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Report of the Comptroller and Auditor General of India for the year ended March 2022

Energy Management in Train Operations and Renewable Energy Initiatives in Indian Railways

SUPREME AUDIT INSTITUTION OF INDIA

लोकहितार्थ सत्यनिष्ठा

Dedicated to Truth in Public Interest

Union Government (Railways) Performance Audit Report No. 6 of 2024

GAURAV RAI

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Report of the
Comptroller and Auditor General of India

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Laid in Lok Sabha/Rajya Sabha on _____

Union Government (Railways)
Performance Audit
Report No. 6 of 2024

PREFACE

This Report of the Comptroller and Auditor General of India has been prepared for submission to the President of India under Article 151(1) of the Constitution of India for being laid before the Parliament.

The report contains results of audit of the Ministry of Railways of the Union Government, on the matter of 'Energy Management in Train Operations and Renewable Energy Initiatives in Indian Railways'.

The instances mentioned in this Report are those, which came to the notice in the course of the test audit for the period April 2017 to March 2022, as well as those, which came to the notice in earlier years, but could not be reported in the previous Audit Reports.

The audit has been conducted in conformity with the Auditing Standards issued by the Comptroller and Auditor General of India.

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Executive Summary

Executive Summary

The national railway system of India, operated by the Ministry of Railways is one of the largest railway networks in the world. As a result, it is a major consumer of energy and fuel. Fuel cost forms one of the major components of working expenses of Indian Railways (IR), which stood at 15.81 *per cent*, 16.54 *per cent*, 16.71 *per cent* and 14.13 *per cent* respectively during the years 2017-18, 2018-19, 2019-20 and 2020-21. It increased again to 14.53 *per cent* in 2021-22. After salaries and pension, fuel cost is the third highest cost component of revenue expenditure in IR. In the budget for 2015-16, to reduce the fuel input cost by ₹3,000 crore every year, IR envisaged an estimated saving of ₹ 41,000 crore (Mission 41K) towards energy bills by 2025. To reduce its energy consumption and greenhouse gas emissions, Indian Railways has implemented several energy-saving measures.

The Performance Audit on "Energy Management in Train Operations and Renewable Energy Initiatives in Indian Railways" was conducted to assess whether IR's major initiatives with regard to energy management, development of renewable energy resources and conservation of energy were meeting the outcomes envisaged. The report on the subject has been structured in four chapters as indicated below:

Chapter 1- Introduction covering basic genesis of the subject and giving a background for conducting this Audit.

Chapter 2 - Performance parameters affecting the energy usage in IR.

Chapter 3 - Energy saving initiatives of IR and related Audit findings.

Chapter 4 - Renewable Energy Initiatives of IR and progress thereon.

Summary of the findings

- Percentage of fuel cost to working expenditure during the review period ranged from 14.13 to 16.71.
- The average passenger to freight SEC ratio of 3.35 is 1.67 times the average passenger to freight SFC ratio of 2.01 during the review period.
- Passenger SFC, freight SFC and passenger SEC showed decreasing trends but Freight SEC showed an increasing trend.
- The percentage of GTKMs increased for electric traction and decreased for diesel traction during 2017-18 to 2021-22.

- Single Policy or Master Circular for implementation of energy conservation measures has not been issued by IR.
- IR has made large savings in energy costs through Open Access but the same has not been achieved across Zones.
- Corresponding to reduction of unelectrifed RKMs by 56.40 *per cent* during the review period, fuel consumption for traction purpose reduced by 34.85 *per cent*.
- Energy Audit was not conducted in some of the ZRs.
- Metering arrangement/mechanism did not exist to measure energy fed back to the grid, hence savings in energy bills could not be quantified.
- Non-shutting down of stationary diesel locomotives was noticed in ten Divisions of seven ZRs resulting in detention of Loco in on-position beyond 30 minutes on 5,45,352 occasions for 35,41,594 hours during 2017-18 to 2021-22
- 'Vision 2020' envisaged 10 *per cent* of the total energy used by IR would be from renewable sources by the year 2020. However, IR could not install solar power plants and wind power plants as planned originally.

Summary of Recommendations

IR needs to:

- Examine and reduce the fuel costs in six Zones, which show high figures of fuel cost to working expenditure/increasing trend despite the progressive changeover to the cheaper electric traction.
- Address the increasing trend in freight SEC.
- Automate the system for calculating SFC and SEC to effectively optimize fuel and energy consumption.
- Compile and issue all the measures for energy conservation in a single policy document/ master circular for clarity and focus in implementation at Zonal level.
- Rectify the low increase in electric GTKM in four Zones, as compared to increase in electrified route KM due to non-utilization of electric traction in the electrified routes.
- Prepare timelines for conversion to 100 per cent three phase electric locomotives with due consideration of the life of the existing conventional locomotives, production capacity for three phase locos etc.

- Evolve mechanism for automated capture of regenerated energy data from engine of three phase locomotives and EMUs.

- Replicate across all Zones the method adopted by WCR to get credit for the regenerated power fed back to the grid.

- Ensure conducting Energy Audits regularly for monitoring and to optimize energy consumption.

- Issue a comprehensive policy circular detailing the new measures and targets for different areas of renewable energy that is proposed to be tapped.

Chapter 1 Introduction

Indian Railways (IR) is one of the largest means of transportation in India and it is ranked as fourth largest railway network in the world. IR use Electricity and Diesel as main source of energy for operation of trains. The availability of energy is a major factor for sustained economic growth of any country, particularly for a developing country like India. With the growing demand in freight and passenger segments, the requirement for energy (Diesel and Electric) has increased manifold. Hence, IR has to adopt measures for efficient Energy Management and also develop renewable energy resources.

Fuel cost forms one of the major components of working expenses of IR, which stood at 15.81 *per cent*, 16.54 *per cent*, 16.71 *per cent* and 14.13 *per cent* respectively during the years 2017-18, 2018-19, 2019-20 and 2020-21. It increased again to 14.53 *per cent* in 2021-22. After salaries and pension, fuel cost is the third highest cost component of revenue expenditure in IR.

IR has different agencies that manage the energy sourcing. Ministry of Railways (MoR) and Rail India Technical and Economic Services Ltd., (RITES) have formed (August 2013) a joint venture company viz., Railway Energy Management Company Limited (REMCL) in the shareholding pattern of 49 *per cent* and 51 *per cent* respectively for undertaking the projects of IR related to power trading activities, transmission lines and power evacuation planning[1], harnessing renewable energy like solar and windmill power plants, energy conservation initiatives, efficient coordination in power generation through captive power plant, energy audits etc.

REMCL is the nodal agency to call for tenders and finalise the solar plant installation in Public Private Partnership with Design, Built, Finance, Operate and Transfer (DBFOT) basis. As per capacity allocated to Zonal Railways by Railway (MoR), REMCL takes inputs from Zonal Railways i.e. availability of roof top space and vacant land. It is the job of REMCL to finalise the tenders and coordinate with the Ministry of New and Renewable Energy (MNRE) regarding Central Financial Assistance (CFA) and Viability Gap Funding (VGF).

Four Memorandums of Understanding (MoU) were signed (during August 2015) between MoR, Ministry of Power (MoP) and MNRE and their Organizations for cooperation in the areas of Electricity Transmission, Energy Conservation and Promotion of Renewable Energy in a time bound manner. These include two MoUs specifically aimed at increasing solar power generation in IR, as under:

- MoU between MoR and MNRE where both parties recognize the importance of Solar Energy for sustainable development and towards enhancing the renewable energy in the overall energy mix.

[1] ***Power evacuation means a facility that allows generated power to be immediately transmitted from a generating plant to the grid for further transmission/ distribution to load centres.***

- MoU between REMCL and Energy Efficiency Services Limited (EESL) for implementation of Energy Efficiency projects which result in potential savings to Zonal Railways at various Railway Buildings owned and managed by Railways.

1.1 Background

IR envisaged, in the budget for 2015-16, to reduce the fuel input cost by ₹3,000 crore annually and an estimated saving of ₹41,000 crore (Mission 41K) towards traction energy bills by 2025.

Under Mission 41K, various measures were proposed by the IR to conserve energy for rolling stock. From the efficient energy utilization perspective, 'three-phase electric traction' offers a unique feature of 'regenerative braking' where the kinetic energy of the train is re-converted into electrical energy and is fed back to the electric grid.

The Minister of Railways while addressing a conference on Solar Energy opportunities in the Rail Sector in 2019 had stated that Indian Railways, by 2030, would become Net Zero Emitter of Carbon Pollution. Looking at cost and environmental benefits, lately, the emphasis has shifted from diesel to electric traction, and in recent past, IR has decided to speed up the process of electrification to fully electrify the Broad-Gauge network by December 2023.

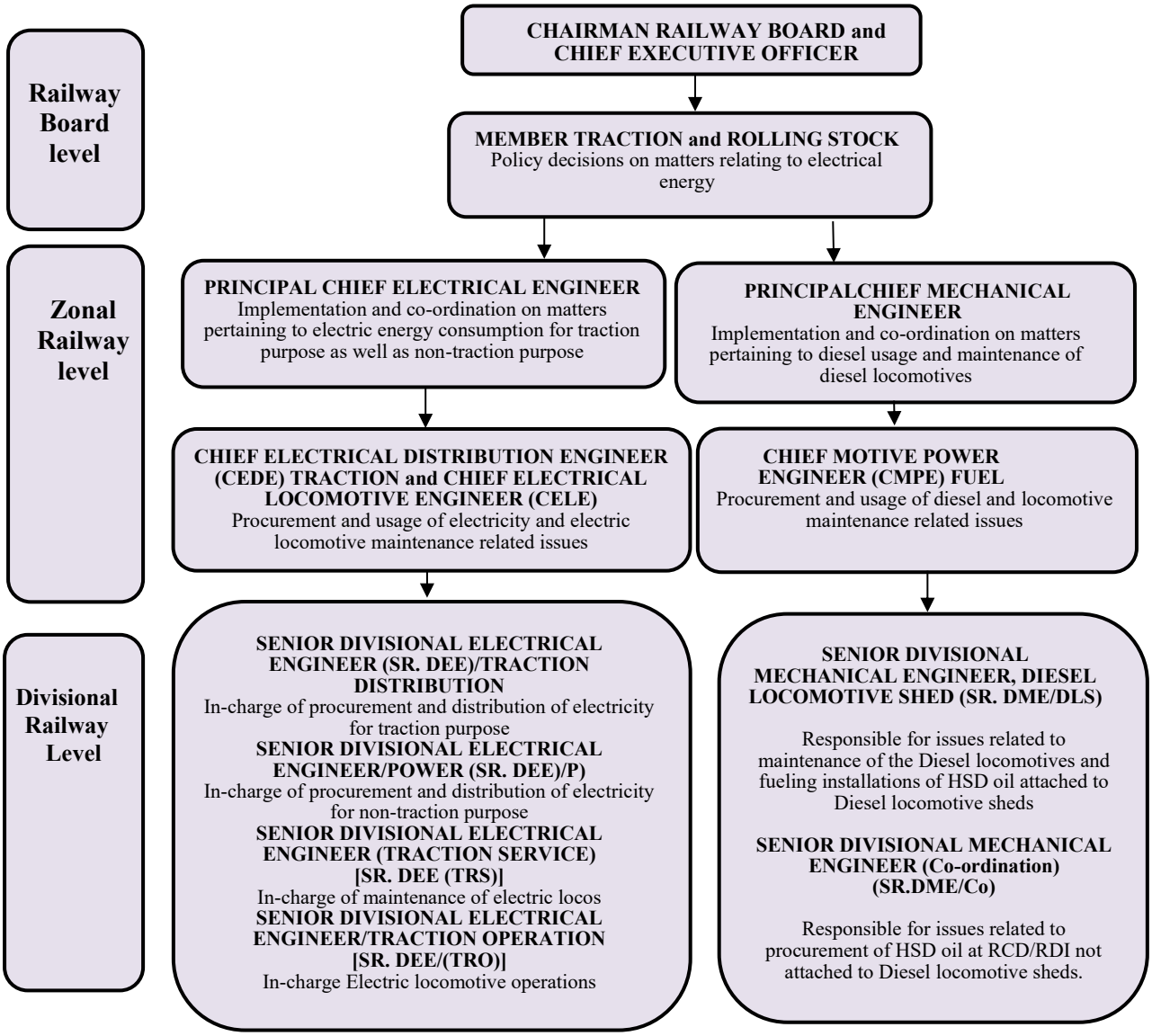
IR also introduced energy efficient Head on Generation (HOG) scheme. In this scheme, the complete electric power for air-conditioning, train lighting etc. of the rail coaches is received from the locomotive. This will replace the power from diesel generators. In addition to being green and noise free, it will also save about Rupees one crore per annum per train.

1.2 Past Audit coverage

Audit on "Energy Conservation Measures in Indian Railways" appeared in "Para 3.3 of CAG's Audit Report No. 14 of 2017 (Railways).

Theme Based Audit on "Installation and Commissioning of Solar Power Plants in Indian Railways" appeared in Para 6.1 of CAG's Audit Report No. 19 of 2019 (Railways).

1.3 Organisational Structure



1.4 Audit objectives

The Performance Audit has been conducted to ascertain whether:

1. The measures laid down by IR to achieve the saving envisaged are adequate, effective, monitored and implemented;
2. IR's major initiatives with regard to energy management and conservation viz., Mission 41K, for the period 2015-2025, have been able to achieve the desired objectives; and
3. IR initiated sufficient and effective measures to develop renewable energy resources.

1.5 Scope of Audit

Performance Audit focused on energy procurement process adopted in IR, implementation of policies and instructions of Ministry of Railways (MoR) regarding energy conservation measures and their monitoring for optimal Energy Management along with the development and implementation of renewable energy initiatives by IR during the period of five years from 2017-18 to 2021-22. The scope of audit covered the actions taken in respect of audit observations highlighted in the previous Audit Reports as mentioned in **Para 1.2** of this Report.

1.6 Methodology

The Audit methodology entailed examination of primary as well as secondary sources. Audit methodology also included examination of records of MoR, Zonal Railways (ZRs) and selected Divisions for assessing the implementation and efficiency of measures taken by these units in connection with Energy Management in train operations and renewable energy initiatives in IR.

Entry and Exit conferences were held in the Zonal Railways and in the Railway Board. Responses received from the ZRs and the Railway Board have been incorporated.

1.7 Sample Selection

The sample size adopted for examination of various issues is given in **Table 1**

Table 1: Sample selection details

Description	Criteria for selection of units	No. of units selected
1	2	3
Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	100% Implementation of Policies/orders of MoR in connection with Energy management and conservation	Electrical, Mechanical, Operating and Engineering Department
Divisions	Two Divisions having highest consumption of energy during review period.	32
Diesel locomotive shed	Two diesel locomotive sheds in each Zone.	29
Electric locomotive shed	Two electric locomotive sheds in each Zone.	28
EMU car shed	One EMU car shed maintaining highest number of EMUs in relevant Zones.	13
Traction Sub Stations (TSS)	Three TSS from each selected division.	96
Railway's own Solar Plants	Highest capacity plant (in MW) selected for physical inspection.	16
Railway's own Wind Power Plants	Highest capacity plant (in MW) selected for physical inspection	3

Source: Sampling record

Details of sample selection are shown in **Annexure 1**.

1.8 Audit criteria

The criteria for the Performance Audit had been derived from the following sources:

(i) Letters/circulars/orders issued by Railway Board/Zonal Headquarters in connection with energy conservation and management.

(ii) Files/records maintained by Zonal/Divisional Authorities and Indian Railways Annual Statistical statements (ASS).

(iii) Mission 41K document published (2017) by MoR.

(iv) Guidelines issued by Ministry of New and Renewable Energy (MNRE) and Energy Saving measures prescribed by the Bureau of Energy Efficiency (BEE).

1.9 Acknowledgement

We wish to acknowledge the cooperation and assistance extended by officials of various directorates concerned in Ministry of Railways as well as in Zonal Railways in providing information, records, clarifications and discussion with concerned officers, which facilitated completion of Audit.

Chapter 2 Performance Parameters

Railways compile statistical data on various aspects of Railways working and the same is published in the form of monthly and Annual Statistical Statements as per detailed instructions given in Railway Boards' Statistical Manual Vol. I and II. Every Zonal Railway has a full-fledged statistical department and a Statistical Directorate is functioning in the Railway Board to compile and collect data about the working and performance of their respective Zones. Hence sufficient statistical data is available on every facet of Railway working.

Railway statistics have been broadly classified under the following categories:

(i) Economics & Financial statistics

(ii) Commercial statistics

(iii) Operating statistics

(iv) Rolling Stock & Workshop Statistics; and

(v) Administrative statistics

Audit has analyzed some important financial and operating statistics in connection with fuel and energy for the review period and Audit findings are mentioned in the succeeding paragraphs.

2.1 Fuel cost vis-à-vis working expenditure

Fuel cost[2] forms one of the major components of working expenses of IR. Percentage of fuel cost to working expenditure during the year from 2017-18 to 2021-22 for IR is shown in **Table 2**.

Table 2: Working Expenditure and Fuel Cost

Year	Total Working Exp (₹ in crore)	Total Fuel Cost (₹ in crore)	Percentage of Fuel Cost to Working Expenses
1	2	3	4
2017-18	1,75,091.98	27,676.44	15.81
2018-19	1,82,555.47	30,190.24	16.54
2019-20	1,72,786.66	28,864.94	16.71
2020-21	1,37,536.45	19,437.57	14.13
2021-22	2,09,366.64	30,428.84	14.53

Source: Annual Statistical Statement (ASS) of respective years

[2] ***Fuel cost comprise of cost of diesel and electric energy used for traction and non-traction purpose***

It was observed that the percentage of fuel cost to working expenditure increased during 2017-18 to 2019-20 and decreased in 2021-22. The year 2020-21 being COVID year is considered as outlier. Analysis of fuel cost and working expenditure of ZRs for the same period revealed variations in six Zones as detailed below:

- NWR and SWR consistently recorded a higher percentage of fuel cost to working expenditure as compared to the IR. During 2021-22, the percentage recorded by NWR and SWR were 27.29 *per cent* and 27.71 *per cent* respectively which was almost double the percentage for IR of 14.53 *per cent*.
- The percentage of fuel cost to working expenditure increased marginally by more than two *per cent* in NEFR, NWR, SWR and WR in 2021-22 with reference to the year 2017-18.

The high figure of fuel cost to working expenditure/increasing trends in these six Zones, despite the progressive changeover to the cheaper electric traction indicates a potential for reduction in fuel costs. The same needs to be examined and reduced.

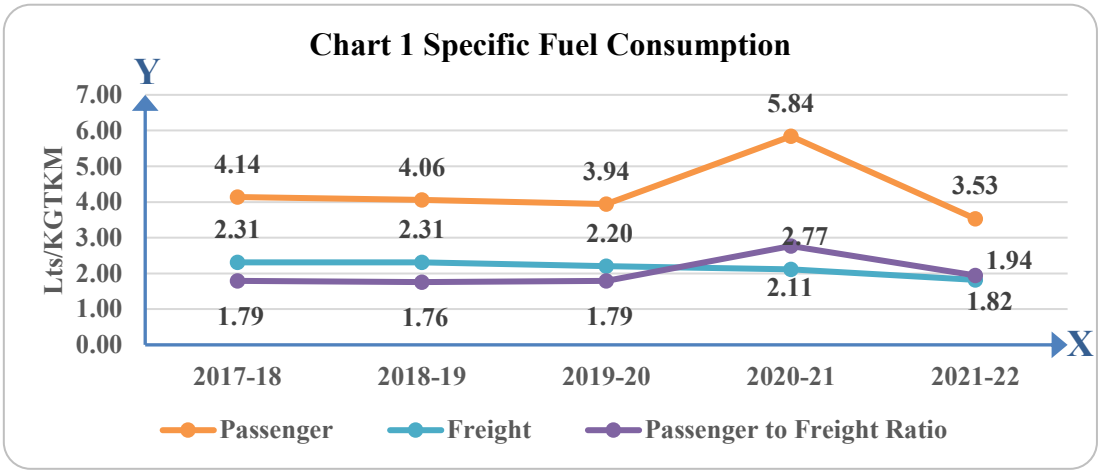
2.2 Specific Fuel Consumption and Specific Energy Consumption

Reducing fuel/energy consumption ought to be a persistent endeavor of IR in order to improve its operating ratio. The electric locomotives are far more fuel efficient compared to their diesel counter-parts as they use high efficiency three-phase induction motors[3] as opposed to diesel locomotives which use less efficient internal combustion engines.

2.2.1 Specific Fuel Consumption

Fuel efficiency of Diesel Locomotives is measured in terms of Specific Fuel Consumption (SFC). It is the average amount of fuel consumed by diesel engines in litres for hauling 1000 Gross Tonnes of train load for a Kilometer (Ltrs/KGTKM). The figures of SFC for Diesel traction used for Passenger and Freight traffic for the year 2017-18 to 2021-22 are shown in **Chart 1**

[3] ***A three-phase induction motor is an electromechanical energy conversion device which converts three-phase input electrical power into output mechanical power.***



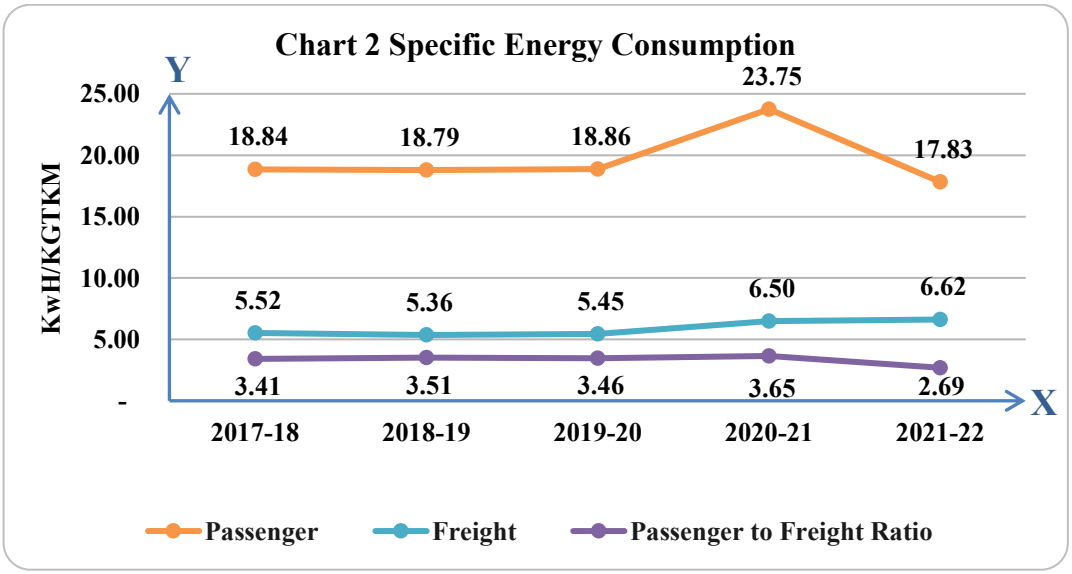
Source: ASS of respective years and records of O/o the PCME of ZRs

As is clear from **Chart 1,** both passenger and freight SFC showed decreasing trend during review period except for the year 2020-21(COVID year) where increase in passenger SFC was noticed. Further, the Passenger SFC was almost twice the freight SFC during the years.

2.2.2 Specific Energy Consumption

Energy efficiency of Electric traction is measured in terms of Specific Energy Consumption (SEC). It is the average number of units (KwH) of electric energy consumed to haul 1000 Gross Tonnes of train load for a Kilometer (KwH or Units/KGTKM). The SFC and SEC figures for IR are indicated in **Annexure 2.**

The figures of SEC for Electrical traction used for Passenger and Freight traffic for the year 2017-18 to 2021-22 are shown in **Chart 2**.



Source: ASS of respective years

It was observed that:

- The passenger SEC fluctuated between 17.83 KwH/KGTKM to 23.75 KwH/KGTKM but showed an overall decreasing trend except for the outlier in 2020-21, the covid year. However, the freight SEC showed an increasing trend during the years from 5.36 KwH/KGTKM to 6.62 KwH/KGTKM which is a matter of concern and needs to be addressed.
- The average passenger to Freight SEC ratio of 3.35 is 1.67 times the average Passenger to Freight SFC ratio of 2.01. In view of the shift toward electric traction in IR, the higher SEC ratio is a matter of concern as it would adversely affect the operating ratio.

  CR administration stated (December 2021) that SEC ratio of 'Passenger to Freight locomotives' being much higher than SFC ratio needs to be reconsidered. SEC/SFC should be converted to same basic unit and then only they can be compared. The contours of the relationship (between SFC in Diesel locomotive and SEC in Elect locomotive) would define the tenability of the respective comparison of SFC in Passenger/Freight and SEC in Passenger/Freight. Responses furnished by MoR (January 2024) did not include a reply on this issue.

  Audit has compared the passenger to freight ratios for SFC and SEC and not made a direct comparison between SFC and SEC. The concern raised by the Audit is that the higher ratio of SEC for passenger to freight haulage, as compared to SFC, indicates a potential to use measures to reduce SEC for passenger trains, which would have a positive impact on operating ratio. Therefore, this issue needs to be analysed to identify measures that would reduce the SEC for passenger trains.

2.2.3 Measurement of SFC and SEC

SFC and SEC are critical parameters for measuring efficiency of traction and savings of fuel and energy. These figures are manually compiled offline on aggregate basis. MoR compiled the statistical data of SFC and SEC for the year 2021-22 and published in the Annual Statistical Statements (ASS) on 13th April 2023 after a lapse of more than one year.

It was observed that two of the parameters i.e. energy consumed and distance travelled are being captured on board in the locomotives and the third parameter, i.e. the tonnage hauled is also available in online systems such as FOIS. Therefore, there is scope to automate the calculation of SFC and SEC by integrating the requisite data on a system, replacing the much slower manual method being currently followed. This would allow for better monitoring and corrective action, where required, for improving energy efficiency of traction.

2.3 Gross Tonne Kms (GTKMs) by type of traction

Electric and Diesel traction constituted the principal modes of traction on IR. As per instructions given in Railway Board's Statistical Manual, figures of GTKMs are used for working out fuel expenses, allowance is made for gradient, banking engines etc. The share of traffic in terms of GTKMs for passenger and freight services hauled under Electric and Diesel traction types over the years from 2017-18 to 2021-22 for IR is shown in **Table 3**.

Table 3: GTKMs for passenger and freight services – Traction wise

Year	GTKM – Passenger		Percentage of GTKMs by type of traction		GTKM-Freight		Percentage of GTKMs by type of traction	
	Electric	Diesel	Electric	Diesel	Electric	Diesel	Electric	Diesel
1	2	3	4	5	6	7	8	9
2017-18	39,88,26,008	34,38,28,040	53.70	46.30	76,75,69,096	42,38,40,457	64.43	35.57
2018-19	42,62,96,435	34,24,69,061	55.45	44.55	82,87,77,787	43,80,94,247	65.42	34.58
2019-20	44,41,55,689	30,22,10,455	59.51	40.49	82,27,76,178	39,89,17,466	67.35	32.65
2020-21	17,80,59,474	4,96,12,635	78.21	21.79	92,26,92,848	31,52,07,515	74.54	25.46
2021-22	47,56,39,566	16,93,98,327	73.74	26.26	1,14,15,88,633	34,26,51,334	76.91	23.09

Source: ASS of respective years

Audit observed that;

- The percentage of GTKMs increased for electric traction by 20.04 *per cent* for passenger traffic and by 12.48 *per cent* for freight traffic during 2017-18 to 2021-22. In respect of diesel traction, GTKM for passenger and freight decreased by 20.04 *per cent* and 12.48 *per cent* respectively.
- In 11 ZRs[4], the percentage of GTKMs increased for electric traction during the review period in line with the trend for entire IR. In four Zones[5], increase in electric GTKM was low as compared to increase in electrified route KM due to non-utilization of electric traction in the electrified routes.

While accepting the audit observation, MoR confirmed (March 2023) that due to missing links in some of the Railways, the percentage of increase of GTKMs was not commensurate with electrification.

The response indicated the potential for further improving the Electric traction in the Zones concerned.

2.4 Conclusion

Review in Audit revealed that percentage of fuel cost to working expenses showed a decreasing trend overall but some zones were at variance from this trend and there was potential to improve the position further.

[4] ***ER, ECR, ECoR, NR, NER, NWR, SCR, SER, SECR, SWR and WCR***
[5] ***CR, NCR, SR and WR***

The annual SFC and SEC figures were manually compiled, requiring about a year, as there was no automated recording/monitoring of SFC and SEC of individual locomotives. Automated system for calculation SFC and SEC would equip IR to take effective measures at optimizing fuel/energy consumption.

The increasing trend in SEC of freight traffic for the past four years despite induction of more efficient three-phase HHP electric locomotives and the average passenger to freight SEC ratio being 1.67 times the passenger to freight SFC ratio are required to be examined.

The percentage of GTKMs increased for electric traction for both passenger traffic and freight traffic during the review period.

SUMMARY OF AUDIT FINDINGS

- Percentage of fuel cost to working expenditure during the review period ranged from 14.13 to 16.71.
- The average passenger to freight SEC ratio of 3.35 is 1.67 times the average passenger to freight SFC ratio of 2.01 during the review period.
- Passenger SFC, freight SFC and passenger SEC showed decreasing trends but Freight SEC showed an increasing trend.
- The percentage of GTKMs increased for electric traction and decreased for diesel traction during 2017-18 to 2021-22.

2.5 Recommendations

IR needs to:

1. ***Examine and reduce the fuel costs in six Zones, which show high figures of fuel cost to working expenditure/increasing trend despite the progressive changeover to the cheaper electric traction.***
2. ***Address the increasing trend in freight SEC.***
3. ***Automate the system for calculating SFC and SEC to effectively optimize fuel and energy consumption.***

Chapter 3 Energy Saving Initiatives

Indian Railways issued several policies for energy management, conservation of energy and renewable energy initiatives under various schemes/missions/policies like:-

- Indian Railways Vision 2020,
- Mission 41K- 2017,
- IR Environmental Sustainability Annual Report 2019-20,
- Mission 100 per cent Electrification February 2021,
- Green Railways March 2021,
- Utilization of vacant unused railway land for setting up of Solar Plants April 2020 (MoR), and
- National Rail Plan 2020.

Chapter VII of the Indian Railways Manual of AC Traction Maintenance and Operation (Vol. I) deals with Energy Conservation. As per extant provisions, a senior officer of the Electrical Department in each Zonal Railway would be in-charge of matters pertaining to energy conservation. It would be the responsibility of this officer, *inter alia*, to plan for energy conservation measures and monitor their implementation.

3.1 Master plan for implementation of measures for reduction in cost of Energy

IR had been working continuously to improve its energy uses through several policies and measures for energy management as mentioned above.

The issue of non-availability of a dedicated master plan or long-term perspective plan for reduction in cost of Energy was raised with Electrical Engineering Directorate of MoR during entry conference (August 2022). It was stated that plans would be shared with Audit during review at MoR office. While a number of policy documents and instructions were available, no long-term perspective plan or Master plan was furnished to Audit.

Audit observed (November 2022) that only NWR prepared Annual Action Plans for effective and timely implementation of energy conservation measures. Targets for energy conservation were fixed every year to save energy but it was found that targets for energy conservation for non-traction purpose were not achieved in any of the financial years during the review period. The remaining 15 ZRs[6] did not prepare any Master Plan.

[6] ***CR, ER, ECR, ECoR, NR, NCR, NER, NEFR, SR, SCR, SER, SECR, SWR, WR and WCR***

MoR clarified (January 2024) that IR is taking a large number of Energy conservation measures both in traction and non-traction front. The implementation of these measures depends on various factors including suitable technology, human resources, availability of resources, etc. Besides, with experience and knowledge, additional fronts are identified where energy can be conserved. Thus, identification of areas and measures to conserve energy and action thereon is a continuous process. Since, implementation of these measures involve large number of factors, setting a definite time frame for implementation and formulating a strategic plan, for a long term, in this regard is very difficult. It also detailed some of the key measures taken, such as four strategies to achieve Net Zero Carbon emission by 2030, and issue of Energy Efficiency Policy for non-traction installations (Dec 2022). It also gave the details of the positive results achieved, including winning numerous awards through various energy conservation measures.

As pointed out by Audit and as evident from the responses, numerous measures towards energy conservation are being taken through a large number of policy documents/instructions. Some of these specifically relate to energy conservation and some others relate to multiple issues, one of which is energy conservation. In view of the criticality, it would be appropriate to aggregate all instructions in a single policy document/master circular which would provide complete clarity and bring greater focus in implementation at Zonal level.

3.2 Mission 41 K compliance

The Mission 41K document covered all aspects of energy conservation in terms of introduction of advanced energy saving technologies and use of cheaper renewable energy sources. Major initiatives prescribed in Mission 41K document included inter alia procurement of energy through Open Access, induction of three phase locomotives and Electrical Multiple Units having regeneration capacity, rail electrification, production of locomotives with Head on Generation System and other energy initiatives. However, when it came to quantification of cost savings, it only projected the notional savings that would accrue from lower tariff under Open Access till 2025, for which the forecast was ₹ 41,000 crore or 41K by 2025. The forecast indicated in the 41K document is shown in **Table 4**.

Table 4: Projected saving in Mission 41K - Break-up of Projected Financial Savings of ₹ 41,000 crore

(₹ in crore)

Year	Payment of BAU* mode	Payment in new paradigm	Total savings	Cumulative savings
1	2	3	4	5
2015-16	10,598	10,200	397	397
2016-17	11,642	9,000	2,462	2,860
2017-18	12,398	8,491	3,058	5,918
2018-19	13,667	9,270	3,470	9,388
2019-20	15,067	10,121	3,934	13,321

Year	Payment of BAU* mode	Payment in new paradigm	Total savings	Cumulative savings
1	2	3	4	5
2020-21	16,609	11,050	4,454	17,776
2021-22	18,310	12,064	5,039	22,815
2022-23	19,614	12,799	5,535	28,350
2023-24	21,010	13,579	6,074	34,424
2024-25	22,506	14,406	6,660	41,084

Source:-Reproduced from Mission 41K Document
***BAU –Business as Usual**

The implementation of these initiatives were checked for the review period and results are enumerated in the following paras.

3.2.1 Drawal of electrical energy for traction applications through Open Access

With the assistance of REMCL, Indian Railways has been obtaining Open Access from State Electricity Board/Company (State DisComs) which has resulted into huge cost savings to IR.

Before getting Open Access, IR was procuring traction energy from respective State DisComs. Open Access was obtained in 11 States. This involved 14 zones[7] who were procuring energy at different rates ranging from ₹ 6.25 (SER) to ₹ 12.96 (NWR) per unit. From 2017-18 to 2021-22, these 14 ZRs procured energy under Open Access from other suppliers in these 11 States at an average rate of ₹ 5.87 per unit under Open Access, which resulted in huge savings in traction cost.

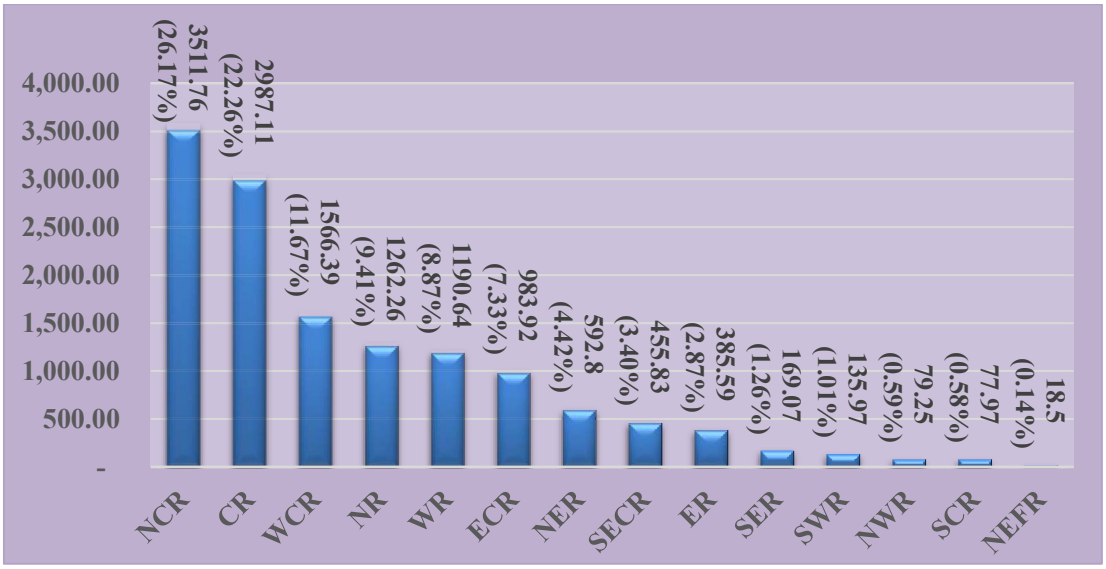
However, State DisComs of seven States[8] did not grant No Objection Certificate (NOC). The overall implication was that seven ZRs had complete Open Acess, another seven[9] ZRs had only partial Open Access and in two ZRs i.e. ECoR and SR, Open Access was not available for the entire Zone.

To cite an illustrative case, after getting NOC from State DisComs, IR entered into contract with Ratnagiri Gas Power Pvt. Ltd. (RGPPL) for power procurement of about 500 MW for consumption in Maharashtra, Gujarat, Madhya Pradesh and Jharkhand in November 2015. Against the above contract, 47 Traction Sub-Station (TSS) duly covering Central and Western Railways, started availing power under Open Access from 26 November 2015. This resulted in savings of ₹ 600 crore per annum (saving of about ₹ 3.50/unit for about 180 crore units) in Maharashtra alone.

IR managed to save ₹ 13,417.06 crore during 2017-18 to 2021-22 on account of availability of complete Open Access in seven Zones and limited Open Access in other seven ZRs. Details of the savings through Open Access is shown in **Chart 3**.

[7] ***Except ECoR and SR where open access not yet received at all.***
[8] ***West Bengal, Tamil Nadu, Andhra Pradesh, Chhattisgarh, Odisha, Kerala and Telangana***
[9] ***ER, ECR, NEFR, SCR, SER, SECR, SWR***

Chart 3: Savings through Open Access during 2017-18 to 2021-22 (₹ in crore)



Source: Records of office of the PCEE of respective Zonal Railways

MoR stated (January 2024) that Mission 41K was based on the premise that IR would get a deemed distribution licensee status (with Open Access) in all the States, resulting in a cumulative savings of ₹ 41,000 crore over the period from 2015-16 to 2024-25. However, so far, only 11 States have allowed open access to Indian Railways despite aggressive pursuance at the highest levels. Even in the Open Access States (11 Nos.) the uniform policy for tariffs is not being adopted and various charges like basic DSM charges, Sign Change Charges etc. are levied on IR. Due to Open Access in only 11 States, ZRs saved ₹ 24,527 crore during November 2015-16 to 2021-22 as against the target of ₹ 22,815 crore.

As MoR did not furnish Zone wise details and year-wise savings, Audit is unable to offer comments on the quantum of savings claimed. However, the huge order of savings underlines the need for continued pursuance of Open Access with State DisComs.

3.2.2 Reducing use of Diesel Traction - Consumption of Diesel

Railway Board circulated to all ZRs (July 2017 and June 2020) a list of immediate and short term austerity measures to control expenditure and enhance earnings. The austerity measures laid down under the category 'Fuel and Energy' *inter alia* included:

a) Enforcing strict monitoring of fuel savings on accounts of change in traction and
b) Ensuring reduction of diesel consumption commensurate with Railway Electrification.

IR completed electrification of 51,261.02 RKMs up to March 2022 (out of 66,066.44 RKMs). During the period 2017-22, electrification of 25,375.40 RKMs (38.41 *per cent* of total RKMs) was completed. The unelectrifed RKMs reduced by 56.40 *per cent from* 33958 RKMs in 2017-18 to 14805 RKMs in 2021-22. Decrease in diesel traction consumption should inavariably be commensurate with the decrease in unelectrified

RKMs. The corresponding decrease in fuel consumption for traction purpose in IR was 34.85 *per cent*.

The details of route electrification and total fuel consumption for traction purpose in IR during review period are shown in **Table 5.**

Table 5: Route electrification and total fuel consumption for traction purpose

Year	Route KMs				HSD Oil issued (in Kilo litre)
	Total at the end of the year	Electrified during the year	Total electrified at end of the year	Total remaining unelectrified at the end of the year	
1	2	3	4	5	6
2017-18	63872.44	4028.44	29914.06	33958.38	28,95,089
2018-19	64488.04	5288.31	35202.37	29285.67	29,03,483
2019-20	65041.80	4331.39	39533.76	25508.04	26,73,209
2020-21	65605.39	5579.19	45111.95	20492.44	12,97,134
2021-22	66066.44	6148.07	51261.02	14805.42	18,86,093
Total		**25375.40**			**1,16,55,008**

Source: Records of PCEE and PCME office of respective ZRs.

In five Zones[10], overall decrease in consumption of diesel ranging from 19 *per cent* to 60 *per cent* was not commensurate to the overall decrease in unelectrified RKM ranging from 85 *per cent* to 100 *per cent*. However, in six Zones[11], more than 50 *per* cent reduction in overall diesel consumption was noticed during the review period due to electrification of route KM. The details of route KMs electrified, route KMs unelectrified and consumption of diesel for traction purposes are given in **Annexure 3.**

Reduction in diesel consumption in ZRs was not commensurate with increase in route electrification carried out mainly due to non-completion of electrification project on end to end route, missing links and non-availability of traction change facility at interchange points etc.

Responses furnished by MoR (January 2024) did not include a reply on this issue.

3.2.2.1 Shortfall in achievement of Railway Electrification targets

In view of cost and environmental benefits, IR is gradually shifting from Diesel to Electric Traction. In February 2021, when electrification was 66 *per cent*, IR had set target for 100 per cent electrification of its network by December 2023. IR envisaged that after 100 *per cent* electrification, there will be a saving in diesel oil consumption

[10] ***(i) CR 85% and 19%, (ii) ER 86% and 57%, (iii) ECoR 100% and 29%, (iv) NCR 94% and 60% and (v) SER 100% and 48%. Figures against each Zones indicate the percentage decrease in unelectrified RKMs and corresponding decrease in consumption of diesel for traction during review period.***

[11] ***ER by 57%, ECR by 76%, NCR by 60%, NER by 66%, SR 67% and WCR by 77%***

to the tune of 2.8 billion liters per annum and reduction of CO_2 emission by 342 million tons per annum.

Railway Board fixed annual target for railway electrification work for each Zone. An abstract of the electrification target fixed and actual achievement of IR during 2017-18 to 2021-22 is shown in **Table 6**.

Table 6: Shortfall in achievement of Railway electrification target in IR

Year	Target in RKMs	Achievement in RKMs	Shortfall	Percentage of Shortfall
1	2	3	4	5
2017-18	4,830.00	4028.44	801.56	16.60
2018-19	9,966.00	5288.31	4,677.69	46.94
2019-20	10,592.00	4331.39	6,260.61	59.11
2020-21	7,121.00	5579.19	1,541.81	21.65
2021-22	8,170.00	6148.07	2,021.93	24.75

Source: Records of Electrical Directorate of Railway Board and PCEE office of respective ZRs.

The above statistics show shortfalls ranging from 16.60 to 59.11 *per cent in IR.* Analysis of annual target and achievement across the Zones revealed that during the review period, eight Zones had a shortfall of over 1000 RKMs against annual targets for electrification fixed by MoR as indicated in **Table 7**.

Table 7: Shortfall in achievement of annual electrification target in Zones

Sl No	Zone	Target in RKMs	Achievement in RKMs	Shortfall in achievement in RKMs	Years when target not achieved
1	2	3	4	5	6
1	CR	2,845	1,369	1,476	2017-18 to 2021-22
2	NR	4,854	2,892	1,962	2017-18 to 2021-22
3	NCR	2,360	1,337	1,023	2017-18 to 2021-22
4	NEFR	2,403	977	1,426	2017-18 to 2021-22
5	NWR	4,437	2,740	1,647	2017-18 to 2021-22
6	WR	4,582	2,147	2,435	2017-18 to 2021-22
7	SWR	2,782	1,256	1,526	2018-19, 2019-20, 2020-21, 2021-22
8	WCR	2,541	1,407	1,134	2017-18, 2018-19, 2019-20

Source: Records of Electrical Directorate of Railway Board

Non-achievement of target of electrification in ZRs and delay in completion of projects was attributed to:-

- Delay in doubling work of some projects and termination of contracts (CR, NEFR).
- Termination of contracts due to poor progress of works by contractors, unavailability of adequate traffic block etc. (ER, NEFR).

- Non-completion of gauge conversion by the Engineering Department and due to late wild life clearance by State authorities to carry out RE work (NER).
- Delay of four years (SR) in completing the work due to poor formation.
- Delay in gauge conversion work, Covid-19, final adjustment of 21 KM section (Palari–Bhoma- SECR).
- Non availability of fund and consequent non-performance of executing agencies – RVNL, IRCON and RITES (WCR).

Reasons for the shortfall in electrification work were not made available by NR, NWR, and SCR.

Audit observed that only three zones[12] could achieve 100 *per cent* electrification of its routes. Further, 75 *per cent* routes were electrified in eight zones[13] and in remaining five zones (NWR, NEFR, SCR, SWR and WR) progress of electrification was between 22.70 *per cent* and 73.93 per *cent*. Overall Route Kilometers electrified stood at 77.59 *per cent* till 31 March 2022.

However, despite substantial increase in electrification, the overall increase of 39 *per cent* on electric GTKM in IR during the review period was not commensurate to the overall increase of 71 *per cent* in electrified route KM. The same trend was noticed in four Zones[14] as increase in electric GTKM was low as compared to increase in electrified route KM. The details are stated in **Annexure 4**.

Responses furnished by MoR (January 2024) did not include a reply on this issue.

3.2.3 Three-phase High Horse Power (HHP) Locomotives and Electrical Multiple Units (EMUs)

IR is inducting new generation three-phase High Horse Power (HHP) locomotives with three phase AC asynchronous traction motor. The earlier traction motors of electric locomotives were DC series type which required higher degree of maintenance. On the other hand, three phase locomotives are more powerful, have regenerative braking and are suitable for heavy freight operations as well as passenger service with high speed potential.

3.2.3.1 Induction of three-phase locomotives

As per Para 1503 and 1526 of Indian Railway Code for Mechanical Department (Workshop), Zonal Railways are required to submit requirement of new locomotives (three-phase locomotives) to Railway Board each year. A tentative locomotive allotment plan for electrical locomotives is prepared by Railway Board centrally and

[12] ***ECoR, SER and WCR.***
[13] ***CR, ER, ECR, NR, NER, NCR, SR and SECR***
[14] ***(i) CR: 47% increase in electric route KM and 9% increase in electric GTKM; (ii) NCR; 55% increase in electric route KM and 5% increase in electric GTKM; (iii) SCR; 56% increase in electric route KM and 33% increase in electric GTKM and (iv) WR: 115% increase in electric route KM and 14% increase in electric GTKM***

intimated to all GMs in December-January. Zonal Railways are also required to create infrastructural facilities along with creation of posts and deployment of staff in locomotive sheds for homing allotted locomotives.

IR had an average holding of 8287 locomotives during 2021-22, out of which 4300 (51.89 *per cent*) were three-phase locomotives**.** The position of average locomotive holding in IR during 2017-18 to 2021-22 is shown in **Table 8.**

Table 8: Average locomotive holding in IR (in numbers)

Year	Average holding of three-phase locomotives	Average holding of conventional locomotives	Total Average holding	Percentage population of three-phase locomotives
1	2	3	4	5
2017-18	1,420	4,092	5,512	25.76
2018-19	1,888	4,033	5,921	31.89
2019-20	2,684	3,964	6,648	40.37
2020-21	3,421	3,983	7,404	46.20
2021-22	4,300	3,987	8,287	51.89

Source: Records in the office of Principal Chief Electrical Engineer (PCEE) of respective ZRs

In IR, around 48 *per cent* electric locomotives are still of conventional type which require frequent maintenance as against around 52 *per cent* three-phase locomotives which are more powerful high tractive effort locomotives. Average increase of three-phase locomotives was around 26 *per cent* in 2021-22 as compared to 2020-21, whereas population of conventional locomotives decreased by three *per cent* in 2021-22 as compared to the year 2017-18.

Analysis of holding of three-phase and Conventional locomotives in ZRs revealed the following:

- There was increase in the holding of three-phase locomotives in all the ZRs.
- The three-phase locomotive holding in NCR increased from 8 locomotives in 2017-18 to 227 locomotives in 2021-22. In CR, the three-phase locomotive holding increased from 237 in 2017-18 to 357 locomotives in 2021-22.
- In other ZRs the percentage of increase in three-phase locomotives varies in range of 124 *per cent* (SCR) to 390 *per cent* (ER).

MoR stated (March 2023), that the percentage of three-phase electric locomotives has been increasing consistently i.e., from 54.74 *percent* in 2021-22 to 58.44 *percent* in 2022-23 (upto December 2022). The achievement claimed by MoR differs from the data furnished by the ZRs as shown in **Table 8**. As MoR did not furnished details for their claim, the same could not be reconciled with data available with Audit.

Given the advantages of three phase locomotives over the conventional ones, MoR should prepare the targeted plan with timelines for conversion to 100 *per cent* three

phase locomotives considering the relevant parameters like the life of the existing conventional locomotives, production capacity for three phase locos etc.

3.2.3.2 Energy generated through regenerative braking

IR inducted the three-phase electric locomotives with features of regenerative braking in 1996. Further, IR had decided (2007) that all new EMUs will be produced with three-phase technology having regeneration capacity. The energy regenerated is being monitored through the energy meters installed in the locomotives and EMUs. Regenerated energy can be used by trains running in the same section. If no train is running in the same section, the regenerated energy would be fed back to the grid.

As provided in Para 10.1 of Mission 41K document, these three phase locomotives and EMUs can regenerate energy at the rate of 20 and 30 *per cent* respectively.

3.2.3.3 Quantification of energy regenerated by three phase Electric Locomotives and EMUs

One of the important measures adopted by the IR is giving regular training and counseling to locomotive Pilots for use of coasting and regenerative braking features for effective regeneration of energy during operations. The period between the instants T1 when the brakes are applied and T2 when acceleration is resumed is called the Coasting period. In this period the power supply is cut off and the train runs under its own momentum. The speed of the train keeps decreasing on account of resistance to the motion of the train. Energy is generated by the engine during the coasting period.

Image 1: Locomotive metering panel showing energy consumed and regenerated

Source: Locomotive metering panel taken in CR loco shed

The records of energy consumed and regenerated are captured by the three-phase locomotives and the records were maintained by the locomotive sheds of 11 ZRs. The position in 11 ZRs [15] is summarized for the years 2017-18 to 2021-22 and shown in **Table 9**.

[15] ***CR, ER, ECR, ECoR, NR, NCR, SR, SER, SWR, WR and WCR***

Table 9: Total energy regenerated in braking

Year	Data captured from number of locomotives	Total energy consumed (in KWh)	Total energy regenerated (in KWh)	Percentage of energy regenerated
1	2	3	4	5
2017-18	1,785	2,94,88,81,911	35,80,30,001	12.14
2018-19	2,191	4,06,98,74,061	50,01,01,069	12.29
2019-20	2,724	5,80,77,32,951	76,83,70,890	13.23
2020-21	3,154	6,12,39,74,500	79,65,73,276	13.01
2021-22	3,651	8,61,86,43,016	1,09,32,00,919	12.68

Source: Records of respective locomotive sheds and PCEE office of ZRs

It can be seen from the above that the regenerated electric energy by three-phase locomotives with reference to actual consumption of electricity was less than the norm of 20 *per cent.*

In the case of EMUs, the review of data for electricity consumption and regenerated energy by the three phase EMUs of seven Car Sheds of seven ZRs revealed that energy regenerated was compliant to the norms of 30 *per cent* during review period in seven ZRs.[16]

Image 2: EMU metering panel showing energy consumed and regenerated

Source: EMU metering panel taken in CR EMU shed

For measuring efficiency in all the three-phase type of locomotives and EMUs, the data for energy consumed and regenerated was being maintained manually by the respective locomotive sheds at the time of arrival of the locomotive in shed for maintenance. There was no automated mechanism to capture engine data.

MoR stated (March 2023) "locomotive Pilots are regularly counseled for effective regeneration of energy during operation".

[16] ***CR, ER, SR, SCR, SER, SWR and WR***

3.2.3.4 Feeding back regenerated energy to Grid and claiming credit from Power Supply Companies

Though the energy regenerated by three phase locomotives and EMUs is fed to the grid, there needs to be an arrangement between the Railway Administration and the respective power supplying companies/State Electricity Board for claiming of credit by the Railways for the unused portion of the regenerated energy fed back to the grid.

MoR stated (June 2019) in the ATN of Para 3.3 on 'Energy Conservation measures in Indian Railways' of Report No. 14 of 2017 that matter of getting credit for energy fed to the grid shall be pursued further in this regard to find out the possibilities.

The above aspect was again reviewed in all ZRs and it was observed that:

(i) In WCR, there are two Availability Based Tariff (ABT) meters of exact specifications provided in the Traction Sub-Station (TSS) - Railways and also in Grid Sub-station (GSS) - State Load Dispatch Centre (SLDC). Both the ABT meters are installed and maintained by Railways. The ABT meters report power imported, exported and net of the two. Bills are drawn by the SLDC based on the net ABT meter reading placed at GSS. It has also been confirmed by WCR (November 2022) that billing is done based on the net reading at GSS. Hence the regenerative power exported by WCR is already factored in the payments made by WCR to Generation companies (GENCOs)/SLDC. Thus, through the net billing, WCR was getting credit of the power regenerated and fed back to the grid.

(ii) Audit test checked the records of six TSSs of WR and observed that all TSSs were connected through Open Access for supply of electricity. ABT meters at four TSS were either not installed or were under commissioning stage. TSS at Vasai Road has ABT meter but they do not maintain record for Import/Export of energy. During the test check of metering arrangement of energy consumed and regenerated at TSS Gholvad, it was noticed that as per the meter installed for the two transformers, the total energy consumed was 5141953 Mega Watt Hour (MWH) (Export) and energy fed back to the grid was 2130 MWH (Import) till 19/09/2022 from its date of installation i.e. 08/05/2019. IR paid for energy consumed but records for getting the credit for 2130 MWH regenerated and fed back to the grid was not available. The cost of 2130 MWH @ ₹5.50 per unit works out to ₹1.17 Crore. This issue was raised with Railway. However, no reply was received (November 2022). In reply to Audit query on details of energy fed back to the grid, WR stated that the energy produced as a part of regeneration (due to braking) has been fed to Over Head Equipment (OHE) of Traction Distribution (TRD) section and same is being consumed by other rolling stocks and no regenerative power is being fed back to State DisCom.

Based on the position observed in WCR, as stated in the previous paragraph, IR should also make efforts to install ABT meters in all TSS and pursue with the DisComs for net billing.

(iii) CR had not taken any action with regards to the issued raised in the ATN *ibid*, after September 2017. At the instance of Audit observation of 2021, the issue was again raised by CR with Maharashtra State Load Dispatch Centre (MSLDC) officials in February 2022. MSLDC clarified (March 2022) that the energy generated on account of re-generative breaking does not fall in any category specified by the DSM Regulations and hence, it was not considered for computation of DSM bill. Thereafter, CR also requested REMCL in April 2022 to take up the above issue with the appropriate Commission. When CR requested to send ABT meter data, MSLDC stated that in near future raw/process ABT meter data shall be made available to all utilities.

It was seen in audit that CR had been able to derive saving in the energy consumption as a result of regenerative features of three-phase locomotives. However, CR has not devised any mechanism for metering and claiming credit for the unused portion of the regenerated energy fed back to the grid. Audit pursued the above matter of energy fed to the grid, CR furnished year-wise data of regenerated energy fed back to the grid for the year 2015-2022 (upto February 22). Based on this data, Audit calculated that during the period, CR did not get any credit for regenerated energy amounting to ₹ 65.66 crore fed back to the grid due to non-availability of any measuring mechanism.

(iv) In remaining 13 ZRs, no instance of regenerative braking energy fed back to the grid during the review period was found on record.

Thus, energy generated by ZRs is fed back to the grid and no credit is received by ZRs and situation continues to be the same even after lapse of six years (2017 to 2022).

MoR stated (March 2023 and January 2024) that State authorities are not offering any banking facility to Zonal Railways due to which receiving credit for the surplus energy fed back to the grid is not feasible. IR has regularly pursued this with different States but without any avail.

Railway Administrations needs to check its response vis-à-vis the position in WCR where the regenerative power exported is already factored in the payments made by WCR to GENCOs/State Load Dispatch Centre SLDC. Other zones need to follow this model to get credit for net energy fed back to the grid and consequently bring down their energy cost.

3.2.4 Analysis of non-traction energy – target for cost reduction and achievement

Electricity consumed in offices, railway stations, yards, residential, water supply, air conditioning, workshops, maintenance depots etc., is the non-traction energy. Mostly, non-traction energy is procured from existing State Electricity Boards (SEBs). IR has been actively taking policy initiatives by issuing of various Guidelines/Circulars on General Power Supply Systems like use of LED lights, Star rated equipment, replacement of T-8 FTL by energy efficient T-5 and CFL fittings, energy efficient ceiling fans, occupancy sensors, etc., to save electrical consumption for non-traction applications.

In IR, there was overall increase in connected load during the review period due to enhanced activities but the total consumption of energy for non-traction purpose decreased as detailed in **Table 10**.

Table 10: Consumption of non-traction energy and connected load

Year	Actual consumption for non-traction purpose (KWH)	Connected Load (KW)
2017-18	2,02,23,68,915	41,04,594
2018-19	1,94,42,66,611	42,20,636
2019-20	1,96,37,37,870	42,80,725
2020-21	1,75,26,08,915	43,99,695
2021-22	1,83,95,99,973	44,56,372

Source:-Record maintained in office of the PCEE of respective Zonal Railways

Review of records of ZRs revealed that the target of reduction of five *per cent* fixed by the MoR in non-traction energy for 2021-22 in comparison to 2020-21was not achieved in any of the ZRs mainly due to increasing connected load as Passenger Amenities are being upgraded for ease of passengers like providing escalators, lifts, ACs in running room etc. In addition, the staff quarters are also being provided with additional Electrical Assets like ACs, water coolers etc. Actual consumption of energy in non-traction has decreased in all ZRs except three ZRs (NWR, SWR and WR).

MoR stated (January 2024) that the audit observation is noted.

3.3 Implementation of energy efficiency measures

Information given by the Minister of Railways and Ministry of Commerce and Industry, in a written reply to a question in Lok Sabha on 3 July 2019 was posted by the Press Information Bureau, Delhi on that date. The press release, titled "Energy Efficient Indian Railways", stated Indian Railways' commitment to take new steps for energy conservation and to increase energy efficiency and listed the measures taken for energy conservation by IR such as regular energy audit at consumption points, switching off stand by transformer at TSS, provision of Auxiliary Power Unit in diesel

locomotives, shutting down of diesel locomotives when expected detention is more than 30 minutes. These measures were reiterated by MoR in March 2021

Audit observations on implementation of above energy efficiency/conservation measures are discussed below:

3.3.1 Regular energy audits at consumption points

On the basis of guidelines issued by Bureau of Energy efficiency (BEE), MoR directed (July 2008) all Zonal railways to conduct energy audit of areas like major administrative buildings, hospitals, pumping installations, locomotive sheds, major railway stations and workshops as a one-time exercise and send the reports. It also directed that energy audit of all traction sub stations and workshops be taken up periodically. As per the notification, every designated customer viz. Traction Sub-Stations (TSSs), locomotive sheds, railway production units and workshops shall have its first energy audit conducted within 18 months of notification issued by Government under Clause (i) of Section 14 of the Energy Conservation Act, 2001. The interval for time and conduct and completion of subsequent energy audits shall be three years with effect from the date of submission of previous energy audit report by the accredited energy auditor to the management of the designated consumer. Energy Conservation Act, 2001 stipulates Energy Audit by accredited auditors of all installations with a load of 500 KW and above and industries with a load of 5 MW and above.

Review of record related to Energy Audits revealed the following:-

- Energy Audit was not conducted at all for any of the activity centres in ECR and data was not made available by SCR.
- In NR and NWR, Energy Audit of the TSSs in the selected divisions was not conducted.
- Recommendations of Energy Auditors were not accepted fully in 13 ZRs.[17]

MoR accepted audit contention and stated (March 2023 and January 2024) that Zonal Railways are taking action to get the Mandatory Energy Audit (MEA) conducted as per BEE guidelines.

3.3.2 Shutting down of Diesel locomotives when expected detention is more than 30 minutes

MoR (May 2008) reiterated their earlier policy of shutting down locomotives when the detention at any location was likely to be more than 30 minutes. Operating department (Control Room) should inform driver if expected detention was more than 30 minutes at any place and instruct the driver for switching off the locomotive.

MoR, in a press release in April 2018, listed the steps taken to bring energy/fuel efficiency in Railways. In this list, it was inter alia stated that 'to avoid idle running of

[17] ***CR, ER, EcoR, NR, NCR, NER, NEFR, NWR, SR, SER, SECR, SWR and WR***

the Engine of Diesel locomotive, a Joint Procedure Order (JPO) has been jointly issued at Railway Board level with Operating Department and accordingly at Zonal Railways level also for shutting down of diesel locomotives in case of idling of the locomotive. Monitoring of idling of diesel locomotives has been started through Remote Monitoring and Management of Locomotive and Trains (REMMLOT) fitted in Diesel Locomotive.

Records of non-shutting down of diesel locomotives when expected detention is more than 30 minutes were made available to audit by ten Divisions of seven ZRs[18] and were not made available in nine ZRs[19]. The position arising from information provided by seven Zones is reflected in **Table 11**.

Table 11: Position of non-shutting down of diesel locomotives during 2017-18 to 2021-22

Zone (Division)	No. of times locomotives detained beyond 30 minutes	Detention beyond the permitted 30 minutes in on position (in minutes)
1	2	3
ECR (Danapur and Dhanbad)	14,554	64,70,323
ECoR (Waltair)	3,363	5,84,045
NFR (Alipurdwar Jn and Katihar)	25,708	1,21,78,380
SER (Chakradharpur)	38,889	32,74,764
SECR (Bilaspur and Nagpur)	1,30,684	21,66,108
SWR (UBL)	1,42,458	17,34,19,740
WR (Ahmedabad))	1,89,696	1,44,02,280
Total	**5,45,352**	**21,24,95,640**
Total Detention beyond 30 minutes (in Hours) = 3541594 hours		

Source:-Record maintained in yards by Operating Department

As can be seen from the above table, the Diesel Locomotives were detained in switched on position beyond 30 minutes on 5,45,352 occasions for 35,41,594 hours during 2017-18 to 2021-22. These statistics pertains to only ten Divisions and this implies a substantive potential for fuel/cost saving when this aspect is considered across IR.

Responses furnished by MoR (January 2024) did not include a reply on this issue.

[18] ***ECR, ECoR, NFR, SER, SECR, SWR and WR***
[19] ***CR, ER, NR, NCR, NER, NWR, SR, SCR and WCR***

3.3.3 Status of implementation of other Energy Conservation Initiatives

Audit also reviewed the following energy conservation measures mentioned in MoR's press releases dated 03 July 2019 and 10 March 2021:

- Provision of energy efficient Light Emitting Diode (LED) lighting in Railway installations including Railway stations, service buildings, Residential quarters, coaches, EMUs/MEMUs for reduction in electricity consumption.
- Use of energy efficient Brushless Direct Current (BLDC) motor fans in coaches.
- Emphasis on use of 5 Star rated electrical equipment.
- Regular training of locomotive pilots for use of coasting, regenerative braking features and switching off blowers of electric locomotives in case yard detention is more than 15 minutes.
- Trailing locomotives of Multi Units (MU) hauling light loads are switched off to save energy.
- Energy consumption on electric locomotives is regularly monitored through microprocessor based energy meters provided in all the electric locomotives and benchmarking is done based on average energy consumption.
- Monitoring the fuel consumption with respect to trip ration of diesel locomotive drivers.
- Monitoring of idling of diesel locomotives is being done through Remote Monitoring and Management of Locomotives and Trains (called as REMMLOT).
- Use of 5 per cent bio-diesel in traction fuel-Blending of bio-diesel with High Speed Diesel (HSD) to the extent of 5 *per cent* to save HSD.
- 20 *per cent* Compressed Natural Gas (CNG) substitution in DEMUs-CNG usage emits less Greenhouse Gases (GHG) than liquid fuels.

Indian Railways has the distinction of being the only Railway in the world to be using CNG run power cars for passenger transportation. IR has also started conversion of DEMU Driving Power Car (DPC) into dual fuel mode DEMU/DPC with CNG. 25 Numbers of DPCs have been converted and are under operation.

Examination of position on the measures implemented revealed that the above stated measures for saving energy were implemented by majority of the Zonal Railways (77 *per cent*) except one measure i.e. CNG substitution in DEMUs which was not implemented in 11 ZRs[20] and information was not made available in five ZRs[21]. Savings of ₹ 401.56 crore in energy consumption during the period 2017-18 to

[20] ***CR, ECR, ECoR, NR, NCR, NWR, SR, SECR, SWR, WR and WCR***
[21] ***ER, SCR, SER, NER and NEFR***

2021-22 due to implementation of measures was reported by 13 ZRs.[22] The status of implementation of Energy Conservation Initiatives during review period are given in **Annexure 5**.

3.4 Payment of Deviation Settlement Mechanism (DSM) charges

Deviation Settlement Mechanism (DSM) is a regulatory mechanism by which grid stability is achieved by imposing penalty and incentives for over drawal/injection or under drawal/injection from the schedule. DSM is a frequency linked mechanism and not related to any market conditions. Payment of DSM charges indicate either over drawal/injection or under drawal/injection of energy from the schedule. It was noticed in audit that ₹ 673.19 crore was included as DSM charges in ECR from April 2017 to March 2022. Similarly, CR paid DSM charges of ₹ 79.87 crore (8 *per cent* of total energy charges) during the year 2021-22.

MoR stated (January 2024) that the contract signed by Railways with the Generating Company is for fixed load. However, the power drawn by Railways is not linear in nature and varies continuously during the day, depending on the number of trains that are running at any point of time. The excess load drawn by Railways, over the Contract Demand (which is fixed), has to be arranged either through the Energy Exchange or by paying DSM charges. Rail traffic and power demand has been increasing continuously over the years. To meet the requirement of additional power, payment of DSM charges albeit at higher rate is a better option as some State DisComs are not readily giving NOC for purchase of additional power through Energy Exchange.

The reply is generic in nature. The specific cases pointed out by audit in respect of ECR and CR needs to be examined to ascertain reasons for the large DSM charges and to explore possible corrective action.

3.5 Conclusion

IR have initiated many measures for energy management and conservation of energy in its operations. These measures include drawing electricity through Open Access, use of high power three-phase locomotives, 100 *per cent* electrification of tracks, generation of electricity through regenerative breaking, Head on Generation system etc. During the review it was observed that measures for energy savings were prescribed in multiple policy documents/instructions and a comprehensive single policy or master circular for achieving these targets was not available. Audit found that ZRs were not able to get credit for regenerated energy fed back to grid.

[22] ***CR-₹ 7.20 cr, ER-₹ 27.66 cr, ECR-₹ 9.43 cr, NR-₹ 43.79 cr, NER-₹ 0.08 cr, NEFR-₹ 22.05 cr, NWR-₹ 46.17 cr, SR-₹ 196.63 cr, SER-₹ 15.86 cr, SECR-₹ 1.36 cr, SWR-₹ 13.67 cr, WR-₹ 14.20 cr, WCR-₹ 3.46 cr***

SUMMARY OF AUDIT FINDINGS

- Single Policy or Master Circular for implementation of energy conservation measures has not been issued by IR.
- IR has made large savings in energy costs through Open Access but the same has not been achieved across Zones.
- Corresponding to reduction of unelectrifed RKMs by 56.40 *per cent* during the review period, fuel consumption for traction purpose reduced by 34.85 *per cent*.
- Metering arrangement/mechanism did not exist to measure energy fed back to the grid, hence savings in energy bills could not be quantified.
- Energy Audit was not conducted in some of the ZRs.
- Non-shutting down of stationary diesel locomotives was noticed in ten Divisions of seven ZRs resulting in detention of Loco in on-position beyond 30 minutes on 5,45,352 occasions for 35,41,594 hours during 2017-18 to 2021-22

3.6 Recommendations

IR needs to:-

1 ***Compile and issue all the measures for energy conservation in a single policy document/ master circular for clarity and focus in implementation at Zonal level.***

2 ***Rectify the low increase in electric GTKM in four Zones,[23] as compared to increase in electrified route KM due to non-utilization of electric traction in the electrified routes.***

3 ***Prepare timelines for conversion to 100 per cent three phase electric locomotives with due consideration of the life of the existing conventional locomotives, production capacity for three phase locos etc.***

4 ***Evolve mechanism for automated capture of regenerated energy data from engine of three phase locomotives and EMUs.***

5 ***Replicate across all Zones the method adopted by WCR to get credit for the regenerated power fed back to the grid.***

6 ***Ensure conducting Energy Audits regularly for monitoring and to optimize energy consumption.***

[23] ***CR, NCR, SCR and WR***

Chapter 4 Renewable Energy Initiatives

A natural resource is a renewable resource, if it is replenished by natural process at a rate comparable to or faster than its rate of consumption by human. Road map to a cleaner planet and sustainable model lies in making optimum use of environment friendly non-conventional/non-polluting energy, production of which is not dependent on fossil resources.

4.1 Renewable Energy Initiatives

Vision 2020 published by MoR in December 2009 envisaged that by the year 2020, 10 *per cent* of the total energy used by IR would be from renewable sources.

Railway Board identified measures related to 'renewable energy' such as provision of wind mill plants wherever feasible, use of solar Photo Voltaic[24] (PV) cells, use of combination of solar and wind mill energy at locations such as offices, hospitals, base kitchen, major running rooms and training institutes. Audit observations on various renewable energy initiatives of IR are detailed below.

4.1.1 Non achievement of target on Renewable Energy Initiatives

Indian Railways consumes over 20 billion kWh of electricity annually. The KGTKM load haulage in IR is 2 billion units per annum at the rate of 10 units/KGTKM. As per Vision 2020 target, IR should fulfil 10 *per cent* i.e., 2000 million units of its energy requirements through renewable sources. Against this, the planned installed capacity of non-conventional/renewable energy was 1000 MW for Solar Energy and 200 MW for Wind Energy in IR.

Status (March 2022) of use of renewable energy sources against the Vision 2020 target of 10 per cent in IR is given in **Table 12**.

[24] ***Solar electricity systems capture the sun energy using photovoltaic (PV) cells. The cells convert the sunlight into electricity, which can be used to run household appliances and lighting. PV cells don't need direct sunlight to work- you can still generate some electricity on a cloudy day.***

Table 12: Actual use of renewable energy sources during 2017-18 to 2021-22

Type	Generation capacity (MW) from 2017-18 to 2021-22			Energy generated (Million Units) for 2021-22		
	Planned	Actual	As % of planned	Planned	Actual	As % of planned
1	2	3	4	5	6	7
Solar						
IR	261.26	71.72	27%	119.37	81.37#	
Solar Power Developer (SPD)	175.91	80.59	46%	134.13		
Solar Total	**437.17**	**152.31**	**35%**	**253.50**	**81.37**	**32%**
Wind						
IR (By March 2016)	36.50	36.50	100%	63.95	51.70	81%
Wind Power Developer (WPD)	163.50	56.40	34%	98.81	89.15	90%
Wind Total	**200.00**	**92.90**	**46%**	**162.76**	**140.85**	**87%**
TOTAL	**637.17**	**245.21**	**38%**	**416.26**	**222.22**	**53%**

Source: Records of respective ZRs;
Note: Out of the total 56.40 MW (col. 3-WPD), 6 MW started generating power from July 2022.
 # This is combined figure, breakup for IR and SPD was not available/furnished.

Against the target of 2000 million units per annum, IR could generate and use only 222 million units (11 *per cent* of target) of renewable energy sources during the year 2021-22. In regard to use of Solar and Wind energy, IR is nowhere close to achieving their target due to lack of coordinated effort in that area.

MoR stated (January 2024) that Vision 2020 broadly outlined the thrust areas of IR in the year 2009. Due to various reasons including non-availability of proper technical knowledge and resources, experience of Railways in this area, etc, sufficient progress towards proliferation of renewable energy could not be made, as envisioned in Vision 2020. However, in recent years, with advancement in technology, gaining of more experience, availability of resources and funds, increased thrust by the Government of India for Renewable Energy, etc. and with the announcement of Mission Net Zero Carbon Emission by 2030, IR has started taking active steps towards proliferation of renewable energy. Till December 2023, total installed Solar Capacity was 216.36 MW and installed Wind Capacity was 103 MW. To proliferate renewable energy over IR, some of the major steps/projects taken up (by IR) recently under developer mode are as stated in response to **Para 4.1.2.1**. Indian Railways aim to achieve Net Zero Carbon Emission by the year 2030 and active measures are being taken now in this direction.

4.1.2 Solar Energy Initiatives

IR had started installing solar power plants in 2014-15 on administrative buildings, stations and hospitals. Harnessing of solar energy was enhanced in the ensuing year taking total capacity to about 10 MW by 2015-16. This included one Megawatt (MW) solar power plant on rooftop of Katra Railway station and 6.5 MW solar plants (five locations each of 500 KWp, 20 locations each of 100 KWp, 200 locations each of 10 KWp) at various locations. Further, as part of IR Solar Mission to reduce dependence on fossil fuels and keeping in line with Budget 2015-16 announcement of Minister of Railways, IR had planned to set up 1000 MW solar power plant in the next five years i.e., 2015-16 to 2020-21. To achieve this, IR planned to setup solar power plant on rooftops of railway stations, buildings and on railway land as follows:

a) 500 MW solar plants on roof tops of railway buildings through developer mode with power purchase agreement (PPA) by IR which will be used for meeting non-traction loads.

b) 500 MW solar plants to be put up on land-based systems with PPAs to be signed by IR with developers, primarily to meet traction loads.

Further, Zonal Railways had identified additional capacity for installing 100 MW solar power on rooftops. REMCL had invited tenders for the same in September 2016. For all these rooftop installations, Viability Gap Funding (VGF) from MNRE had been obtained.

The areas involved in developing the solar energy resources mainly included the following:-

- Setting up of solar plants (rooftop).
- Utilization of vacant unused Railway Land for setting up of Solar Plant.
- Provision of shelters/platforms using solar panels in place of conventional sheds/ shelter.
- Grant of Central Financial Assistance (CFA) to Solar Power Developers.
- Setting up of 10 KW/5 KW Solar Photovoltaic (PV) power plant on roof tops of ‘D’ and ‘E’ Category Stations.

4.1.2.1 Progress on Solar Energy Initiatives

Progress on the initiatives of Indian Railways towards harnessing solar energy was examined in Audit and the status on the achievement is shown in the **Table 13**.

Table 13: Status of Solar Power installation

Issue	Capacity proposed for solar power installation	Actual capacity of the solar power installation	Reasons for the shortfall in achievement of capacity
1	2	3	4
Setting up of solar plants (rooftop)	500 MW Planned 437 MW as below: (IR-261.26 MW) (SPD-175.91 MW)	IR-71.72 MW SPD-80.59 MW	Failure of the contract awarded by REMCL (ER and NR), delay in the execution (SR), less generation of solar power (NR and CR), non-receipt of NOC from State Electricity Board (SWR), non-availability of feasible rooftop sites (NEFR) and short closure of contract (ECoR) etc.
Utilization of vacant unused Railway Land for setting up of Solar Plant	500 MW	No progress	As part of this strategy, MoR issued directives (April 2020) for utilization of vacant unused Railway Land for setting up of Solar Plant over IR. MoR identified vacant surplus land of 1,27,197 acres. The work was targeted for completion in three phases. The last phase was to be completed by 31st March 2023. No development achieved in this regard. REMCL has not finalized even the bids.
Provision of shelters/platforms using solar panels in place of conventional sheds/ shelter	No target fixed during review period	26 KW (Dankuni-ER- 10 KW) (Shahibabad–NR- 16 KW)	Not applicable
Setting up of 10KW/5KW Solar Photovoltaic (PV) power plant on roof tops of 'D'	Part of 1000 MW solar power plants on rooftops of Railway stations,	No progress	MoR decided (February 2017) to set up 10kW/5kW Solar Photovoltaic (PV) power plant on roof-top of D and E category stations at 800 stations as a part of

Issue	Capacity proposed for solar power installation	Actual capacity of the solar power installation	Reasons for the shortfall in achievement of capacity
1	2	3	4
and 'E' Category Stations	buildings and Railway land.		1000 MW solar power plants on rooftops of Railway stations, buildings and Railway land. MoR nominated NR as nodal railway for finalizing tender for the above work. However, there was no progress in this work due to poor response from developers. Further, it was observed that the work appearing in Pink book of NR was deleted by the MoR from the Pink book of 2020-21.

Source: Records of ZRs.

The above table indicates that IR could not install solar plants as planned.

MoR stated (January 2024) that tenders for setting up solar power plant in vacant railway lands had been floated by REMCL which received poor response from the solar power developers. Due to this reason, no progress could be made. It was later planned to set up solar plants near TSSs which would directly feed solar power to TSSs. However, the response for the same was also not good and no progress could be made here also. However, to proliferate renewable energy over IR, some of the major steps/projects taken up recently under developer mode are as follows:

a. RUMS[25]- Letter of Award issued in September 2021, Power Purchase Agreement (PPA) signed in November 2021.

b. IRCON[26]- PPA signed in May 2022.

c. 100 MW RE - RTC[27]- Power Sale Agreement (PSA) signed with Solar Energy Corporation of India (SECI) in May 2022.

d. BSUL - Terms of Reference signed with BSUL in January 2023.

e. 50 MW wind power plant - Letter of Award issued in July 2022, Power Purchase agreement (PPA) signed in March 2023.

f. 50 MWp Solar Power plant in Bhilai has been commissioned in April 2023.

[25] ***Rewa Ultra Mega Solar***
[26] ***Indian Railway Construction International Limited***
[27] ***Renewable Energy Round the Clock***

It is worth mentioning here that solar power is available only during the day and the railway functioning requires power to be available 24x7 (as trains run in the night too). In other time periods when solar is not available, power has to be supplemented from other energy sources viz. thermal/exchange/storage etc. This would increase the overall cost of power for the Railways. Hence, standalone solar projects, in general, are not of much utility to Railways traction needs. Therefore, IR is now progressively shifting towards Round the Clock (RTC) Renewable Energy (RE) projects for its power requirements for traction purpose. The following progress has been made in this direction:

a. 900 MW RE-RTC- Letter of Award issued in April 2023, Power Purchase agreement (PPA) signed in June 2023.

b. 695 MW (utilising existing solar tied up) and 750 MW RE RTC tenders are also in pipeline.

While the steps/projects taken up under developer mode are acknowledged, the fact remains that most of them were taken up after the shortfall in achievement of capacity was reported to MoR in December 2022 in the form of Provisional Para.

4.1.3 Wind energy initiatives

4.1.3.1 Harnessing wind energy through wind-based power plants

IR had targeted to increase its installed capacity of wind power to about 200 MW. Of this, 10.5 MW capacity windmill plant was set up in Tirunelveli district in Tamil Nadu for meeting energy requirements of Integral Coach Factory (ICF), Chennai. Further, 26 MW windmill power plant was commissioned in October 2015 in Jaisalmer, Rajasthan. Installation of balance capacity (163.5 MW) was planned through tariff-based bidding and partly through investment by Railways through REMCL.

These capacities were to be created based on requirement of non-solar Renewable Purchase Obligation (RPO) in various States. IR planned to install 56 MW windmill through tariff-based bidding for meeting non-traction loads in Maharashtra, Andhra Pradesh, Tamil Nadu and Madhya Pradesh. In addition, REMCL also planned to set up 100 MW capacity windmill plants.

Audit observed that 14 ZRs[28] did not have their own wind-based power plant. In ER, one wind based power plant installed in January 2013 was out of order due to defective control panel/battery since March 2020. In SR, five windmill plants of 2.1 MW capacity each commissioned in January 2019 with annual estimated power generation of 283 lakh units, had generated 801 lakh units upto March 2022 resulted in saving of

[28] ***CR, ECR, ECoR, NR, NCR, NER, NEFR, NWR, SCR, SER, SECR, SWR, WR and WCR***

₹ 50.86 crore. However, there was shortfall of 119 lakh units during the period on account of less wind in some months.

MoR did not give reply for this observation (January 2024).

4.1.3.2 Harnessing wind energy through PPA/Contracts

In addition to harnessing wind energy through Railways' own plants, IR is purchasing wind energy through PPA /Contracts. In this regard the following was observed:

(i) During the period covered by this review, only CR had signed contracts for procurement of energy from wind power through PPA/contracts. Two Zones (NWR and WCR) had signed PPAs prior to 2017-18.

(ii) In CR, two contracts were awarded for purchasing of 56.4 MW wind energy.

The first contract was awarded by REMCL to M/s Inox Wind Infrastructure Services Ltd, Noida in January 2018 for supply of 6 MW power for non-traction purpose. The landed tariff was ₹ 7.40 per unit and ₹ 8.34 per unit for 33 kV and 11 kV respectively. However, Maharashtra State Electricity Distribution Company Limited (MSEDCL) refused to issue NOC for Open Access for availing power for want of separate meter connection for industrial and residential load. Further, in April 2020, MSEDCL issued circular stating that no concession would be provided to RE sector and therefore cross subsidy charges shall be payable. Due to this change in policy (April 2020) by MSEDCL, landed cost for non-traction purposes became approximately ₹ 9.21 per KWH for 11 KV which was more than the landed rate of ₹ 8.34 per KWH for direct purchase of power from MSEDC. However, till end of March 2022, CR didn't receive power from this generator for traction purpose.

The second contract was awarded to M/s NTPC Vidyut Vyapar Nigam Ltd (NVVN) for purchase of 50.4 MW of wind energy for traction purposes in December 2018 and PPA was signed in March 2019 for 25 years at landed tariff rate of ₹ 3.37 per unit (KWH). Supply of power against the contract was commenced from June 2019.

(iii) NWR did not sign any PPA/contract for purchase of wind energy during the review period. However, the PPA executed in October 2014 through a contract under Open Access awarded to REMCL was still active. The landed rate applicable during the review period was ₹ 6.27 per KWh. NWR saved ₹ 0.09 crore for purchase of 2.42 lakh KWh wind energy during 2019-20 and of ₹ 0.15 crore for purchase of 8.65 lakh KWh wind energy during 2020-21 as the rate of non-renewable energy was higher than that of wind energy. During the remaining three year of the review period, there was no savings as the rate of wind energy purchased was more than the rate of non-renewable energy.

(iv) WCR entered into a 25 years PPA with REMCL (October 2014) for setting up 26 MW wind energy power project in Jaisalmer district of Rajasthan through developer mode. The energy produced by this plant would be exclusively supplied to WCR for use in Rajasthan. During 2021-22, WCR was supplied 260.18 lakh units of energy under this PPA at a unit rate of ₹ 6.27, which was higher than the average unit rate of non-renewable energy ₹ 5.37 during the same year. WCR, thus, suffered a loss of ₹ 2.34 crore on purchase of wind energy during 2021-22.

The PPA contracts awarded for purchase of wind energy are given in **Annexure 6.**

The responses of MoR to audit observations in this Chapter indicate that the earlier measures identified have proved to be of limited feasibility as per the experience of subsequent years and have by and large not met the objectives. New initiatives have been taken to generate and use renewable energy which are mostly in the initial stages. MoR should issue a comprehensive policy circular detailing the new measures and targets for different areas of renewable energy that is proposed to be tapped. This would provide clarity for implementation**.**

4.2 Conclusion

In regard to use of green renewable energy sources IR has a long way to go. Not only was the actual capacity creation lower than planned, actual generation of solar energy was also lower vis-à-vis capacity created.

SUMMARY OF AUDIT FINDINGS

'Vision 2020' envisaged 10 *per cent* of the total energy used by IR would be from renewable sources by the year 2020. However, IR could not install solar power plants and wind power plants as planned originally.

4.3 Recommendation

IR needs to issue a comprehensive policy circular detailing the new measures and targets for different areas of renewable energy that is proposed to be tapped.

New Delhi
Dated: 04 April 2024

(SUBIR MALLICK)
Deputy Comptroller and Auditor General

Countersigned

New Delhi
Dated: 05 April 2024

(GIRISH CHANDRA MURMU)
Comptroller and Auditor General of India

Abbreviations

List of Abbreviations	
ABT	Availability Based Tariff
ADI	Ahmedabad
AMC	Annual Maintenance Contract
APDJ	Alipurduar Jn.
APU	Auxiliary Power Unit
ATN	Action Taken Note
BEE	Bureau of Energy Efficiency
BLDC	Brushless Direct Current
CAG	Comptroller and Auditor General
CFA	Central Financial Assistance
CFL	Compact Fluorescent lamp
CLW	Chittaranjan Locomotive Works
CMD	Contracted Maximum Demand
CNG	Compressed Natural Gas
CR	Central Railway
DEMU	Diesel Electric Multiple Units
DHN	Dhanbad
DisCom	Distribution company
DNR	Danapur
DPC	Driving Power Car
DSM	Deviation Settlement Mechanism
ECoR	East Coast Railway
ECR	East Central Railway
EESL	Energy Efficiency Services Limited
EMU	Electric Multiple Unit
ER	Eastern Railway
FOIS	Freight Operations Information System
FTL	Fluorescent Tube Light
GENCO	Generation Company
GHG	Greenhouse Gases
GM	General Manager
GSS	Grid Sub-Station
GTKM	Gross Tonnes of load for a Kilo Meter
HHP	High Horse Power
HOG	Head on Generation
HQrs	Headquarters
HSD	High Speed Diesel
ICF	Integral Coach Factory
IR	Indian Railway
IRCON	Indian Railway Construction Company Limited
JPO	Joint Procedure Order
JV	Joint Venture

List of Abbreviations	
KIR	Katihar Jn
KVA	Kilo Volt Amperes
KwH/KGTKM	Kilo Watt Hours/1000 Gross Tonne Kilo Metres
KWp	Kilowatt 'peak' power (output of solar arrays)
LED	Light Emitting Diode
LoA	Letter of Award
MEA	Mandatory Energy Audit
MEMU	Mainline Electric Multiple Unit
MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
MoR	Ministry of Railways
MoU	Memorandum of Understanding
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MSLDC	Maharashtra State Load Dispatch Centre
MW	Mega Watt
NCR	North Central Railway
NEFR	North East Frontier Railway
NER	North Eastern Railway
NOC	No Objection Certificate
NR	Northern Railway
NVVN	NTPC Vidyut Vyapar Nigam Ltd
NWR	North Western Railway
OHE	Over Head Equipment
PCEE	Principal Chief Electrical Engineer
PPA	Power Procurement Agreement
PV	Photo voltaic
RB	Railway Board
RBE	Regenerative Braking Energy
RCD	Railway Consumer Depot
REMCL	Railway Energy Management Company Limited
REMMLOT	Remote Monitoring and Management of Locomotive and Trains
RGPPL	Ratnagiri Gas Power Pvt. Ltd.
RITES	Rail India Technical and Economic Services Ltd
RKMs	Route kilometers
RPO	Renewable Purchase Obligation
RVNL	Rail Vikas Nigam Limited
SCR	South Central Railway
SEB	State Electricity Board
SEC	Specific Energy Consumption
SECR	South East Central Railway
SER	South Eastern Railway
SERC	State Electricity Regulatory Commission

List of Abbreviations	
SFC	Specific Fuel Consumption
SLDC	State Load Dispatch Centre
SR	Southern Railway
SWR	South Western Railway
TRD	Traction Distribution
TSS	Traction Sub Station
UBL	Hubli
VGF	Viability Gap Funding
WCR	West Central Railway
WR	Western Railway
ZRs	Zonal Railways

Annexures

Annexure - 1
(Ref: Para No. 1.7)
Details of sample selection

ZR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	Divisions (Electrical, Mechanical, Operating and Engineering Deptt)	Diesel Loco Shed	Electric Loco Shed	EMU Car shed	Traction Sub Stations (TSS)	Railway's own Solar Plants	Railway's own Wind Power Plants
1	2	3	4	5	6	7	8	9
CR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1Mumbai, 2 Bhusawal	1 Pune, 2 Kalyan	1 Ajni, 2 Kalyan	1Kurla	Mumbai Division TSS 1 Thakurli, 2 Thane 3 Sion Bhusawal Division TSS 1 Bhusawal L, 2 Pimparkhed, 3 Pachora	1 Zonal Regional Training Institute, Bhusawal	Not available
ER	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1 Howrah, 2 Asansol	1 Howrah, 2 Bardhaman	1 Howrah 2 Asansol	1Barasat	HWH Division TSS 1 Rampurhat, 2 Dhatrigram, 3 Dankuni ASN Division TSS 1 Kumardubi, 2 Tapsi 3 Pandabeswar	1 Naihati station Plafform shed	Gadadharpur
ECR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1 Dhanbad, 2 Danapur	1 Samastipur, 2 Patratu	1 Gomo, 2 Deen Dayal Upadhyay,	1Jhajha	Dhanbad Division TSS 1 Koderma, 2 Tolra, 3 Ray Danapur Division TSS 1 Lakhisarai, 2 Danapur, 3 Khusroopur	1Sonepur	Not available

Annexure - 1
(Ref: Para No. 1.7)
Details of sample selection

ZR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	Divisions (Electrical, Mechanical, Operating and Engineering Deptt)	Diesel Loco Shed	Electric Loco Shed	EMU Car shed	Traction Sub Stations (TSS)	Railway's own Solar Plants	Railway's own Wind Power Plants
1	2	3	4	5	6	7	8	9
ECoR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1 Khurda Road 2 Waltair	1Vishakhapatnam	1 Waltair 2 Angul	1Khurda Road	Khurda Road 1 Kendrapara Road 2 Kendujhargarh 3 Talcher Road Waltair 1 Simhachalam North, 2 Vizianagaram 3 Rayagada	Vadlapudi Wagon workshop	Not available
NR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1 Delhi 2 Lucknow	1Tughlakabad 2 Ludhiana	1 Ghaziabad 2 Ludhiana	Delhi	Delhi Division 1 Sahibabad, 2 Nerala 3Chanaykyapuri Lucknow Division 1 Amousi, 2 Sultanpur 3 Birapatti	New Delhi Platform-2/3	Not available
NCR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1 Prayagraj. 2 Jhansi	1 Jhansi	1 Kanpur, 2 Jhansi	Kanpur	Prayagraj Division 1 Mirzapur, 2- Etawah 3- Shikohabad Jhansi Division 1 Lalitpur 2 Gwalior 3- Datia	GM office	Not available
NER	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1 Lucknow 2 Varanasi	1 Izatnagar, 2 Gonda	1 Gorakhpur 2 Saiyedpur Bhitri	1Aunrihar	Varanasi Division- 1Chhapra 2 Gazipur Ghat 3.Numkhar	DEMU Shed-Aurihar,	Not available

Annexure - 1
(Ref: Para No. 1.7)
Details of sample selection

ZR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	Divisions (Electrical, Mechanical, Operating and Engineering Deptt)	Diesel Loco Shed	Electric Loco Shed	EMU Car shed	Traction Sub Stations (TSS)	Railway's own Solar Plants	Railway's own Wind Power Plants
1	2	3	4	5	6	7	8	9
						Lucknow Division 1 Gorakhpur 2 Burhwal 3 Baruachak		
NEFR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1 Katihar 2 Alipurduar	1 Siliguri 2 New Guwahati	1Malda Town 2 Siliguri	Nil	Katihar Division 1 Samsi 2 Dalkhola 3 Gunjaria Alipurudar Division 1New Mainaguri 2 Pundibari 3 Gossaigaonh	Dibrugarh Workshop	Not available
NWR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1 Jaipur. 2 Ajmer	1. Abu Road 2. Bhagat Ki Kothi	Nil	Nil	Jaipur Division 1. Phulera 2. Kairthal 3. Jaipur Ajmer Division 1. Sareri 2. Ghosunda 3. Mavli	Jaipur	Not available
SR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1 Chennai 2 Salem	1Goldenrock 2.Ernakulam	1Royapuram 2 Erode	Avadi	Chennai Division 1 Avadi 2. Ennore 3. Acharapakkam Salem Division 1.Bommidi 2. Mettur Dam 3. Pettavaytalai	Chennai Central Station	Savalaperi

Annexure - 1
(Ref: Para No. 1.7)
Details of sample selection

ZR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	Divisions (Electrical, Mechanical, Operating and Engineering Deptt)	Diesel Loco Shed	Electric Loco Shed	EMU Car shed	Traction Sub Stations (TSS)	Railway's own Solar Plants	Railway's own Wind Power Plants
1	2	3	4	5	6	7	8	9
SCR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1 Secunderabad 2 Vijayawada	1 Kazipet, 2 Moula Ali	1 Lallaguda 2Vijayawada	1 Moula Ali	Secunderabad Division 1Aler, 2 Kazipet, 3 Vikarabad Vijayawada Division 1 Rajahmundry, 2Tadepalligudem, 3 Samalkot	Secunderabad station	Not available
SER	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1 Kharagpur 2 Chakradharpur	1Bondamunda	1 Tata Nagar 2 Santra Gachi	1Tikiapara	Kharagpur Division 1Balichak, 2 Balasore 3 Dalbhumgarh Chakradharpur Division 1 Rajkharswan, 2 Chakradharpur 3 Rajgangpur	Service Building at Garden Reach	Not available
SECR	Electrical, Mechanical, Operating and Engineering Department	1 Bilaspur 2 Nagpur	1 Raipur 2 Motibag, Nagpur	1.Bhilai 2.Bilaspur	Bhilai	Bilaspur Division 1.Bilaspur 2.Nowrozabad 3.Champa Nagpur Division 1.Paniajob 2.Kachewani 3.Rajnandgaon	Raipur station	Not available
SWR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1 Bengaluru 2 Hubballi	1Krishnarajapuram 2 Hubballi	NIL	Banaswadi,	Bengaluru Division 1. Someshwara	Hubballi Workshop	Chikjajur

Annexure - 1
(Ref: Para No. 1.7)
Details of sample selection

ZR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	Divisions (Electrical, Mechanical, Operating and Engineering Deptt)	Diesel Loco Shed	Electric Loco Shed	EMU Car shed	Traction Sub Stations (TSS)	Railway's own Solar Plants	Railway's own Wind Power Plants
1	2	3	4	5	6	7	8	9
						2. Bidadi 3. White-Field Hubballi 1. Bellary Cant. 2. Gadag 3. Kariganuru		
WR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1 Ahmedabad 2 Mumbai Central	1 Sabarmati 2 Vatva	1 Vadodara 2 Valsad	Mumbai Central	Mumbai Central Division 1 Vasai Road 2 Golvad 3 Madhi Ahmedabad Division 1Gandhinagar, 2 Sabarmati 3 Ambliyasan	Churchgate Station Building	Not available
WCR	Zonal HQrs (Electrical, Mechanical, Operating and Engineering Department)	1 Jabalpur 2 Bhopal	1 Itarsi 2 New Katni Jn.	1 New Katni Jn 2 Tugalakabad	Nil	Jabalpur Division- 1 Majhgawanphatak 2 Karhiya-Bhadeli 3 Bina. Bhopal Division 1 Sukhi Sewaniyan, 2 Powerkheda 3 Bina	Bina	Not available
IR		**32**	**29**	**28**	**13**	**96**	**16**	**3**

Annexure - 2
(Ref: Para No. 2.2.2)
Specific Energy Consumption and Specific Fuel Consumption for IR

Year	GTKM -Passenger (Col 8 of ASS 16)		GTKM Freight (Col 9 of ASS 16)		Consumption of Fuel/Energy by locomotives						Diesel (KL)	
	Electric	Diesel	Electric	Diesel	Diesel Locos (No)(Col 4 of ASS 22)	Diesel (Kilo liters) (Col 5 of ASS 27A)	Cost per KL (Col 68 of ASS 27A)	Electric Locos (No) (Col 4 of ASS 22)	Energy (MwH - 1000 KwH) (Col 72 of ASS 27A	Cost per KwH (Col 74 of ASS 27A)	Passenger (ASS 27B col 3)	Freight (ASS 27B col 5)
1	2	3	4	5	6	7	8	9	10	11	12	13
2017-18	398826008	343828040	767569096	423840457	5639	2765199	59443.54	5427	12658844	6.18	1422344	979714
2018-19	426296435	342469061	828777787	438094247	5743	2632124	68831.92	5710	13434168	5.52	1388884	1011022
2019-20	444155689	302210455	822776178	398917466	5520	2357426	66440.56	6564	13854733	5.54	1190143	876450
2020-21	178059474	49612635	922692848	315207515	4615	1060787	84146.82	6848	10805513	6.06	289838	663523
2021-22	475639566	169398327	1141588633	342651334	4168	1458801	99051.95	7510	17367376	5.70	597869	624716

Year	SFC		MwH - 1000 KwH		SEC		SFC = Total Diesel Consumption (in Lts)/Total Diesel KGTKM (Col 12 +Col 13)X 1000/(Col 3 + Col 5)	SEC = Total Electric Consumption (in Units)/Total Electric KGTKM (Col 16 + Col 17) X1000/ (Col 2+Col 4)	Diesel traction cost per KGTKM (Col 8 X Col 20) /1000	Electric traction cost per KGTKM (Col 11 X Col 21)	Cost Ratio (Diesel/ Electric) per KGTKM (Col 22/ Col 23)
	Passenger (Col 12X1000/ Col 3)	Freight (Col 13X1000/Col 5)	Passenger (ASS 27B Col 3)	Freight (ASS 27B Col 5)	Passenger (Col 16X1000)/ Col 2	Freight (Col 17 X 1000/ Col 4)					
1	14	15	16	17	18	19	20	21	22	23	24
2017-18	4.14	2.31	7513121	4239565	18.84	5.52	3.13	10.08	186.00	62.27	2.99
2018-19	4.06	2.31	8012055	4442497	18.79	5.36	3.07	9.92	211.63	54.78	3.86
2019-20	3.94	2.20	8375910	4486212	18.86	5.45	2.95	10.15	195.84	56.24	3.48
2020-21	5.84	2.11	4228798	5996017	23.75	6.50	2.61	9.29	219.90	56.29	3.91
2021-22	3.53	1.82	8480838	7552969	17.83	6.62	2.39	9.91	236.50	56.51	4.18

Source: Annual Statistical Statement of the respective years.

Annexure – 3
(Ref: Para No. 3.2.2)
Statement showing details of consumption of Diesel for traction and non-traction purposes

Zone	Year	Total route KMs	Route KMs electrified during the year	Total route KMs electrified at end of the year	Route KMs remaining unelectrified at the end of the year	Percentage Decrease in unelectrified route KMs during the review period	HSD Oil issued (in Kilo litre)	
							For Traction	Percentage decrease in consumption during the review period
1	2	3	4	5	6	7	8	9
CR	2017-18	3816	181	2503	1313		240364	
CR	2018-19	3853	232	2735	1118		240150	
CR	2019-20	3853	210	2945	908		221732	
CR	2020-21	3853	407	3352	501		132056	
CR	2021-22	3891	339	3691	200	84.77%	194799	18.96%
ER	2017-18	2763	71.77	1790.75	972.25		120150	
ER	2018-19	2804	262.6	2053.35	750.65		122080	
ER	2019-20	2820	169.27	2222.62	597.38		108453	
ER	2020-21	2820	253.74	2476.36	343.64		31760	
ER	2021-22	2820	210.01	2686.35	133.65	86.25%	51633	57.03%
ECR	2017-18	3677.51	430.35	2350.41	1327.1		183041	
ECR	2018-19	3798.17	603.99	2954.4	843.77		186057	
ECR	2019-20	3882.88	402.3	3356.7	526.18		138428	
ECR	2020-21	4008.2	237.61	3594.31	413.89		42758	
ECR	2021-22	4053.77	212.06	3806.37	247.4	81.36%	44006	75.96%
ECoR	2017-18	2756.51	272.77	2107.81	648.7		119339	
ECoR	2018-19	2771.09	430.39	2538.2	232.89		118598	
ECoR	2019-20	2800.11	169.95	2708.15	91.96		106778	
ECoR	2020-21	2801.49	66.76	2774.91	26.58		75682	
ECoR	2021-22	2817.59	42.68	2817.59	0	100.00%	84648	29.07%
NR	2017-18	7301	336	3502	3799		417290	
NR	2018-19	7318	901	4403	2915		428333	
NR	2019-20	7323	401	4804	2519		391426	
NR	2020-21	7323	686	5490	1833		144061	
NR	2021-22	7331	568	6058	1273	66.49%	248591	40.43%

Annexure – 3
(Ref: Para No. 3.2.2)
Statement showing details of consumption of Diesel for traction and non-traction purposes

Zone	Year	Total route KMs	Route KMs electrified during the year	Total route KMs electrified at end of the year	Route KMs remaining unelectrified at the end of the year	Percentage Decrease in unelectrified route KMs during the review period	HSD Oil issued (in Kilo litre)	
							For Traction	Percentage decrease in consumption during the review period
1	2	3	4	5	6	7	8	9
NCR	2017-18	3222	216	2025	1197		92135	
NCR	2018-19	3222	338	2363	859		95321	
NCR	2019-20	3222	218	2581	641		85776	
NCR	2020-21	3222	126	2707	515		30355	
NCR	2021-22	3222	439	3146	76	93.65%	36929	59.92%
NER	2017-18	3439.55	165.81	750.5	2689.05		130815	
NER	2018-19	3477.05	433.21	1183.7	2293.35		129429	
NER	2019-20	3472.95	543.41	1727.12	1745.83		111566	
NER	2020-21	3470.9	560.53	2287.65	1183.25		26122	
NER	2021-22	3471.6	509.37	2797.02	674.58	74.91%	43867	66.47%
NFR	2017-18	4136.13	101	101	4035.13		211893	
NFR	2018-19	4200.2	158	259	3941.2		224724	
NFR	2019-20	4239.32	67	326	3913.32		223100	
NFR	2020-21	4239.13	333	659	3580.13		139329	
NFR	2021-22	4304.08	318	977	3327.08	17.55%	197595	6.75%
NWR	2017-18	5586	530	609	4977		338536	
NWR	2018-19	5583	631	1240	4343		336531	
NWR	2019-20	5644	561	1801	3843		342610	
NWR	2020-21	5651	385	2186	3465		243450	
NWR	2021-22	5679	683	2869	2810	43.54%	322808	4.65%
SR	2017-18	5080	215	2975	2105		151611	
SR	2018-19	5081	181	3156	1925		141006	
SR	2019-20	5081	187	3343	1738		133599	
SR	2020-21	5087	190	3533	1554		28240	
SR	2021-22	5087	611	4144	943	55.20%	50070	66.97%

Annexure – 3
(Ref: Para No. 3.2.2)
Statement showing details of consumption of Diesel for traction and non-traction purposes

Zone	Year	Total route KMs	Route KMs electrified during the year	Total route KMs electrified at end of the year	Route KMs remaining unelectrified at the end of the year	Percentage Decrease in unelectrified route KMs during the review period	HSD Oil issued (in Kilo litre)	
							For Traction	Percentage decrease in consumption during the review period
1	2	3	4	5	6	7	8	9
SCR	2017-18	6228.8	608	3072	3156.8		284653	
SCR	2018-19	6230	432	3504	2726		293795	
SCR	2019-20	6382	110	3614	2768		273853	
SCR	2020-21	6424.6	401	4014	2410.6		110414	
SCR	2021-22	6471.4	770	4784	1687.4	46.55%	193062	32.18%
SER	2017-18	2740.46	111.43	2343.45	397.01		42884	
SER	2018-19	2712.76	43.36	2386.81	325.95		39713	
SER	2019-20	2712.76	39.94	2426.75	286.01		30927	
SER	2020-21	2753.03	203.83	2630.57	122.46		15434	
SER	2021-22	2742.62	112.05	2742.62	0	100.00%	22227	48.17%
SECR	2017-18	1999.27	329.91	1599.98	399.29		62747	
SECR	2018-19	2099.06	180.76	1780.74	318.32		57626	
SECR	2019-20	2142.68	73.52	1854.26	288.42		55758	
SECR	2020-21	2330.65	197.44	2051.7	278.95		28462	
SECR	2021-22	2379.84	155	2207	172.84	56.71%	39286	37.39%
SWR	2017-18	3522.22	93	554.46	2967.76		83144	
SWR	2018-19	3523.72	36	590.46	2933.26		84342	
SWR	2019-20	3566.11	138	728.46	2837.65		86553	
SWR	2020-21	3579.39	477	1205.46	2373.93		48786	
SWR	2021-22	3605.54	512	1717.46	1888.08	36.38%	78082	6.09%
WR	2017-18	4600	116.4	1761.7	2838.3		260474	
WR	2018-19	4805	124	1885.7	2919.3		260211	
WR	2019-20	4889	664	2549.7	2339.3		230704	
WR	2020-21	5017	577.29	3127	1890		148012	
WR	2021-22	5165	664.9	3791.9	1373.1	51.62%	243344	6.58%

Annexure – 3
(Ref: Para No. 3.2.2)
Statement showing details of consumption of Diesel for traction and non-traction purposes

Zone	Year	Total route KMs	Route KMs electrified during the year	Total route KMs electrified at end of the year	Route KMs remaining unelectrified at the end of the year	Percentage Decrease in unelectrified route KMs during the review period	HSD Oil issued (in Kilo litre)	
							For Traction	Percentage decrease in consumption during the review period
1	2	3	4	5	6	7	8	9
WCR	2017-18	3004	250	1868	1136		156013	
WCR	2018-19	3010	301	2169	841		145567	
WCR	2019-20	3011	377	2546	465		131946	
WCR	2020-21	3025	477	3023	2		52213	
WCR	2021-22	3025	2	3025	0	100.00%	35146	77.47%
IR	**2017-18**	**63872.44**	**4028.44**	**29914.06**	**33958.38**		**2895089**	
IR	**2018-19**	**64488.04**	**5288.31**	**35202.37**	**29285.67**		**2903483**	
IR	**2019-20**	**65041.8**	**4331.39**	**39533.76**	**25508.04**		**2673209**	
IR	**2020-21**	**65605.39**	**5579.19**	**45112.95**	**20492.44**		**1297134**	
IR	**2021-22**	**66066.44**	**6148.07**	**51261.02**	**14805.42**	**56.40%**	**1886093**	**34.85%**

Source: Records of PCME office of respective ZRs

Annexure - 4
(Ref: Para No. 3.2.2.1)
Total Route KMs, Electrified Route KMs and electric GTKM

Zone	Year	Total route KMs	Electrified Route KMs at the beginning of the year	Route KMs to be electrified during the year (Target)	Route KMs electrified during the year	Total electrified Route KMs at end of the year	Percentage increase in total electrified Route KMs during review	Percentage of electrified route to Total Route KMs	GTKM - passenger electric (Col 8 stmnt 16)	GTKM- freight electric (Col 9 stmnt 16)	GTKM- electric total	Percentge increase in GTKM- electric total during review
1	2	3	4	5	6	7	8	9	10	11	12	13
CR	2017-18	3816	2322	341	181	2503		65.59%	50892291	61368358	112260649	
CR	2018-19	3853	2503	640	232	2735		70.98%	53155996	69208962	122364958	
CR	2019-20	3853	2735	637	210	2945		76.43%	53551555	65884811	119436366	
CR	2020-21	3853	2945	757	407	3352		87.00%	19368100	59943835	79311935	
CR	2021-22	3891	3352	470	339	3691	47.46%	94.86%	45529974	77043403	122573377	9.19%
ER	2017-18	2763	1719	124	72	1791		64.81%	15637543	18995027	34632570	
ER	2018-19	2804	1791	393	263	2053		73.23%	15690654	19925733	35616387	
ER	2019-20	2820	2053	260	169	2223		78.82%	16841707	21603889	38445596	
ER	2020-21	2820	2223	168	254	2476		87.81%	9286912	31869108	41156020	
ER	2021-22	2820	2476	210	210	2686	50.01%	95.26%	23335547	37064903	60400450	74.40%
ECR	2017-18	3678	1920	314	430	2350		63.91%	23289455	60382904	83672359	
ECR	2018-19	3798	2350	766	604	2954		77.78%	24917375	64772122	89689497	
ECR	2019-20	3883	2954	669	402	3357		86.45%	25479317	68305054	93784371	
ECR	2020-21	4008	3357	209	238	3594		89.67%	10102601	79790163	89892764	
ECR	2021-22	4054	3594	193	212	3806	61.94%	93.90%	34344578	97643418	131987996	57.74%
ECoR	2017-18	2757	1835	397	273	2108		76.47%	16260753	74877209	91137962	
ECoR	2018-19	2771	2108	399	430	2538		91.60%	21140617	78809829	99950446	
ECoR	2019-20	2800	2538	146	170	2708		96.72%	22965425	93617133	116582558	
ECoR	2020-21	2801	2708	141	67	2775		99.05%	7329943	112646874	119976817	
ECoR	2021-22	2818	2775	39	43	2818	33.67%	100.00%	21621820	131456650	153078470	67.96%
NR	2017-18	7301	3166	463	336	3502		47.97%	39497055	28525502	68022557	
NR	2018-19	7318	3502	1364	901	4403		60.17%	40224373	32750907	72975280	

Annexure - 4
(Ref: Para No. 3.2.2.1)
Total Route KMs, Electrified Route KMs and electric GTKM

Zone	Year	Total route KMs	Electrified Route KMs at the beginning of the year	Route KMs to be electrified during the year (Target)	Route KMs electrified during the year	Total electrified Route KMs at end of the year	Percentage increase in total electrified Route KMs during review	Percentage of electrified route to Total Route KMs	GTKM - passenger electric (Col 8 stmnt 16)	GTKM- freight electric (Col 9 stmnt 16)	GTKM- electric total	Percentge increase in GTKM- electric total during review
1	2	3	4	5	6	7	8	9	10	11	12	13
NR	2019-20	7323	4403	1443	401	4804		65.60%	42192325	37217384	79409709	
NR	2020-21	7323	4804	827	686	5490		74.97%	3735263	63617844	67353107	
NR	2021-22	7331	5490	757	568	6058	72.99%	82.64%	40512186	81507285	122019471	79.38%
NCR	2017-18	3222	1809	377	216	2025		62.85%	55634248	99081479	154715727	
NCR	2018-19	3222	2025	668	338	2363		73.34%	55555468	100358315	155913783	
NCR	2019-20	3222	2363	616	218	2581		80.11%	57878372	85875698	143754070	
NCR	2020-21	3222	2581	178	126	2707		84.02%	28207316	81111847	109319163	
NCR	2021-22	3222	2707	521	439	3146	55.36%	97.64%	59475571	103558590	163034161	5.38%
NER	2017-18	3440	585	112	166	751		21.82%	5938227	2253918	8192145	
NER	2018-19	3477	751	824	433	1184		34.04%	6905245	2085086	8990331	
NER	2019-20	3473	1184	696	543	1727		49.73%	9391631	3544192	12935823	
NER	2020-21	3471	1727	491	561	2288		65.91%	6421280	13216121	19637401	
NER	2021-22	3472	2288	735	509	2797	272.69%	80.57%	16605194	14873983	31479177	284.26%
NEFR	2017-18	4136	0	354	101	101		2.44%	0	0	0	
NEFR	2018-19	4200	101	306	158	259		6.17%	0	0	0	
NEFR	2019-20	4239	259	566	67	326		7.69%	0	0	0	
NEFR	2020-21	4239	326	650	333	659		15.55%	0	0	0	
NEFR	2021-22	4304	659	527	318	977	867.33%	22.70%	0	0	0	NA
NWR	2017-18	5586	79	573	530	609		10.90%	0	115320	115320	
NWR	2018-19	5583	609	1417	631	1240		22.21%	138087	203465	341552	
NWR	2019-20	5644	1240	915	561	1801		31.91%	232740	208928	441668	
NWR	2020-21	5651	1801	539	385	2186		38.68%	614348	921481	1535829	

Annexure - 4
(Ref: Para No. 3.2.2.1)
Total Route KMs, Electrified Route KMs and electric GTKM

Zone	Year	Total route KMs	Electrified Route KMs at the beginning of the year	Route KMs to be electrified during the year (Target)	Route KMs electrified during the year	Total electrified Route KMs at end of the year	Percentage increase in total electrified Route KMs during review	Percentage of electrified route to Total Route KMs	GTKM - passenger electric (Col 8 stmnt 16)	GTKM- freight electric (Col 9 stmnt 16)	GTKM- electric total	Percentge increase in GTKM- electric total during review
1	2	3	4	5	6	7	8	9	10	11	12	13
NWR	2021-22	5679	2186	993	683	2869	371.10%	50.52%	5257984	3170416	8428400	7208.71%
SR	2017-18	5080	2760	141	215	2975		58.56%	40612100	20912908	61525008	
SR	2018-19	5081	2975	287	181	3156		62.11%	43947257	23040411	66987668	
SR	2019-20	5081	3156	515	187	3343		65.79%	46728047	21055404	67783451	
SR	2020-21	5087	3343	291	190	3533		69.45%	16550636	26993368	43544004	
SR	2021-22	5087	3533	627	611	4144	39.29%	81.46%	43822487	33148602	76971089	25.11%
SCR	2017-18	6229	2464	405	608	3072		49.32%	48065782	77398638	125464420	
SCR	2018-19	6230	3072	600	432	3504		56.24%	51706427	82096310	133802737	
SCR	2019-20	6382	3504	658	110	3614		56.63%	53825587	76167333	129992920	
SCR	2020-21	6425	3614	420	401	4014		62.48%	20369119	85439804	105808923	
SCR	2021-22	6471	4014	848	770	4784	55.73%	73.93%	52539108	114811750	167350858	33.39%
SER	2017-18	2740	2232	0	111	2343		85.51%	23166573	101352962	124519535	
SER	2018-19	2713	2343	48	43	2387		87.98%	23295532	107695055	130990587	
SER	2019-20	2713	2387	178	40	2427		89.46%	22273029	116079494	138352523	
SER	2020-21	2753	2427	255	204	2631		95.55%	5154630	123655798	128810428	
SER	2021-22	2743	2631	57	112	2743	17.03%	100.00%	19594102	143010848	162604950	30.59%
SECR	2017-18	1999	1270	250	330	1600		80.03%	11781355	99712183	111493538	
SECR	2018-19	2099	1600	280	181	1781		84.84%	12376230	108529581	120905811	
SECR	2019-20	2143	1781	305	74	1854		86.54%	13018281	104187772	117206053	
SECR	2020-21	2331	1854	247	197	2052		88.03%	4822680	111352325	116175005	
SECR	2021-22	2380	2052	177	155	2207	37.94%	92.74%	14151286	130288298	144439584	29.55%
SWR	2017-18	3522	461	90	93	554		15.74%	3871008	2048516	5919524	

Annexure - 4
(Ref: Para No. 3.2.2.1)
Total Route KMs, Electrified Route KMs and electric GTKM

Zone	Year	Total route KMs	Electrified Route KMs at the beginning of the year	Route KMs to be electrified during the year (Target)	Route KMs electrified during the year	Total electrified Route KMs at end of the year	Percentage increase in total electrified Route KMs during review	Percentage of electrified route to Total Route KMs	GTKM - passenger electric (Col 8 stmnt 16)	GTKM- freight electric (Col 9 stmnt 16)	GTKM- electric total	Percentge increase in GTKM- electric total during review
1	2	3	4	5	6	7	8	9	10	11	12	13
SWR	2018-19	3524	554	289	36	590		16.76%	4186852	1873619	6060471	
SWR	2019-20	3566	590	948	138	728		20.43%	4442394	1718274	6160668	
SWR	2020-21	3579	728	630	477	1205		33.68%	2580650	4642455	7223105	
SWR	2021-22	3606	1205	825	512	1717	209.75%	47.63%	6325160	6632272	12957432	118.89%
WR	2017-18	4600	1645	270	116	1762		38.30%	33250597	52489439	85740036	
WR	2018-19	4805	1762	891	124	1886		39.24%	33820043	58306084	92126127	
WR	2019-20	4889	1886	1378	664	2550		52.15%	34076105	50437296	84513401	
WR	2020-21	5017	2550	852	577	3127		62.33%	14754658	49540567	64295225	
WR	2021-22	5165	3127	1191	665	3792	115.24%	73.42%	32521441	65204608	97726049	13.98%
WCR	2017-18	3004	1618	619	250	1868		62.18%	30929021	68054733	98983754	
WCR	2018-19	3010	1868	794	301	2169		72.06%	39236279	79122308	118358587	
WCR	2019-20	3011	2169	662	377	2546		84.56%	41259174	76873516	118132690	
WCR	2020-21	3025	2546	466	477	3023		99.93%	28761338	77951258	106712596	
WCR	2021-22	3025	3023	0	2	3025	61.94%	100.00%	60003128	102173607	162176735	63.84%
IR	**2017-18**	**63872**	**25886**	**4830**	**4028**	**29914**		**46.83%**	**398826008**	**767569096**	**1166395104**	
IR	**2018-19**	**64488**	**29914**	**9966**	**5288**	**35202**		**54.59%**	**426296435**	**828777787**	**1255074222**	
IR	**2019-20**	**65042**	**35202**	**10592**	**4331**	**39534**		**60.78%**	**444155689**	**822776178**	**1266931867**	
IR	**2020-21**	**65605**	**39534**	**7121**	**5579**	**45113**		**68.76%**	**178059474**	**922692848**	**1100752322**	
IR	**2021-22**	**66066**	**45113**	**8170**	**6148**	**51261**	**71.36%**	**77.59%**	**475639566**	**1141588633**	**1617228199**	**38.65%**

Source: Railway Board's record – Annual Statistical Statement

Annexure – 5
(Ref: Para No. 3.3.3)
Statement showing status of implementation of Energy conservation Initiatives during review period

Sl No	Measures taken by Indian Railways for Energy Conservation	ZR where implemented	ZR where not implemented	ZR where details were not made available to audit
1	2	3	4	5
1	Provision of energy efficient Light Emitting Diode (LED) lighting in Railway installations including Railway stations, service buildings, Residential quarters, coaches, EMUs/MEMUs for reduction in electricity consumption.	CR. ER, ECR, ECoR, NR, NCR, NEFR, NWR, SR, SER, SECR, SWR, WR, WCR,		NER, SCR,
2	Use of energy efficient Brushless Direct Current (BLDC) motor fans in coaches.	CR. ER, ECoR, NR, NCR, NEFR, NWR, SR, SCR, SECR, SWR, WR, WCR,		ECR, NER, SCR,
3	Emphasis on use of 5 Star rated electrical equipments.	CR. ER, ECR, ECoR, NR, NCR, NEFR, SER, SECR, SWR, WR, WCR,	NWR, SR,	NER, SCR
4	Regular training of Loco pilots for use of coasting, regenerative braking features and switching off blowers of electric locos in case yard detention is more than 15 minutes.	CR. ER, ECR, ECoR, NR, NCR, NER, NWR, SER, SECR, SWR, WR, WCR,SR		NEFR, SCR,
5	Trailing locomotives of multi units (MU) hauling light loads are switched off to save energy.	CR. ER, ECR, ECoR, NR, NCR, NER, NEFR, NWR, SER, SECR, WR, WCR,SR		SCR, SWR,
6	Energy consumption on electric locomotives is regularly monitored through microprocessor based energy meters provided in all the electric locomotives and benchmarking is done based on average energy consumption.	CR. ER, ECR, ECoR, NR, NCR, NER, NWR, SER, SECR, SWR, WR, WCR, SR		NEFR, SCR,
7	Monitoring the fuel consumption with respect to trip ration of diesel locomotive drivers.	ER, ECR, ECoR, NR, NCR, NER, NEFR, NWR, , SECR,WR	CR.SER, SWR, WCR	SR, SCR
8	Monitoring of idling of diesel locomotives is being done through remote monitoring and management of Locomotives and trains (called as REMMLOT).	CR. ER, ECR, ECoR, NR, NCR, NER, NEFR, NWR, SECR, SWR, WR, WCR, SR		SCR, SER,
9	Use of 5% bio-diesel in traction fuel-Blending of bio-diesel with High Speed Diesel (HSD) to the extent of 5 % to save HSD.	ER, NR, NER, NEFR, SR, SWR,	CR, ECR, ECoR, NCR, NWR, WR, WCR,	SCR, SER, SECR,
10	20% Compressed Natural Gas (CNG) substitution in DEMUs-CNG usage emits less Greenhouse Gases (GHG) than liquid fuels. Indian Railways have the distinction of being the only railway in the world to be using CNG run power cars for passenger transportation. IR has also started conversion of DEMU Driving Power Car (DPC) into dual fuel mode DEMU/DPC with CNG. 25 numbers of DPCs have been converted and are under operation.		CR, ECR, ECoR, NR, NCR, NWR, SR, SECR, SWR, WR, WCR (not applicable),	ER, SCR, SER, NER, NEFR

Authority: Press Information Bureau, Government of India, Ministry of Railways of 03.07.2019 and 10.03.2021

Annexure – 6
(Ref: Para No. 4.1.3.2)
Statement showing details of PPA/contracts awarded for purchase of wind energy

Zone	Year	Name of agency	Contract Period	Letter of Acceptance (LoA) date	Power Purchase Agreement date	Landed rate/Unit (in ₹)	Capacity (MW)	Whether energy supplied is as per LoA
1	2	3	4	5	6	7	8	9
CR	2017-18	*Mls. lnox Wind Infrastructure Services Ltd, Noida*	25 years	05.01.2018	02.05.2018	7.40 for 33KV 8.34 for 11 KV	6.00	No
	2019-20	M/s NVVN	25 years	19.12.2018	06.03.2019	3.37	50.40	Yes
ER	2017-18 to 2021-22	Nil	NAP	NAP	NAP	NAP		NAP
ECR	2017-18 to 2021-22	Nil	NAP	NAP	NAP	NAP		NAP
ECoR	2017-18 to 2021-22	Nil	NAP	NAP	NAP	NAP		NAP
NR	2017-18 to 2021-22	Nil	NAP	NAP	NAP	NAP		NAP
NCR	2017-18 to 2021-22	Nil	NAP	NAP	NAP	NAP		NAP
NER	2017-18 to 2021-22	Nil	NAP	NAP	NAP	NAP		NAP
NFR	2017-18 to 2021-22	Nil	NAP	NAP	NAP	NAP		NAP
NWR	2017-18 to 2021-22	Nil	NAP	NAP	NAP	NAP		NAP
SR	2017-18 to 2021-22	Nil	NAP	NAP	NAP	NAP		NAP
SCR	2017-18 to 2021-22	Nil	NAP	NAP	NAP	NAP		NAP
SER	2017-18 to 2021-22	Nil	NAP	NAP	NAP	NAP		NAP
SECR	2017-18 to 2021-22	Nil	NAP	NAP	NAP	NAP		NAP
SWR	2017-18 to 2021-22	Nil	NAP	NAP	NAP	NAP		NAP
WR	2017-18 to 2021-22	Nil	NAP	NAP	NAP	NAP		NAP
WCR	Prior to2017-18	REMCL	25 Years	NA	29.10.2014	6.27	26.00	Yes
WCR	2017-18 to 2021-22	NIL	NAP	NAP	NAP	NAP		NAP

Note: NAP - Not Applicable