1.0 INTRODUCTION

A study was conducted by CPRI for MERC in the years 2008-09 and 2009-10 to assess the level of achievable technical performance parameters for all stations of MSPGCL except the newly installed 250 MW units. CPRI has recommended schemes into three broad categories (based on the time required to implement and the cost involved) to meet the targeted performance parameters:

- Immediate : below 12 months
- Medium term: 2-3 years
- Long Term : over 3 years

The objective of the study is to assess the implementations of various measures for improvements in achievable performance parameters at Maharashtra State Power Generating Company Ltd (MSPGCL) thermal power stations.

This report pertains to the study of Bhusawal TPS (Units 2-3).

1.1 Design unit heat rates (UHR) & station heat rates (SHR)

Table 1 (see Annex 2) gives the design UHRs and SHRs of the station for the units under study. Table 2 (see Annex 2) gives the capacity and age of units.

1.2 Performance against targets

Table 3 gives the petitioned, approved and achieved key performance indices (KPI) including SHR for FY 2009-2010, FY 2010-2011 and FY 2011-2012 (till date) for the station under study.

2. STUDY & FIELD VISITS

The study of the MSPGCL is taken up in Bhusawal during January 3rd-4th week 2012.

3. STUDY & FINDINGS

3.1 Assessment of the overall action plans for implementation of measures and benefits projected and accrued

The measures are classified as:

i. Immediate measures without financial implication (See Annex 3)
ii. Immediate measures with financial implication (See Annex 4)

iii. Medium term measures (See Annex 5)
iv. Long term measures (See Annex 6)

The schemes have been classified into 14 areas for better project management as given in Table 4 (Annex 2).

The summary of the implementation for TPS is given as follows:

CPRI Recommendations	Total Nos.	Implemented	In practice	Not Feasible	Pending at Station	Pending for HO guidelines
IMMEDIATE TERM - Having NO FINANCIAL IMPLCATIONS (NFI)	170	4	117	11	0	38

CPRI Recommendations	Total Nos.	Implemented thru Capex/ Revenue	Processed thru DPR	Processed thru Non DPR	Processed thru Revenue / Capex	Schemes to be covered in DPR/Non DPR/Capex /Revenue	Not Feasible/ Not required	Pending for HO guidelines
IMMEDIATE TERM - Having FINANCIAL IMPLCATIONS (FI)	88	13	27	1	2	17	9	19
MEDIUM TERM MEASURES	38	11	13	2	1	5	3	3
LONG TERM MEASURES	17	6	5	0	1	3	2	0
TOTAL	143	30	45	3	4	25	14	22

The benefits accrued by the station are as follows:

Boiler Side
100 % Replacement of Economizer & LTSH coils
Since replacement of these coils no Boiler tube leakages in the ECO & LTSH zones are observed. **A heat rate improvement of 8.75 kcal/ kWh is expected.**

Bottom ash hopper refractory has been completely replaced during the COH of unit 2 in Oct 2011. Due to this, availability of clinker grinder is improved.

All coal burners (24 Nos) have been replaced with ASTM-A536 grade material. Therefore erosion and wearing out of coal burners is minimized. The worn out orifices have been replaced. **Equal coal flow within the coal pipes is expected.**

Air ingress in the flue gas duct path between APH to ID outlet
Flue gas duct patching work is carried out.

This reduced ID fan loading by 10 A per ID fan and hence reduction in auxiliary consumption is achieved.

ID /FD / PA fan & motors overhauling works .
ID fan impeller, IGV and GV body replaced. PA and FD fans/motors overhauling is carried out.
The vibrations are now reduced for all fans.
Air preheater baskets replacement work :
Worn out and eroded baskets replaced. Heat rate improvement of 1kcal/kWh is observed.

Major Repairs at pent house
Pent House repair work is carried out with sealing.
Heat rate improvement of 2 kcal/kWh observed.

Valve replacement work
Main steam control valve of PRDS (AS49), FW 78 & 79 replaced by new ones.

Non Destructive Test
NDT of HP tubes is carried out

30 % boiler skin insulation replacement
Radiation losses are reduced & heat rate improvement of 2 kcal/kWh is observed.

Turbine Side

1) **Turbine overhaul work** Inspection of bearing Nos 1 to 7, Servicing of governing system & MOP, Servicing of HPT/IPT/ESV/IV control valve, Generator seal body inspection, H2 cooler cleaning, Overhaul of HPT/IPT/LPT, RLA of turbine, Generator rotor removal & insertion**.**
   The overall availability and reliability of set is increased. Heat rate improvement by 10 kcal/kWh in last 2 months observed.

2) **LPH1 replacement work & Condenser cleaning** Condenser cleaned by hydro jet followed by bullet shot method, Condenser tube leakage attending, Generator H_2 cooler cleaning by sulphonic acid.
   The Condenser vacuum improved to 650 mmHg at 150 MW load from 600 mm Hg. Heat rate improvement due to LPH1 tube nest replacement is ≈ 2.25 kcal/kWh.

3) **CW pump system** : CW suction canal cleaning, CWCT fan pond cleaning. CW inlet temperature is now maintained at normal design parameter.

4) **Deaerator work :** Inspection & repair of trays & FST cleaning. **Healthiness and process improvement achieved**.

5) **Chemical cleaning of Coolers** : Main oil coolers, GTR coolers, BFP coolers, DM/GS coolers, Seal oil coolers cleaning done. Oil temperature now maintained at normal design level.

Instrumentation & Testing Side

Installation of DCS in unit 2 PCR :

Schemes covered in the DCS are Main Control and Instrumentation, FSSS, HP LP bypass, TRP, PRDS , Soot blower, Turbovisory System & Interfacing of generator. This station is the **first to implement DCS with all above schemes in MSPGCL**. So more accurate & fast response of system is achieved.

Replacement of all primary sensors:
RTDs, Thermocouples & MI thermocouples are replaced by new ones. **So temperature measurement accuracy and reliability is increased.**

Electrical Maintenance

Installation of VFD for various LT auxiliaries
VFD for 2 Nos of compressors each for units 2 & 3 installed on 15.05.2010**. 144 units saved per compressor per day. Also frequency of maintenance is reduced**

VFD for U3, CT fans – 5 Nos of VFDs installed & for U2, CT fans 5 Nos of VFDs installed. **174 units are saved per day per CT fan.**

5A, 6A & 7A motor controller for conveyor motors installed on 17.01.2011**. Hence 288 units saved per day. Maintenance frequency is reduced.**

3.2 Assessment of the action plans for implementation of immediate measures (without financial implication) and benefits accrued

The summary of implementation of the immediate measures (without financial implications) is as follows:

CPRI Recommendations	Total Nos.	Implemented	In practice	Not Feasible	Pending at Station	Pending for HO guidelines
IMMEDIATE TERM - Having NO FINANCIAL IMPLCATIONS (NFI)	170	4	117	11	0	38

The percentage implementation is 71 %.

Operational changes: Operation in sliding pressure operation in normal operation and use of ATRS during starts has been implemented.

Operational optimization: Operational optimization is being done through monitoring the parameters through GCR. A strong program must be launched for operational optimization (OO) for measure-control through operations-control through maintenance-measure based on the PDCA cycle with close intervals of monitoring and control to 4-6 hours. There should also be close monitoring of DM water make up which reflects on the steam lost through the system.

Leak reduction: Leak reduction is a critical area for the station in improving the performance. Importance must be given to quick response to leaks in steam, water, coal, ash, etc.. A strong leak reduction plan must be in place.

Cleanliness: A cleanliness improvement must be put into place to maintain the cleanliness level from coal dust, ash, etc.

3.3 Assessment of the action plans for implementation of immediate measures (with financial implication) and benefits accrued

The summary of implementation of the immediate measures (with financial implications) is as follows

CPRI Recommendations	Total Nos.	Implemented thru Capex/ Revenue	Processed thru DPR	Processed thru Non DPR	Processed thru Revenue/ Capex	Schemes to be covered in DPR/Non DPR/Capex/Revenue	Not Feasible / Not required	Pending for HO guidelines
IMMEDIATE TERM - Having FINANCIAL IMPLCATIONS (FI)	88	13	27	1	2	17	9	19

The percentage implementation is 15 %.

Hardware changes: many hardware changes like changing of heat exchangers, boiler coils, installation of VFDs, etc., have been successfully implemented.

IEDs: A decision is taken to procure only digital smart and intelligent transmitters and sensors in preference over analog systems. The same is being implemented.

Energy efficient option vs. maintenance comfort: Whenever there is some maintenance inconvenience on account of installation of energy efficiency measures or reduction of additional redundancy, the same may be viewed critically and a balanced view of the benefits vis-à-vis the inconvenience may be taken before a decision is taken on deferment of a measure.

3.4 Assessment of the action plans for implementation of medium term measures and benefits accrued

The summary of implementation of the medium term measures is as follows:

CPRI Recommendations	Total Nos.	Implemented thru Capex/ Revenue	Processed thru DPR	Processed thru Non DPR	Processed thru Revenue/ Capex	Schemes to be covered in DPR/Non DPR/Capex/Revenue	Not Feasible / Not required	Pending for HO guidelines
MEDIUM TERM MEASURES	38	11	13	2	1	5	3	3

The percentage implementation is 29 %.

Traditional replacements: Replacements must not be based on traditional replacements but energy efficiency options must be used because over a period of 20-25 years many new energy efficient hardware options have been evolved. Replacement of old and obsolete technology may not give the full benefits.

Coal weighment: The in motion weigh bridges are yet to be installed. Since they are low value items, the same may be given priority. The belt weighers are yet to be installed. Since they are low value items, the same may be given priority. The gravimetric feeders of rotary type or belt type are yet to be installed. Since they are high value items, some delay can be expected. However, the same needs to be expedited.

Steam path audits: Steam path audits are being carried out during COH. The same may be rigorously followed to quantify the losses and restore the steam path to normalcy for getting the benefit of improved UHR.

3.5 Assessment of the action plans for implementation of long term measures and benefits accrued

The summary of implementation of the long term measures is as follows:

CPRI Recommendations	Total Nos.	Implemented thru Capex/ Revenue	Processed thru DPR	Processed thru Non DPR	Processed thru Revenue / Capex	Schemes to be covered in DPR/Non DPR/Capex /Revenue	Not Feasible/ Not required	Pending for HO guidelines
LONG TERM MEASURES	17	6	5	0	1	3	2	0

The percentage implementation is 35 %.

3.6 Reasons for delay, root cause of delay in implementation.

Reasons for delay are as follows:

i. Decision for Bhusawal TPS Unit 2 is undergoing with EE-R&M activities, this has lead to rethinking on implementation of major CAPEX. Also Unit 3 EE-R&M is in pipeline hence most of the schemes were clubbed in EE-R&M for convenience of implementation as well as better compatibility with EE-R&M solutions.
ii. Some recommendations involved introduction of new technology like Hard Coating of wear components, Smart Soot Blowing, on-line Condition Monitoring etc which were new to introduction & implementer's hence requiring detail study.
iii. Technology providers to some high capital investment requirements are sparse like LMZ LPT retrofit, combustion optimization and response from such specialized vendors was also slow.
iv. In some cases response from OEM/Suppliers was sluggish in spite of repeated follow-ups. Also many times vendors show less interest for proposed trial orders.
v. As per corporate decision success of trial implementation of Scheme was required for replicating at other stations.
vi. Procedural delays due to strategic decisions involving high payback period, high value items requiring pre-bid meetings etc which amounts high processing time.
vii. Certain scheme can be implemented only during COH/AOH like
    - Air Heater Work.
    - ESP Improvement.
    - Boiler Heat Exchanger replacement.

3.7 Avoidable delays in implementation.

Preparedness for implementation: The station was not initially geared up for implementation of schemes. The gearing up has taken time. Presently, it is considerably improved in the preparedness for implementation of schemes.

Excessive reliance on OEM: While the views of the OEM are indisputably of primary importance to the operation, maintenance and safety of the plant, lack of commercial interest in many cases has led to the conclusion that the OEM is not favorable to a particular scheme. This has resulted in e avoidable time delay.

Monsoon preparedness: Better monsoon preparedness could have resulted in some time saving.

Manpower management at the station level: Placing persons with aptitude and skill for implementation program or higher rigor of training of the section level engineers in the implementation process in understanding the mechanism of successful implementation of a scheme.

What if ? –apprehension: The fear of things going wrong and individuals not taking responsibility was present for some period. Now, MSPGCL has formed groups/ expert teams, etc. for different schemes rather than laying onus for implementation on individuals. Many more such groups/ expert teams cutting across the stations of MSPGCL need to be formed to collectively involve in implementation of the schemes in areas of boiler, turbine, C & I, etc., through technology assessment and technology evaluation.

Management model: The management model for implementation involved the traditional procedures which take time. Procedural delays could be minimized by operating in the ***fast track*** or ***mission mode*** for implementation, demonstrating and achieving the objectives of the schemes.

Streamlining of purchase cum authorization processes: Streamlining at the station level by cutting across the hierarchy/proper channel route for movement of papers and approvals (within the MSPGCL framework of rules), could have resulted in reduced process time.

Vendor development program: A strong vendor development program involving a search for prospective vendors, study of the technological options available in the market, preparation of generalized specifications without giving undue advantage to any one vendor, detailed study of costs including POs issued to the vendor from other organizations, etc., needs to be in place for successful procurement and implementation. Haphazard vendor development has resulted in time delay in the actual procurement process in the form of non-responsiveness, non-conformance, re-tendering, etc.. This results in process delay.

Apprehensions of pass through: These have got to be clarified at an early date.

Measures with intangible or tacit benefits: These have suffered the most because of inability to convince the internal controllers. Life cycle approach could be a possible solution.

AOH & COH: These must be done as per schedule at the frequency of annually and once in five years respectively or as per any drawn out schedule. Skipping of overhauls results in degradation.

Uneven inter-station DPR initiating process: Co-ordination of common schemes required at different power stations got delayed because of different times taken by different stations. Some stations have taken almost 6 months more than

others. Bhusawal has shown moderate interest due to its limited no of units and due to E- R & M program.

High processing time: In spite of considerable improvement in procurement processing, the processing time is still much on the higher side for which station level process of procurement and authorization need to be re-looked. Higher procurement processing time and limited number of items identified under capex has led to avoidable delays.

Ambiguity created by E-R & M: The decisions to go in for E-R & M has created an ambiguity whether to continue with the medium term and long term measures in the present or to club it with E-R & M. In cases where E-R & M is envisaged, it is clubbed with E-R & M.

Full time central monitoring and time frames: Though central monitoring was being done to some extent, strong HO monitoring is required for control of the implementation processes with time frameworks. The time frames have not been set or time targets have not been given for implementation of the simple, medium term and long term measures. As a result the progress is differential in different stations.

Success solution in one station is not translated to the others: The success solution in one of the stations has not been transferred or translated into best practice for the others.

Co-ordination in implementations between two sections: In the case of technologies which involves implementation between two or more sections and their integration or inter-section co-ordination was not done by any one section, as a result of which the implementation was one sided.

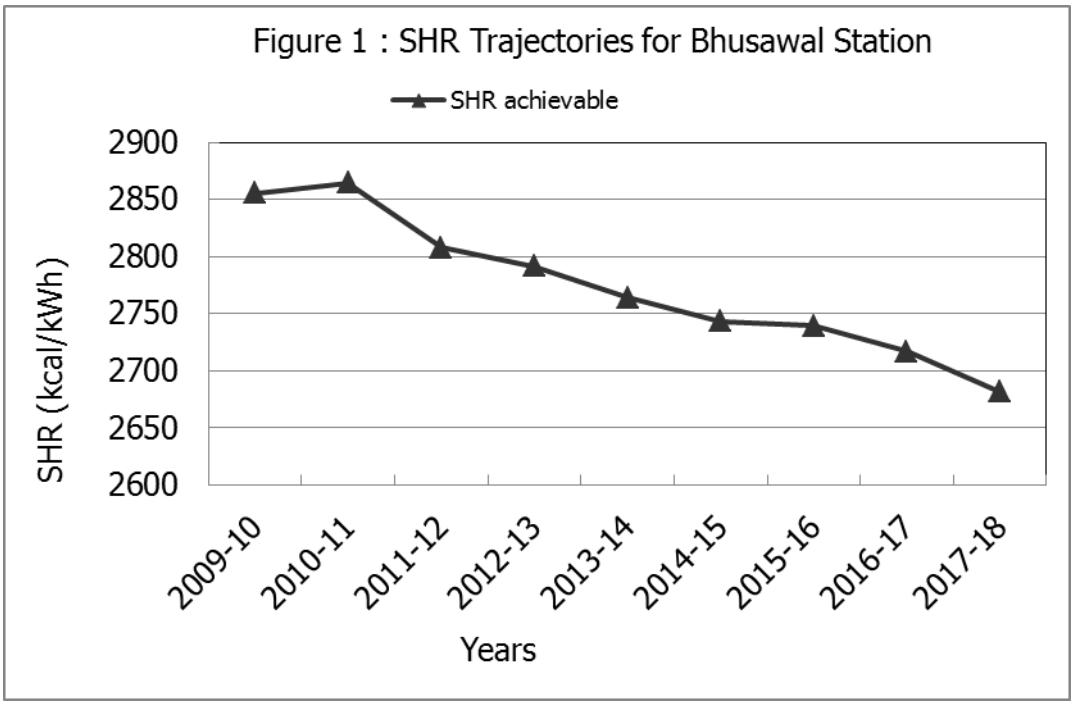
Higher involvement of top management or mentoring by seniors to juniors: Mentoring would have reduced some delay.

4. REVISION OF PERFORMANCE TRAJECTORIES

4.1 Test SHRs and degradation rates measured and revised performance trajectories.

Annual overall station test heat rate			
Unit No.	**Capacity**	**Annual UHR**	**UHR x C**
	MW	**kcal/kWh**	
1	55	3346.2	184040
2	210	2790.2	585933
3	210	2792.4	586396
Station	SHR	kcal/kWh	**2855.5**
Stage 2 only			2791

Station	Overall Station
Degradation rate as per CPRI test TG HR	
	%/year
Bhusawal	0.31

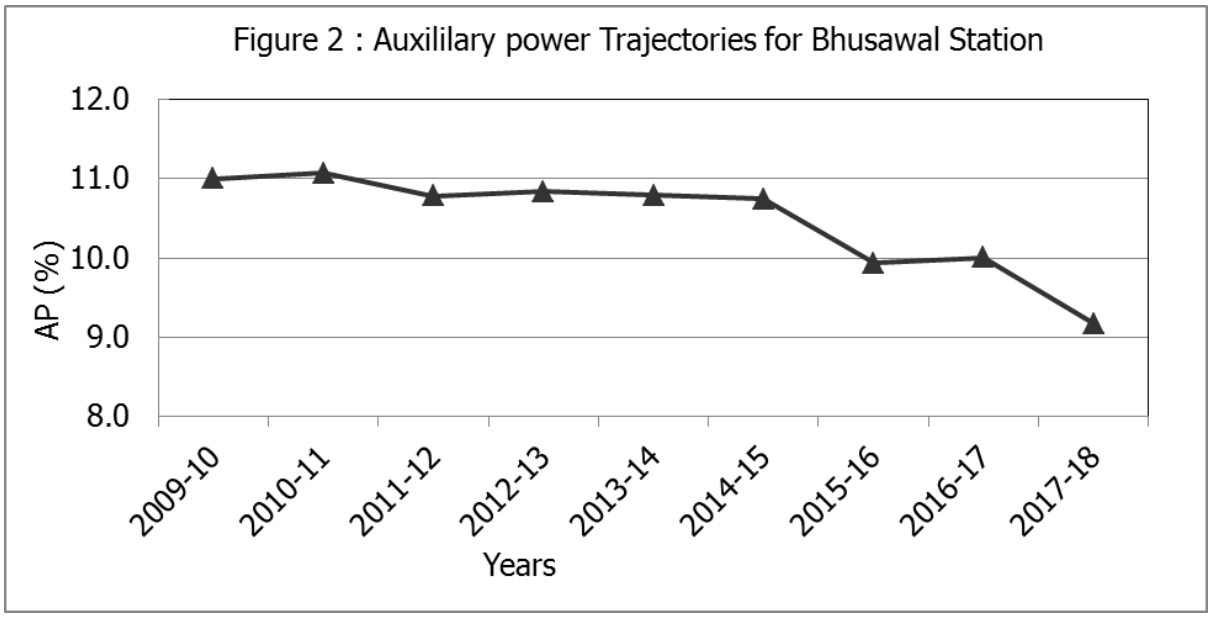


BHUSAWAL								
Year	Previous year heat rate, kcal/kWh	Degradation @ 0.31 % / year	Immediate measures	Medium term measures	Long term measures	EER&M benefit on SHR, kcal/kWh	Annual overall SHR, kcal/kWh	Comments
2009-10	2856						2855.5	[1]
2010-11	2856	8.9					2864.4	[2]
2011-12	2809	8.9	-10.0				2807.7	[3]
2012-13	2808	8.9	-15.0	-10.0			2791.5	[4]
2013-14	2792	8.9	-26.0	-10.0			2764.4	[5]
2014-15	2764	8.9	-20.0	-10.0			2743.2	[6]
2015-16	2743	8.9				-12.6	2739.5	[7]
2016-17	2739	8.9				-31.5	2716.8	[8]
2017-18	2717	8.9				-44.1	2681.6	[9]

Comments	Comments
[1]	Date of test on 10 - 07 - 2009; Unit 1 de-commissioned in 15.12.2010;SHR considered with all units
[2]	Base SHR considers old unit too since it was in service
[3]	U-2 COH ,LTSH Eco Coil Replacement,U-2 30 % Skin insulation Replacement, Turbine Steam Flow path correction; base SHR taken as 2791 with degradation for 2 years
[4]	DPR for Skin Insulation Replacement, Boiler Major Valve replacement; Base SHR subtracts the uncontrolled factor which is not cumulative but only for this year.
[5]	U-3 Eco, LTSH coil replacement,U-3 Vent condenser replacement.
[6]	Smart WSB, Burner Equipment modification, Gas proportionate dampers, APH upgradation.
[7]	Unit 2 R & M for 2 months
[8]	
[9]	Unit 3 R & M for 1 months

BHUSAWAL	**R & M**		**PROJECTIONS**	
Unit No.	2015-2016			
2	2655	2		R & M of Unit 2
3	2743	12		
		2730.21	-12.53	
Unit No.	2016-2017			
2	2655	12		
3	2743	12		
		2698.87	-31.34	No R & M
Unit No.	2017-2018			
2	2655	12		
3	2655	1		R & M of Unit 3
		2655.00	-43.87	

4.2 Test auxiliary power measured and revised performance trajectories



Year	Previous year AP, %	Immediate measures	Medium term measures	Long term measures	Miscellaneous factors	EER&M benefit on AP, %	Annual overall AP, %	Comments
2009-10	11						11.00	[1]
2010-11	11.00				0.07		11.07	[2]
2011-12	10.71				0.07		10.78	[3]
2012-13	10.78	-0.01			0.07		10.84	[4]
2013-14	10.84	-0.01	-0.11		0.07		10.79	[5]
2014-15	10.79		-0.11		0.07		10.75	[6]
2015-16	10.75				0.07	-0.88	9.94	[7]
2016-17	9.94				0.07		10.00	[8]
2017-18	10.00				0.07	-0.90	9.17	[9]

Comments	Comments
[1]	
[2]	Unit 1 taken out of service. Common Loads which were apportioned to 62.5 MW unit after decommissioning of 62.5 MW unit has fallen back on station, this load is works out to be 0.069% in AP of station in 2010-11.
[3]	62.5 MW unit withdrawal effect as above of 0.07 %.
[4]	After Immediate measures, LT aux VFD installation, HT Auxiliary O/H
[5]	
[6]	After Medium Term, BFP upgraded, some schemes excluded. BFP upgraded cartridge repl.
[7]	Unit 2 R & M
[8]	
[9]	Unit 3 R & M; After long term measures , VFD of HT deferred.

BTPS	Test AP% FOR STATION		
Unit No.	2009-10		
1	13.46	62.50	841.25
2	10.45	210.00	2194.50
3	10.82	210.00	2272.20
	11.00	482.50	5307.95
BTPS	Test AP% FOR 210 UNIT		
Unit No.	2009-10		
1	0.00	0.00	0.00
2	10.45	210.00	2194.50
3	10.82	210.00	2272.20
	10.64	420.00	4466.70

5. CONCLUDING REMARKS

i. The Bhusawal TPS has indicated a strong inclination to develop into a corporate culture of operation in its outlook.

ii. For many schemes implementation is done in one unit in a station as a pilot or one pilot station, the benefits are divided by the overall station performance and hence show smaller savings.

iii. Measures of a non-financial nature such as operational optimization, leak reduction, minimizing DM water make up, cleanliness in the power house, etc., need to be taken more seriously and with vigour to achieve and sustain the heat rates.

iv. The installation of in-motion weigh bridges needs to be expedited.

v. The detailed progress and the trajectories are given in the text.

vi. The performance is not as per the original trajectories because the implementation program has been taken up on a pilot basis for one unit or unit station in many cases and afterwards proposed to be taken up in other units. Also, many medium and long term measures have been clubbed with E-R & M schemes which are going to be taken up in next few years. Hence the trajectories will be linked with these R & M schemes.