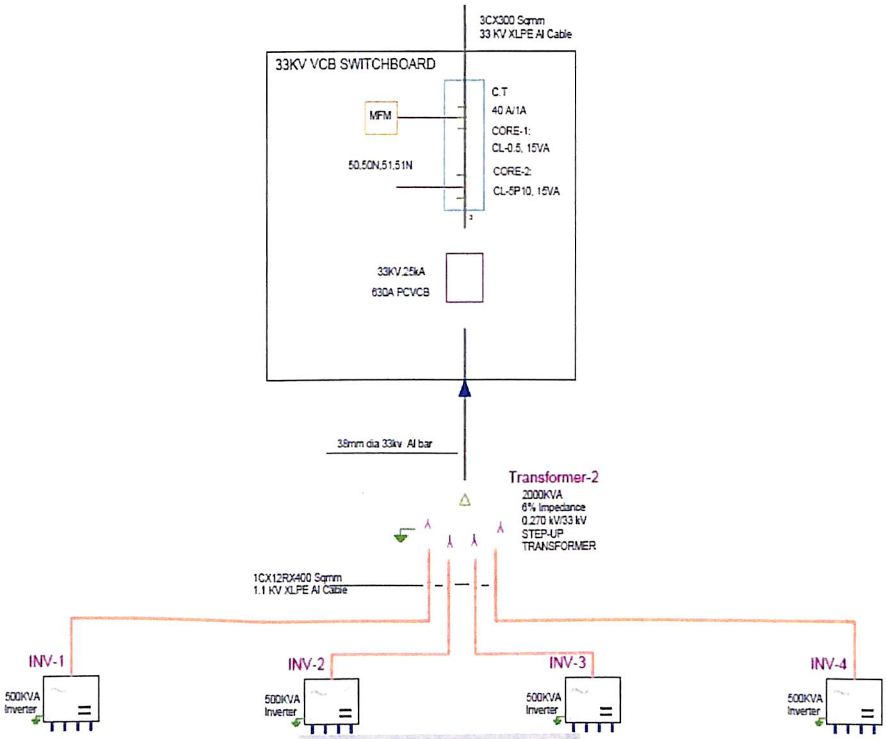

Figure 4.2: Inverter Block

The rated current from each 2MW block at 33kV level is 34.99 Amps. Hence the Current transformer rating proposed in the switchgear panel is of 40 Amps.

Salient Features of Each Inverter Block:

1.	Capacity of each inverter block	2 MW
2	Inverter Rating	500kVA, 270V
3	No. of Inverters	20 Nos
4	Inverter Duty Transformer rating	2000KVA, 33/0.270-0.270-0.270-0.270 KV, 5 Wdg transformer, Z=6%
5	No. of Inverter duty transformers	5 Nos
6	LT Cable of Inverter duty transformer	1C X 12R, 400Sq.mm 1.1kV, XLPE Al. cable
7.	HT Cable/conductor of Inverter duty transformer	38mm dia Al bar
7.	Rating of HT Switchgear	33kV, 630Amps
8.	Current transformer rating in HT switchgear	40/1-1amps.
9.	Outgoing cable of 33kV HT Switchgear panel	3C X 300Sq.mm, 30Mtrs Al. cable

Table 4.2: Salient features of Inverter block

4.1.3 33kV Transmission line:

Power from 2 MW Inverter block is pooled to 33kV Outdoor Switchyard through 33kV transmission line. In 33kV transmission line, 33kV Isolators are placed at regular intervals to mitigate the shutdown time during fault. The conductor used for 33kV transmission line is 100Sq.mm AAAC Dog. The total length of 33kV transmission line is approx. 400 Mtrs. General internal 33kV evacuation system is as shown in the figure 4-4.

4.1.4 Grid Connectivity:

The outgoing 33kV line from 10MW M/s premiere photo voltaic medak pvt.ltd SS is connected to 33kV bus of 33/11kV Kommeru substation with metering arrangement. Further, it is connected to 132/33kV Chennur grid substation through 33kV transmission line. The 33kV line from 33/11kV Dugnepally substation and from 33/11kV Devulavada substation are connecting to the same 33kV line. Nevertheless, none of the 33kV line protection has provided in 33/11kV Kommeru SS, 33/11kV Dugnepally SS and 33/11kV Devulavada SS. So, whenever the fault in any of the substation results in outage of the total line. The same reflects to downtime of M/s premiere photo voltaic medak pvt.ltd, 10MW solar plant, although it is a healthy system. The block diagram of 33kV grid evacuation is shown in the figure-4.3, please refer single line diagram of 33kV grid evacuation system from figure-4.5.

4.2 10MW solar power plant array layout:

The plant located in Chennur, medak district, Telangana. The coordinates of the plant are 18.46°N, 79.43°E.

Total 37680 modules are in the plant and each module capacity of 300Wp. 20 no. of modules are connecting to one string. So, 1884 strings are existing in the plant. The DC capacity of the plant is 1152kWp. The tracking plane is seasonal tilt. The general plan layout of the 10MW solar plant is shown in the figure 4.6

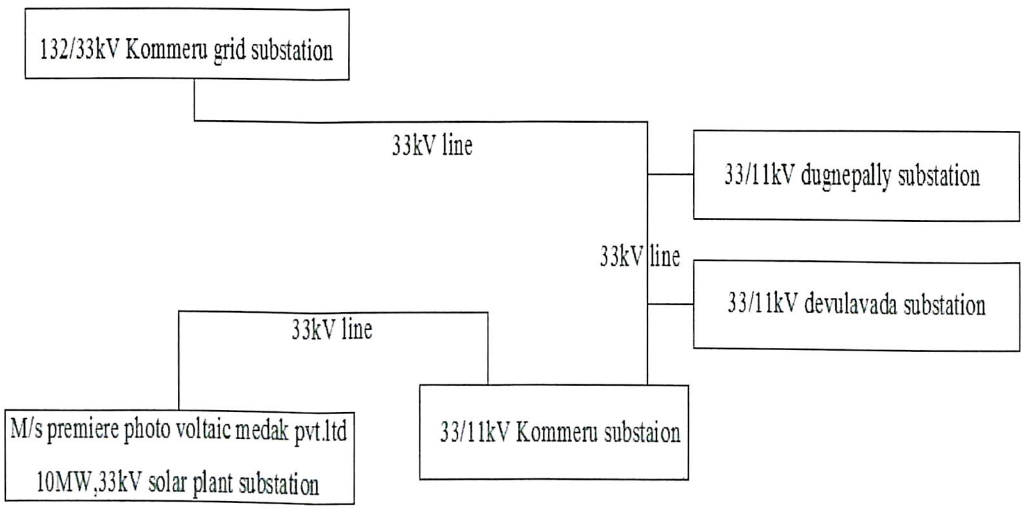

Figure 4.3: 33kV Grid evacuation system

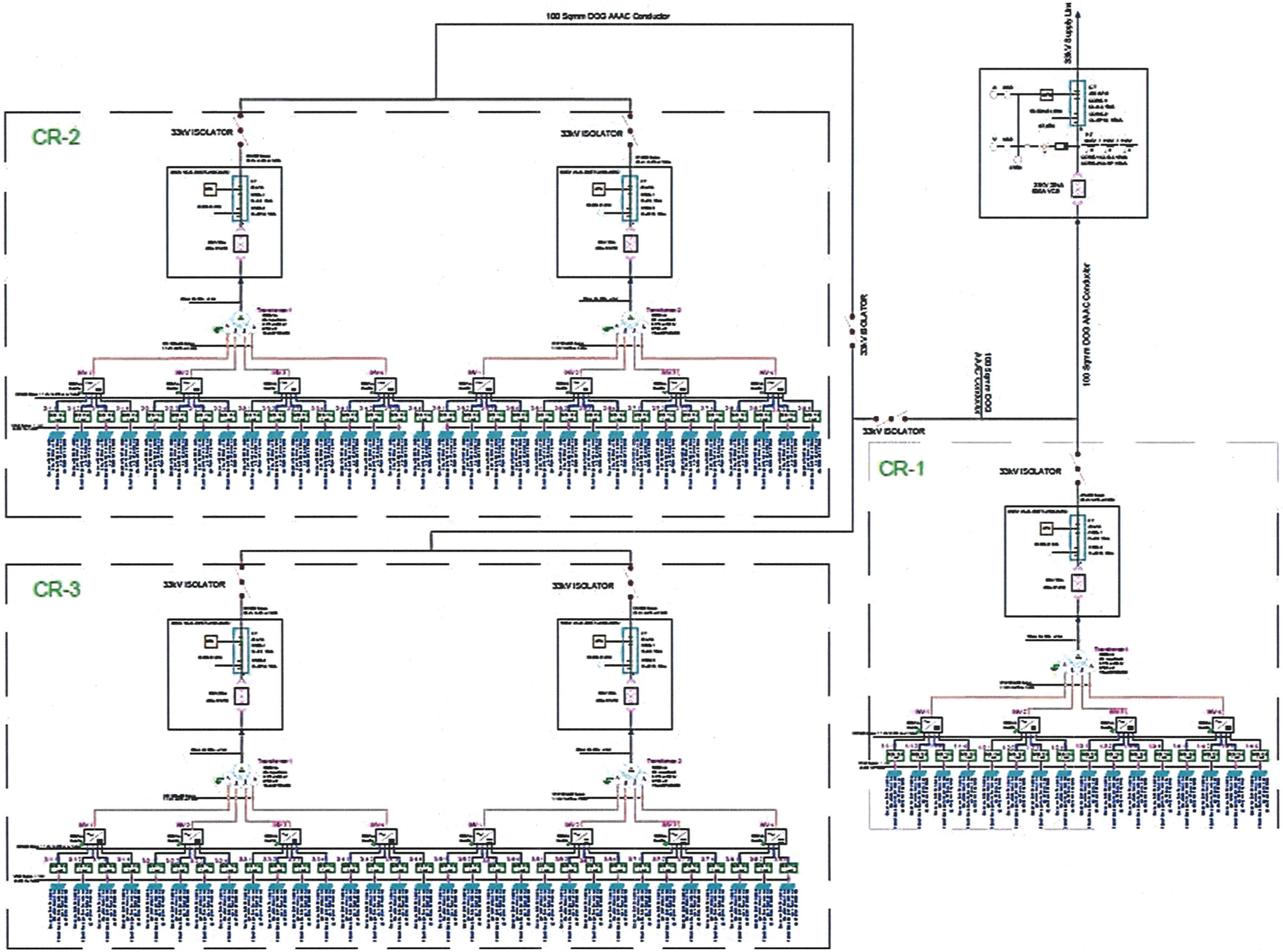

Figure 4.4: Internal 33kV evacuation system

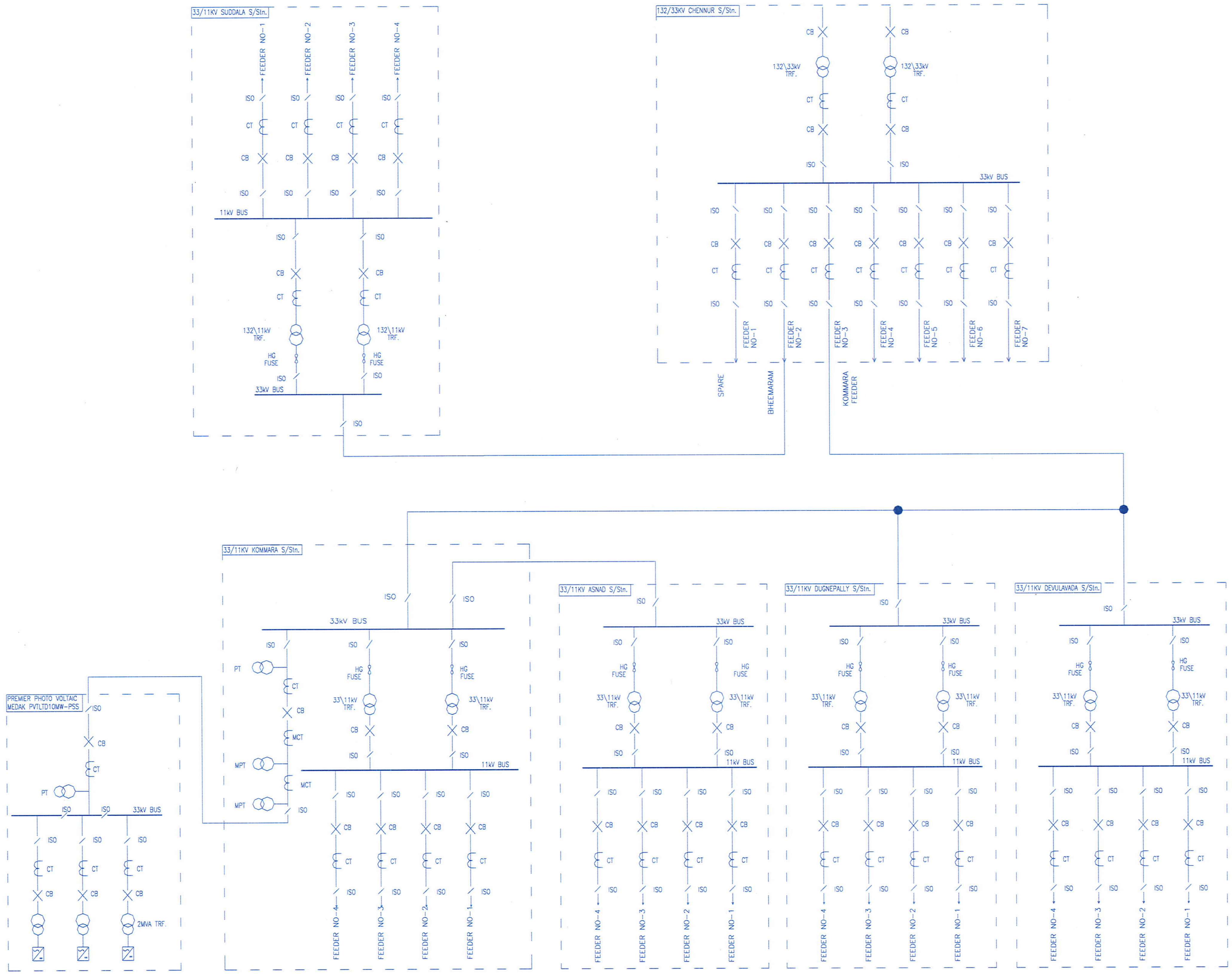

Figure 4.5: Single line diagram of 33kV Grid evacuation system

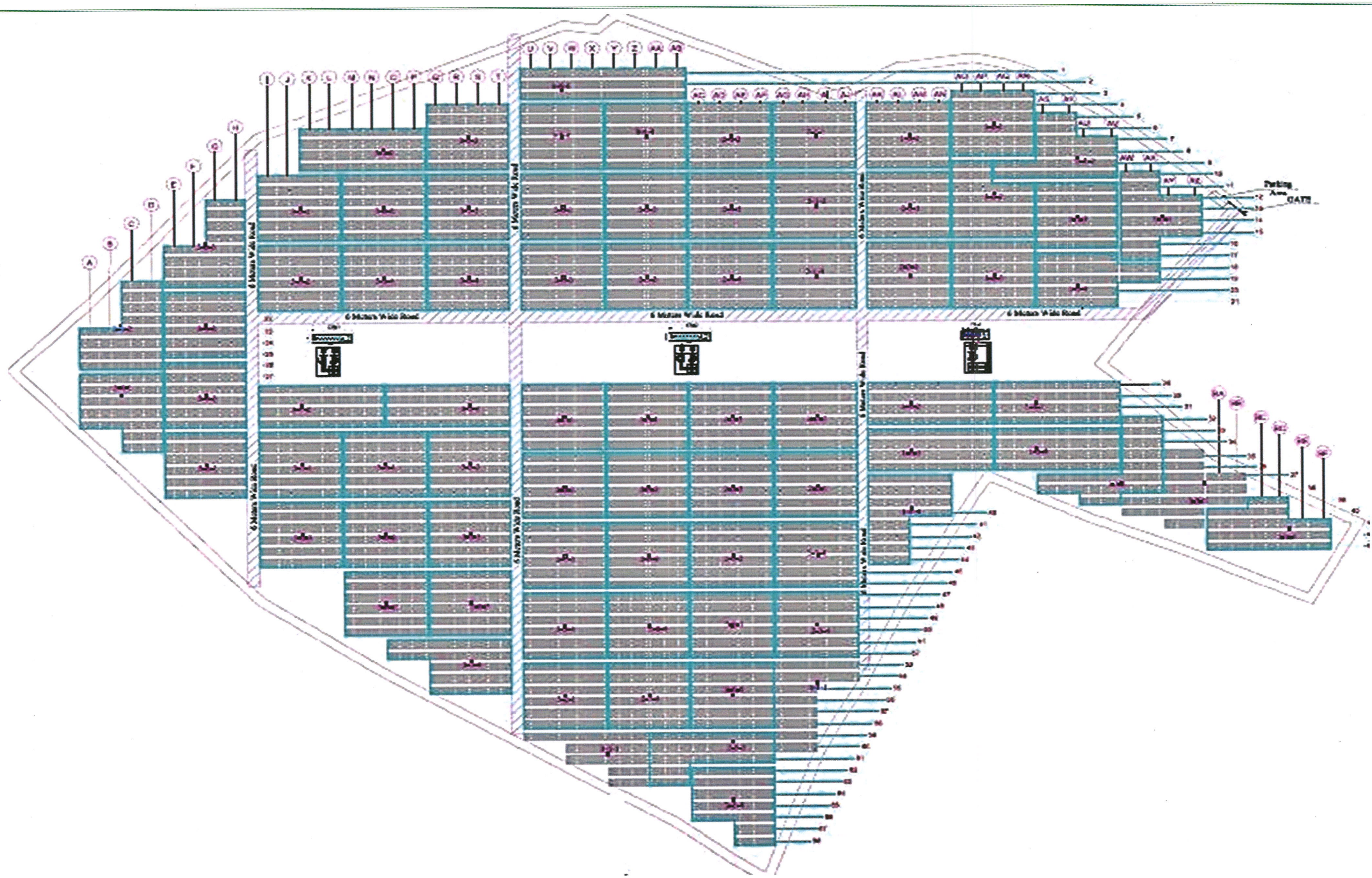

Figure 4.6: 10MW Solar power plant array layout

4.3 Component Description:

4.3.1 Inverter:

A solar inverter or PV inverter, is a type of electrical converter which converts the variable direct current (DC) output of a photovoltaic (PV) solar panel into a utility frequency alternating current (AC) that can be fed into a commercial electrical grid or used by a local, off-grid electrical network.

As of2014, conversion efficiency for state-of-the-art solar converters reached more than 98 percent. While string inverters are used in residential to medium-sized commercial PV systems, central inverters cover the large commercial and utility-scale market. Market-share for central and string inverters are about 50 percent and 48 percent, respectively, leaving less than 2 percent to micro-inverters.

Type	Power	Efficiency	Market share	Remarks
String inverter	up to 100 kW_p	98%	50%	Cost €0.15 per watt-peak. Easy to replace.
Central inverter	above 100 kW_p	98.5%	48%	€0.10 per watt-peak. High reliability. Often sold along with a service contract.
Micro-inverter	module power range	90%–95%	1.5%	€0.40 per watt-peak. Ease of replacement concerns.

Table 4.3: Inverter Market in 2014.

In 10MW solar power plant the inverter is Central inverter, rating of 500KVA, 0.270KV. Inverter make is Delta, model no. RPI 500.

Technical particulars of Inverter:

S.no	Particulars	Rating
1.	Model No	RPI-C500
2.	DC input	450V-1000V DC, MPPT – 450 -820V dc
3.	Rated current (dc)	1200A max.
4.	Maximum short circuit current rating	1500Amps
5.	AC input	243-378V, 3p3W, 50/60Hz
6.	Rating of Inverter	500KVA, 1080 Amps
7.	IP code	IP 65
8.	Protected class	I
9.	Overvoltage class	III

Table 4.4: Technical particulars of 10MW solar plant Inverter

4.3.2 Power Cables:

A power cable is an electrical cable, an assembly of one or more electrical conductors, usually held together with an overall sheath. The assembly is used for transmission of electrical power. Power cables may be installed as permanent wiring within buildings, buried in the ground, run overhead, or exposed. Power cables should meet the respective IS standards.

There are various parts of a cable to be taken care of during construction. The power cable mainly consists of

i. Conductor
ii. Insulation
iii. LAY for Multicore cables only
iv. Bedding
v. Beading/Armouring (if required)
vi. Outer Sheath

4.3.2.1 Conductor

Conductors are the only power carrying path in a power cable. Conductors are of different materials. Mainly in cable industry we use copper (ATC, ABC) and aluminium conductors for power cables. There are different types of conductor as Class 1: solid, Class 2 stranded, Class 5 flexible, Class 6 Extra flexible (Mostly used for cords and welding) etc. Conductor sizes are identified with conductor resistance.

4.3.2.2 Insulation

The insulation provided on each conductor of a cable by mainly PVC (Poly Vinyl Chloride), XLPE (Crosslinked Polyethylene), RUBBER (Various Types of Rubber). Insulating material is based on operating temperature.

Insulation Material	Maximum Operating Temperature
PVC TYPE A	75°C
PVC TYPE B	85°C
PVC TYPE C	85°C
XLPE	90°C
RUBBER – EPR IE-1	90°C
RUBBER – EPR IE-2, EPR IE-3, EPR IE-4, SILICON IE-5	150°C

Table 4.5: Insulating material and its Max. operating temp of power cable

Cores are identified by colour coding by using different colours on insulation or by number printing on cores

4.3.2.3 Beading (Inner Sheath)

This portion of the cable is also known as inner sheath. Mostly it is used in Multi core cables. It works as binder for insulated conductors together in multi-core power cables and provides bedding to armour/braid. This portion of the cable is mainly made of PVC (PVC ST-1, PVC ST-2), RUBBER (CSP SE-3, CSP SE-4 and PCP SE-3, PCP SE-4, HOFR SE-3 HOFR SE-4, HD HOFR SE-3 ETC)

4.3.2.4 Armouring

There are mainly G.I. WIRE ARMOURING, G.I. STEEL STRIP armouring. It is done by placing G.I. WIREs, GI or STEEL STRIPs one by one on inner sheath. Armouring is a process which is done mainly for providing earthing shield to the current carrying conductors as well as it is also used for earthing purpose of the cable for safety. When there is any insulation failure in the conductor, the fault current gets enough paths to flow through the armour if it is properly earthed. Providing extra mechanical protection and strength to cable is an important added advantage of armouring.

4.3.2.5 Outer Sheath

This is outermost cover of the cable normally made of PVC (Poly Vinyl Chloride), RUBBER (Various Types of Rubber) and often the same material as the bedding. It is provided over the armour for overall mechanical, weather, chemical and electrical protection. Outer sheath is protection offered to cable not much electrically but more mechanically.

Material	Advantages	Disadvantages	Max Operating Temperature
PVC	Cheap, Durable, Widely available	Highest dielectric losses, Melts at high temperatures, Contains halogens	70°C for general purpose 85°C for heat resisting purpose
PE	Lowest dielectric losses, High initial dielectric strength	Highly sensitive to water treeing, Material breaks down at high temperatures	
XLPE	Low dielectric losses, Improved material properties at high temperatures	Does not melt but thermal expansion occurs, Medium sensitivity to water treeing (although some XLPE polymers are water-tree resistant)	90°C
EPR	Increased flexibility, Reduced thermal expansion (relative to XLPE), Low sensitivity to water treeing	Medium-High dielectric losses, Requires inorganic filler / additive	90°C
Paper / Oil	Low-Medium dielectric losses, not harmed by DC testing, Known history of reliability	High weight, High cost, Requires hydraulic pressure / pumps for insulating fluid, Difficult to repair, Degrades with moisture	70°C

Table 4.6: Outer sheath material of power cable

10MW solar plant having following cables as mentioned in table 4.7.

S.no	Type of cable	Make	Location
1.	1.1kV, 1C X 6 sq.mm XLPE Cu Cable	Poly cab	Between Modules and SCB (string combiner box)
2.	1.1kV, 1C X 240 Sq.mm XLPE Al cable	Poly cab	Between SCB and Inverter
3.	1.1kV, 12R X 1C X 400sq.mm XLPE Al. cable	Poly cab	Between Inverter and Inverter duty transformer (IDT)

Table 4.7: power cable details

4.3.3 Inverter Duty Transformer:

Inverter duty transformer is to step up the voltage of 0.270kV pooling from inverters to 33kV voltage level without changing in power & frequency. The Inverter duty transformer has 4 no. of LV windings and 1 no. of HV winding. The rating of inverter duty transformer is 2000KVA, 0.27-0.27-0.27-0.27 / 33kV.

Technical particulars of Inverter duty transformer:

S.no	Particulars	Rating
1.	Rating	2000KVA
2.	Make	ESENNAR
3.	LV side voltage	270V
4.	HV side voltage	33kV
5.	Frequency	50Hz
6.	LV side rated current	1069.19 Amps
7.	HV side rated current	34.99 Amps
8.	No. of LV windings	4
9.	No. of HV windings	1
10.	Vector group	Dyn11yn11yn11yn11
11.	Type of Cooling	ONAN
12.	Impedance	6%

Table 4.8: Inverter duty transformer technical details

4.3.4 MV switchboard panel:

Primary Distribution Switchgear are used in power plants and heavy industries. The insulated switchgear is equipped with draw-out vacuum circuit breaker with increased mechanical & electrical life. 33kV Switchgear are based on modular construction which helps in easy installation in small installation area and make them easy to operate. Benefits of MV Switchboard panel:

- Small Installation Area
- Easy to Operate
- Reduced maintenance & increased reliability
- Several Optional equipment available

Technical particulars of 2MW MV switchboard panel:

S.no	Parameter/Component	Rating
1.	Rating	33kV
2.	Busbar Capacity	630Amps
3.	Breaker	630Amps, 33kV, 25kA/1sec
4.	Current transformer	40/1-1A Core-1: CL-0.5, 15VAL-0.5, 15VA Core-2: CL-5P10, 15VA
5.	Connectivity	HV – Cable connection LV – Busbar connection

Table 4.9: MV switchboard panel technical particulars

4.3.5 Conductor:

Conductor is a physical medium to carry electrical energy form one place to other. It is an important component of overhead and underground electrical transmission and distribution systems. The choice of conductor depends on the cost and efficiency. An ideal conductor has following features.

- It has maximum electrical conductivity.
- It has high tensile strength so that it can withstand mechanical stresses.
- It has least specific gravity i.e. weight/unit volume.
- It has least cost without sacrificing other factors.

A. **Types of Overhead Conductors**

a. AAC (All Aluminium Conductor)
- It has lesser strength and more sag per span length than any other category.
- Therefore, it is used for lesser span i.e. it is applicable at distribution level.
- It has slightly better conductivity at lower voltages than ACSR i.e. at distribution level
- Cost of ACSR is equal to AAC.

b. ACAR (Aluminium Conductor, Aluminium Reinforce)
- It is cheaper than AAAC but pro to corrosion.
- It is most expansive.

c. AAAC (All Aluminium Alloy Conductor)

- It has same construction as AAC except the alloy.
- Its strength is equal to ACSR but due to absence of steel it is light in weight.
- The presence of formation of alloy makes it expensive.
- Due to stronger tensile strength than AAC, it is used for longer spans.
- It can be used in distribution level i.e. river crossing.
- It has lesser sag than AAC.
- The difference between ACSR and AAAC is the weight. Being lighter in weight, it is used in transmission and sub-transmission where lighter support structure is required such as mountains, swamps etc.

d. ACSR (Aluminium Conductor Steel Reinforced)

- It is used for longer spans keeping sag minimum.
- It may consist of 7 or 19 strands of steel surrounding by aluminium strands concentrically. The number of strands are shown by x/y/z, where 'x' is number of aluminium strands, 'y' is number of steel strands and 'z' is diameter of each strand.
- Strands provide flexibility, prevent breakage and minimize skin effect.
- The number of strands depends on the application, they may be 7, 19, 37, 61, 91 or more.
- If the Al and St strands are separated by a filler such as paper, then this kind of ACSR is used in EHV lines and called expanded ACSR.
- Expanded ACSR has larger diameter and hence lower corona losses.

Technical particulars of 33kV line overhead conductor:

S.no	Parameter/Component	Rating
1.	Type	AAAC
2.	Name of conductor	Dog
3.	Conductor Dia	100 sq.mm
4.	AC Resistance	0.3904 ohms/km

Table 4.10: 33kV line overhead conductor technical particulars

4.4 Annual Generation report of 10MW M/s Premiere photo voltaic medak pvt. Ltd Solar power plant for the financial year 2018-19:

Units exported to gird during the period July-2018 to June-2019 is tabulated in table 4.11.

S.no	Month	Units Exported (KWH)
1.	Jul-18	918,500
2.	Aug-18	942,500
3.	Sep-18	1,298,200
4.	Oct-18	1,509,400
5.	Nov-18	1,564,200
6.	Dec-18	1,155,700
7.	Jan-19	1,410,100
8.	Feb-19	1,268,700
9.	Mar-19	1,568,500
10.	Apr-19	1,564,800
11.	May-19	1,408,000
12.	Jun-19	1,340,100

Table 4.11: Units Exports during period Jul-2018 to Jun-2019

Units loss during the period July-2018 to June-2019 is tabulated in 4.12.

S.no	Month	Units Loss (KWH)	Reason
1.	Jul-18	59171	Incomer failures
2.	Aug-18	90352	Pin Insulator failures
3.	Sep-18	66103	Grid failure
4.	Oct-18	0	-
5.	Nov-18	14925	LC taken
6.	Dec-18	67970	LC taken
7.	Jan-19	22367	Fault on 33kV incomer at Kommeru SS
8.	Feb-19	70988	
9.	Mar-19	36127	
10.	Apr-19	79741	
11.	May-19	166184	
12.	Jun-19	53659	

Table 4.12: Units loss during period Jul-2018 to Jun-2019

From the above tables we can conclude that the unit loss per annum due to grid failure is 727587 KWH. The tariff of this project is ₹6.45 per unit, So, the total loss of rupees in the financial year is 47 Lakhs.

During the interaction with various officials in the plant/utility headquarter and with the data, it was observed that the studies carried out were generally limited to the 33kV transmission lines only i.e. from 10MW m/s premiere photo voltaic medak pvt.ltd to gird SS.

Chapter 5

INTERPRETATION OF RESULTS

5.1 R&M Implementation Exercise for 10MW M/s Premiere photo voltaic medak pvt. Ltd:

5.1.1 Background:

M/s Premiere photo voltaic medak pvt.ltd is 10MW solar power plant located in Chennur, medak, Telangana. 10MW is divided into 5 no. of 2MW inverter blocks and 10MW is pooling to 132/33kV Chennur grid substation through 33/11kV Kommeru Substation as shown in figure 4.5. The other 2 no. of substations namely 33/11kV Dugnepally and 33/11kV Devulavada are connecting to the 33kV transmission line between 33/11kV Kommeru substation to 132/33kV Chennur grid substation. All these three 33/11kV substations are distribution substations. There is no 33kV line protection from these three distribution substations. If any fault happens on any one of the substations total line will be shutdown. This is the major drawback which effects the generation export from the healthy system. So, the R&M exercise is implemented for M/s premier photo voltaic medak pvt.ltd (10MW solar plant) with two options. One is by implementing breakers at respective positions in transmission line and other method is to construct direct line of 33kV from M/s premier photo voltaic medak pvt.ltd (10MW solar plant) to 132/33kV Chennur grid substation.

5.1.2 Scope of R&M/LE Works:

The broad scope of supply covered design, engineering, manufacturing, inspection, factory testing, packing and forwarding and supply of O&M spares for 33kV transmission line. The scope of services included unloading, storage, material handling at site, insurance, dismantling, erection, testing and commissioning of system/equipment.

A. <u>33kV Transmission line:</u>

Construction of new 33kV transmission line from 10MW solar plant to 132/33kV Chennur grid substation.

B. <u>33kV Switchgear:</u>

Installation of 33kV Circuit Breakers at interconnection point, Procurement, erection, testing and commissioning of 33kV Switchgear.

Here the R&M exercise is carried out for M/s premiere photo voltaic medak pvt.ltd with three proposals.

Proposal-1: Construction of new 33kV Line from 33/11kV Kommeru substation to 33/132kV Chennur grid substation:

By constructing the new 33kV line from 33/11kV Kommeru SS to 33/132kV grid substation can mitigate the downtime of plant. The single line diagram for this proposal is as shown in figure 5.1. Construction of new 33kV line includes conductor, poles/structures, pin insulators, hardware etc. The proposed 33kV line is of 9km with AAAC Panther conductor. In this proposal we are proposing Ring system. So, if any part of the transmission line got effected with any fault, we can easily isolate the fault and run the system with alternate path.

Proposal-2: Implementation of AB switches at various intervals of existing 33kV transmission line:

With implementation of AB switches in the existing lines, down time can be reduced by isolating the fault portion and allowing healthy system to grid. The single line diagram for this proposal is as shown in figure 5.2. Hence, by providing total 3 no. of Circuit breakers as shown in Figure: 5.2, single line diagram the downtime can be reduced. In this proposal, along with the implementation of AB switches, existing 33kV line should be strengthened.

Proposal -3: Construction of new 33kV Line from 33/11kV Kommeru substation to 33/11kV Suddala substation:

With Construction of 33kV line from 33/11kV Kommeru SS to 33/11kV Suddala SS the generation downtime can be reduced. The single line diagram for this proposal is as shown in figure 5.3. The proposal includes the implementation of 33kV feeders on either side of substations and construction of 33kV line. The proposed 33kV line is of 8km with AAAC Panther conductor. In this proposal, by providing new 33kV line from Kommeru SS to suddala SS the 33kV transmission has got the capability of redundancy.

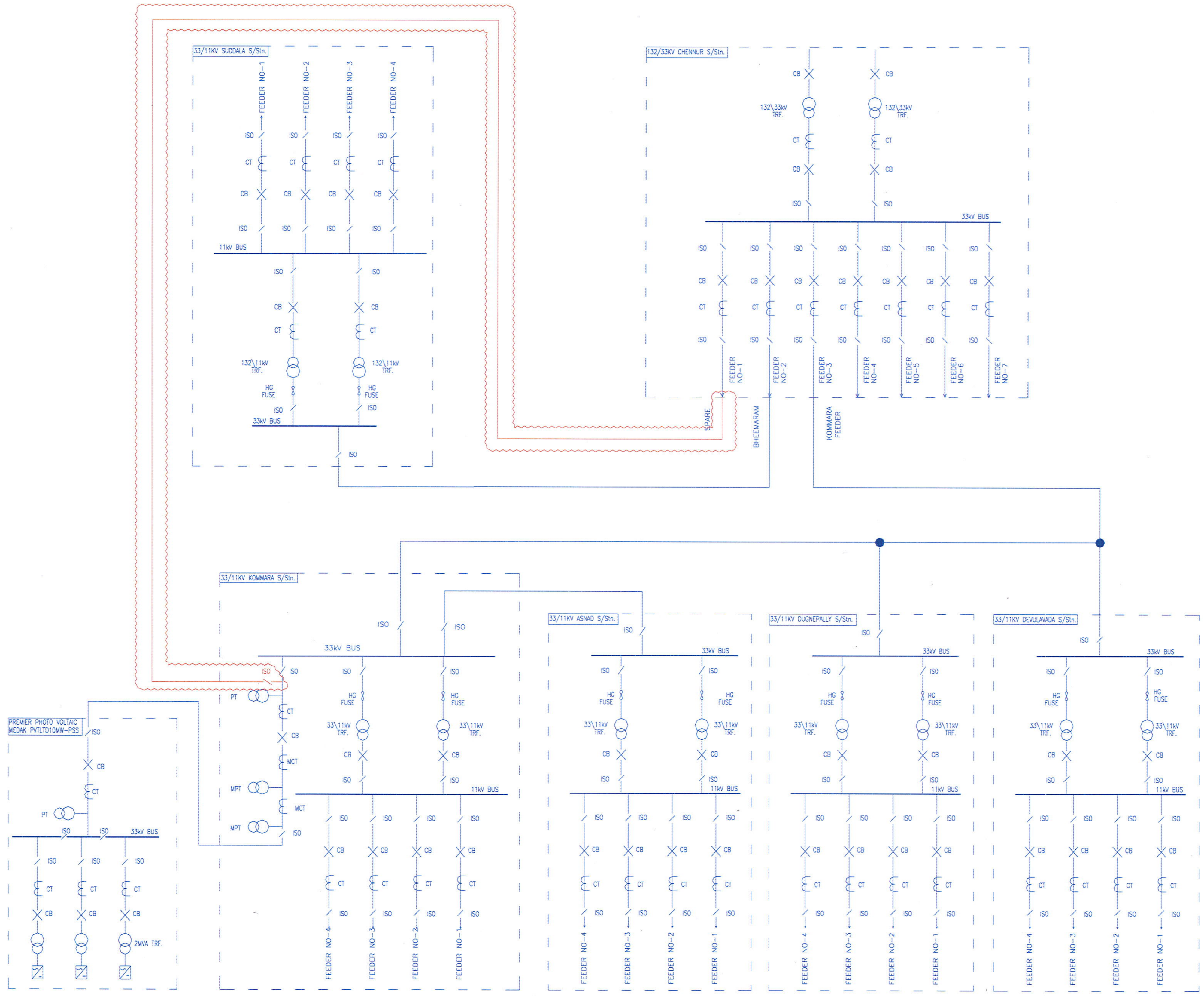

Figure 5.1: R&M exercise on 10MW solar power plant with new direct 33kV line from 11/33kV Kommeru SS to 33/132kV Chennur grid SS.

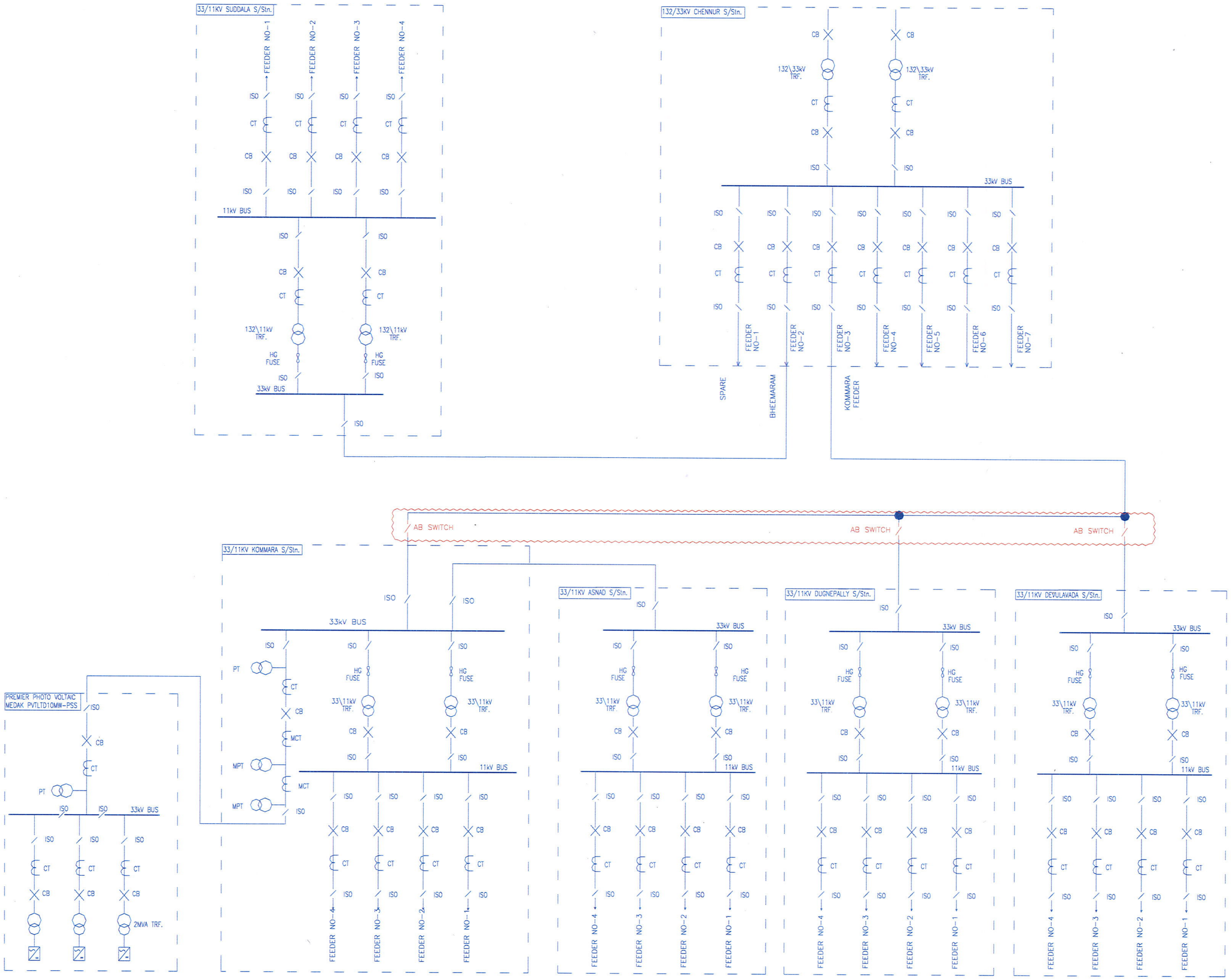

Figure 5.2: R&M exercise on 10MW solar power plant with implementation of AB switches at respective interconnection points of the 33kV transmission line.

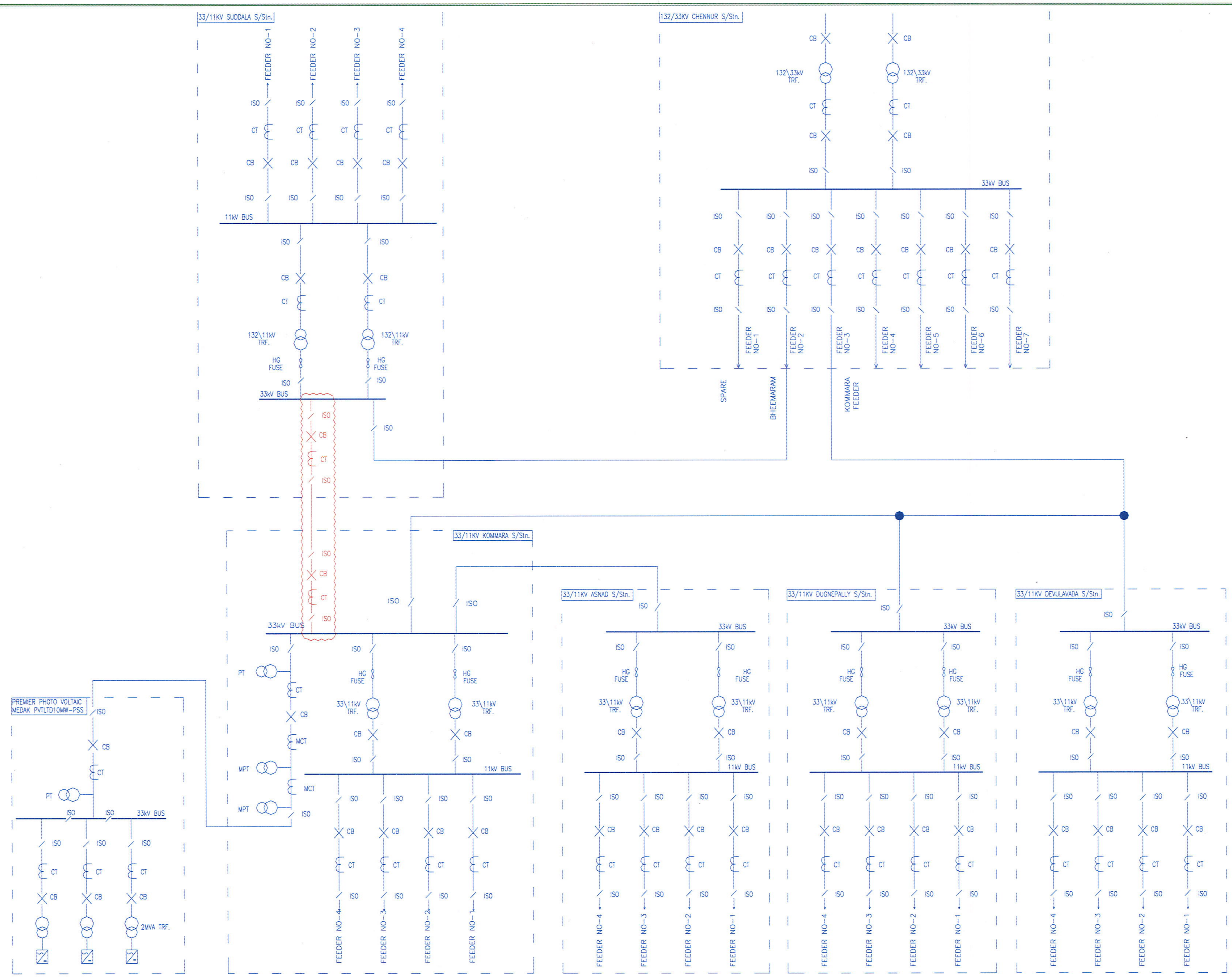

Figure 5.3: R&M exercise on 10MW solar power plant with new direct 33kV line from 11/33kV Kommeru SS to 33/11kV suddala SS.

5.1.3 Other considerations in Proposals:

Selection of Conductor in 33kV Transmission line: The conductor selection will depend on current rating and copper loss contribution. The rated loss calculation with ACSR Dog and AAAC panther will be as follows:

5.1.4 Loss Calculation of 10MW Solar power plant:

The procedure adopted to calculate the present annual (technical) energy (MWh) losses on any distribution network involves estimating the active power (MW) losses during peak demand period, separated into Fixed and Variable losses and then, by reference to the distribution network's demand characteristics, i.e. the daily and seasonal variation in demand, to estimate associated, annual energy losses.

The conversion of Variable losses during periods of peak demand into estimated associated annual energy losses is usually undertaken by determining the system LLF, either from a direct knowledge of the demand characteristics or more commonly by estimating the LLF based on the system Load Factor, i.e. the ratio of average demand to peak demand and using this ratio to determine an approximation to the LLF via an empirical relationship.

5.2 Calculation Method:

5.2.1 Exact Technique:

The exact LLF is derived from the formula:

$$\text{LLF} = \frac{\sum_{i=1}^{i=8760} Hourly\ demand(i)^2}{Maximum\ Demand^2\ x\ 8760}$$

with 365 days in a year and 24 hours daily results in 8,760 hours annually.

5.2.2 Approximation technique:

LLF is related to Annual Load Factor (LF) as

$$\text{LLF} = \alpha * \text{Annual Load Factor} + (1 - \alpha) * (\text{Annual Load Factor})^2$$

The range of α is between 0.15 and 0.30 for distribution networks

5.3 Implementation of loss Calculation for 10MW Solar plant:

Rated output power = 10 MW

$$\text{Respective rated current} = \frac{P}{\sqrt{3} x V\ x\ \cos\theta}$$

$$= \frac{10000}{1.732 \times 33 \times 1}$$

= 175 Amps

Resistance of ACSR Dog at 65°C – 0.3904 Ohm/km.
Resistance of AAAC Panther at 65°C – 0.1667 Ohm/km.

Copper loss: $3 \times I^2 \times R \times L$

I – rated current
R – resistance of conductor at 65°C
L – length of the conductor in Km

The transmission line length is nearly around 9Km.

Copper loss of 33kV transmission line with AAAC Dog conductor:

= 3 X 175 X 175 X 0.3904 X 9
= 322.8 KW

Similarly, Copper loss of 33kV transmission line with AAAC panther conductor:

= 3 X 175 X 175 X 0.1667 X 9
= 137.84 KW

The cost of AAAC dog per km is ₹55000. and the cost of AAAC panther per km is ₹1,20,000.
The tariff for M/s premiere photo voltaic medak pvt.ltd is ₹6.45

Revenue loss with AAAC Dog conductor = 322.8 X 12 X 365 X 6.45

= ₹91.1 Lakhs

Revenue loss with AAAC Panther conductor = 137.84 X 12 X 365 X 6.45

= ₹38.9 Lakhs

S.no	Cost of the Conductor in Lakhs	Revenue loss in Lakhs	Pay Back period with AAAC Panther
AAAC DOG	4.95	91.1	9 Years
AAAC Panther	10.8	38.9	

With this Pay back result, R&M implementation exercise is carried out with AAAC Panther Conductor.

5.4 Techno- Economical Analysis of proposed Options:

5.4.1 Time and Cost Aspects:

The time aspects of the R&M works carried out for two options was as follows.

Option	Completion time (in days)
Proposal-1	77
Proposal-2	30
Proposal-3	77

Table 5.1: Time schedule for both R&M proposals

Duration of project for the proposals was planned as shown in the table: 5.1. Proposal 1 takes 77 days from zero date where proposal -2 and proposal -3 scheduled for 30 and 77 days respectively. The project for the both options was mainly delayed due to delay in supply of critical materials, performance of sub-contractors. For detailed time schedule for the both proposals, please refer Annexure-I

5.4.2 Cost Aspect:

The capital cost for the proposals is tabulated in table 5.2. All the cost mentioned in the table 5.2 is bare cost which excludes taxes.

For detail BOQ and cost analysis, please refer annexure-II

Proposal	Cost (in lakhs)
Proposal-1	**128.5**
Proposal-2	**5**
Proposal-3	**114.5**

Table 5.2: Cost aspects for both R&M proposals

Chapter 6

CONCLUSION AND SCOPE FOR FUTURE WORK

6.1 Conclusion and scope for future work:

With the implementation of R&M exercise in the M/s premiere photo voltaic pvt.ltd, the generation loss, downtime of the plant can be reduced. Among the proposals, proposal-2 Claims the most economic solution and proposal-1 & proposal-3 are the most reliable solutions. With consideration of zero down time of plant after R&M exercise the net profit per annum is nearly to 47 Lakhs. R&M exercise can be done in 10MW solar plant also by which the capacity of the plant can be increased which will be added as a future scope.

ANNEXURE-I Time schedules

PROPOSAL-1

S.no	Activity	Week-1	Week-2	Week-3	Week-4	Week-5	Week-6	Week-7	Week-8	Week-9	Week-10	Week-11
1	R & M Study											
2	Design development											
3	Procurement											
4	Erection											
5	Testing & Commissioning											

PROPOSAL-2

S.no	Activity	Week-1	Week-2	Week-3	Week-4
1	R & M Study				
2	Design development				
3	Procurement				
4	Erection				
5	Testing & Commissioning				

PROPOSAL-3

S.no	Activity	Week-1	Week-2	Week-3	Week-4	Week-5	Week-6	Week-7	Week-8	Week-9	Week-10	Week-11
1	R & M Study											
2	Design development											
3	Procurement											
4	Erection											
5	Testing & Commissioning											

ANNEXURE-II Cost analysis and BOQ

33kV FEEDER BOM

Sl. No.	Item Description	Unit	Qty /Bay	Amount
A	**33 kV EQUIPMENT**			
1	36KV,800 A, 25 kA Vacuum CB.	Nos.	1.00	2.10
2	36KV,800A, 25KA/3S Isolator With 2 No E/s,	Nos.	1.00	0.91
3	36KV,800A, 25KA/3S Isolator Without E/s,	Nos.	1.00	0.60
4	1600/1A, 25 kA/3s Current Transformer1 Ph 4Core	Nos.	3.00	1.08
5	5/1A, 25 kA/3s Current Transformer1 Ph Metering	Nos.	3.00	0.90
6	33KV/root(3)/110/root(3) Voltage Transformer (metering)	Nos.	3.00	0.90
7	30KV,10KA,Cl-3 Surge Arrestor With Acc	Nos.	3.00	0.36
8	33KV C&R Panel - Line feeder	Nos.	1.00	5.50
9	33 kV Bus Post Insulators for erection hardware	Nos.	9.00	0.27
B	**Structures**			
1	33 KV Isolator Structure	MT	0.48	0.34
2	33 KV CT Structure	MT	0.84	0.60
3	33 KV PT Structure	MT	0.43	0.31
4	33 KV TC Tower	MT	2.15	1.53
5	33 KV TD Tower	MT	0.35	0.25
6	33 KV Boom BD	MT	1.23	0.87
C	**Bus Works, Hardware & Stringing**			
1	Terminal Connector Suitable for Moose for 30 kV Lightning Arrestor	No's	3.00	0.02
2	Terminal Connector Suitable for Moose for 33 kV PT	No's	3.00	0.02
3	Terminal Connector Suitable for Moose for 33 kV DBCR Isolator	No's	12.00	0.10
4	Terminal Connector Suitable for Moose for 33 kV Current Transformer	No's	12.00	0.10
5	Terminal Connector Suitable for Moose for 33 kV Circuit Breaker	No's	1.00	0.01
6	T Connector Suitable to Single Moose to Single Moose	No's	3.00	0.02
7	T Connector Suitable to Panther to Single Panther	No's	3.00	0.02
8	ACSR Moose Conductor	Mtr	0.07	0.00
D	**Power Cables & Control Cables**			
1	2Cx2.5 sqmm	kM	0.16	0.14
2	4Cx2.5 sqmm	kM	0.18	0.23
3	10Cx2.5 sqmm	kM	0.08	0.18
4	14Cx2.5 sqmm	kM	0.07	0.20
5	19Cx2.5 sqmm	kM	0.08	0.38
6	3/4 " Nickel Coated DC Brass Glands	No's	12.00	0.02
7	1" Nickel Coated DC Brass Glands	No's	12.00	0.02
8	1.1/8" Nickel Coated DC Brass Glands	No.	22.00	0.04
9	1.1/2" Nickel Coated DC Brass Glands	No.	4.00	0.01
10	1.1/4" Nickel Coated DC Brass Glands	No.	6.00	0.01
11	2.5 Sq.mm Cu Pin Lugs	No.	380.00	0.00
12	4 Sq.mm Cu Lugs	No.	24.00	0.00

18.0357

ANNEXURE-III 33kV Single Circuit Transmission line supply cost per km

S.NO	ITEM DESCRIPTION	UNITS	SC	Rate	Amount
1	ISHB 200*200mm 12mtr long	NO	20	20000	400000
2	Stud RSJ 100*116 11mtr long	NO	5	10000	50000
3	Spun Poles	NO	0	8000	0
4	PSSC STRUT POLES 9.1mtr	NO	0	4012	0
5	Pin Insulator with Pin(Polymer)	NO	60	565	33900
6	Tension Disc Insulators(Polymer)	NO	30	370	11100
7	Al-59 Conductor	km	3.03	127000	384810
A	Fabrication Items for ISHB Pole				
	ISMC (100x50x5mm), 2270mm, (V- Cross Arm) and Supporting Angle L50x50x6mm, 750mm Length (To be Welded on V Cross Arm)	No.s	25	2207	55175
	ISMC 100X50X5mm, 75mm, 0.72Kg Each and ISMC 75x40x5mm, 380mm, 2.713kg Each (For Top Fitting)	No.s	20	302	6040
	Back Clamp 75x8 Flat	No.s	15	296	4440
	Back Clamp (50X8 Flat)	No.s	15	197	2955
	Stay Clamp 50x8 Flat, 520mm (2 no.s/ set)	sets	20	293	5860
	Dummy Clamp For pin Insulator 75x8mm (Top fitting)	sets	5	439	2195
	Strut Clamp 75X8mm Suitable for ISHB 200mm	sets	5	449	2245
	Strut Clamp 75X8mm Suitable for RSJ pole 116x100mm	sets	5	297	1485
	Base Plate 300x5mm	No.s	25	311	7775
	ISMC 100x50x5mm, 3200m length MS channel (For DP Cut Point Channel)	No.s	0	2692	0
	ISMC 100x50x5mm, 3200m length MS channel (For DP Cut Point Channel)	No.s	0	2692	0
	Belting angle ISA 65x65x6mm, 1925mm Long	No.s	0	983	0
	Bracing angle ISA 50x50x6mm,3270mm long	No.s	0	1295	0
	3 holed Fish plates 50x8mm Flat, 0.3mtr Length (2 No.s per set)	sets	10	169	1690
	Danger Board Clamp 25x3mm Flat	No.s	20	36	720
	Barbed wire Clamp 25x3mm Flat	sets	20	55	1100
	M-16- Bolts & Nuts -Spring Washer- 35mm LONG (For top fitting, Belting Angle)	Kgs	8	135	1080
	M-16- Bolts & Nuts -Spring Washer- 240mm LONG (For V Cross Arm and Supporting angle)	Kgs	10	135	1350
	M-16- Bolts & Nuts -Spring Washer- 75mm LONG (For back clamp & Stay Clamp)	Kgs	25	135	3375
	M-8- Bolts & Nuts -Spring Washer- 60mm LONG (For Barbed wire & Danger Board)	Kgs	2	135	270
	M16 - Bolts & nuts spring washer -150mm long	Kgs	0	135	0
	Complete Stay set	sets	0	4000	0
B	HARDWARE				0
1	4 Bolt Hardware for AL-59	sets	30	650	19500
2	Coil earthing electrode 8 S.W.G. GI (4mm Dia.) wire closely wound 115 turns	sets	25	250	6250
3	Barbed wire	Mtr	200	17	3400
4	Danger Board	Nos	20	125	2500
5	salt	kgs	1800	16	28800
6	char coal	kgs	312	30	9360
7	Complete Guarding Set	sets		3500	0
9	wedge connector suitable for Al-59 Conductor	Nos	15	1400	21000
				Total	1068375

ANNEXURE-IV 33kV Single Circuit Transmission Line Erection cost per km

ETC OF 33KV SC LINE 1KM-ISHB POLES							
S.No.			Item Description	Units	QTY	Rate	Amount
I) Erection of Pole with bolts & Nuts							
1	Spun Pole	Erection of Spun Pole	Spun pole of Length 11 mtr /370 WL .	Nos.	0	3500	0
			Excavation as per drawing	Nos.	0		0
			Concrete of pole with coping	Nos.	0	4300	0
			GI wire 8 SWG from top to bottom for each pole .	Nos.	0	100	0
2	Pole	Erection of Pole 200 x 200	ISHB-200x200mm,6.1mm Thick, 37.3Kg/m pole of Length 12mt	Nos.	20	4500	90000
			Excavation (0.6X0.6x2m each)	Nos.	20		0
			Concrete of pole with coping	Nos.	20	5500	110000
			Welding of 1no. base plate of size 300x300x5mm	Nos.	20	190	3800
3	Pole/strut pole earthing	coil Earthing	Excavation (0.6X0.6x1.5m each)	Nos.	25	1200	30000
			coil earthing with salt and charcoal	Nos.	25		
4	strut Pole	PSC struct pole 9.1 Mtr	PSC struct pole 9.1Mtr	Nos.	0		
			Excavation as per drawing	Nos.	0	6750	0
			Concrete of pole as per drawing	Nos.	0		
			GI wire 8 SWG from top to bottom for each pole .	Nos.	0		
5	strut Pole	Erection of Pole 116 x 100	RSJ 116*100mm, Strut Pole,23 Kg/Mtr length 11 meters	Nos.	5		
			Excavation (1.2x0.45x1.75m each)	Nos.	5	7500	37500
			Concrete of pole 0.95cum Pcc(1:4:8)	Nos.	5		
			Welding of 1no. base plate of size 300x300x5mm	Nos.	5		
6	Stay set	Erection of Stay Set	Complete HT Stay set like Stay clamp, 7/8 SWG stay wire, 2 Guy Insulator, Bow assembly, Eye-bolt, M.S stay rod(1.95m long), GI stay plate of 300x300X6mm etc,...	sets	0	4750	0
			Stay excavation (1.0x0.45x1.5)m each	Nos.	0		
			PCC 1:4:8(1x0.45x0.5)m Dry Rubble (1x0.45x1m) each	Nos.	0		
7	V-X Arm & Top fitting	Erection of V-Cross Arm & Top fitting	V-crossarm	Nos.	25	300	7500
			Top Fitting	Nos.	20	100	2000
8	Insulators & Hardware	Erection of Insulators	Erection of Polymer Pin Insulator	Nos.	60	50	3000
			Erection of Polymer Tension Disc Insulators With Clamps & Hardware	Sets	30	200	6000
9		Misc	Miscellaneous like numbering etc.including paint	A/R	25	50	1250
			Anti Climbing Device with hardware	Nos.	20	150	3000
			Danger board with hardware	sets	20		
10	Conductor	Stringing	AL-59 Conductor - Single circuit	CKM	1	21000	21000
			AL-59 Conductor - Double circuit	CKM	0	40000	0
11	Painting	Painting of poles	Application of Red oxide primer for poles(2 coats)	Nos.	25		
			Application of Aluminium/silver paint for poles (2 coats)	Nos.	25	1800	45000
12	Guarding set	Guarding Arrangement	33kV Guarding arrangement for road crossing	sets	0	2500	0
13	DP Str	Erection of DP Structure	Horizontal cross arm (100x50x5mm) With length of 3.2m	Nos.	0	175	0
			Bracing angle L50x50x6mm, 3.27m Long	Nos.	0	75	0
			Belting angle Horizontal (L65x65x6mm) 1.925mt length	Nos.	0	75	0
						Total	360,050.00