Mission 41k

Through Integrated Rail Energy Management System (I-REMS)

The pivot for IR's Regeneration

Saving of

₹41,000 cr. (2015-'25)

Prepared By: Electrical Energy Management Directorate
Railway Board, Ministry of Railways

2017

Executive Summary

Reforming Indian Railways has been identified as a key priority by **Hon'ble Prime Minister**. Accordingly**, Hon'ble Minister of Railways, Shri Suresh Prabhakar Prabhu,** from the day he became head of this Ministry, has been relentlessly working on multiple fronts to speed up growth of Indian Railways (IR) and improve its financial health. While on one side Railways' needs to finance its projects have been met by arranging **low cost funding** from **Extra Budgetary Resources** (**EBR**) like financing from Life Insurance Corporation of India etc., on the other hand, focused efforts to reduce input costs has been made. Realizing that about **one third** of **Indian Railways'** Ordinary Working Expenses goes towards meeting its energy needs, one of the important mission set by the **Hon'ble Minister of Railways** was to substantially bring down its energy cost. The first goal under this mission was to **reduce** annual **electric traction bill** by about **₹3,000 cr.** in next few years.

During 2014-'15, total energy cost of Indian Railways was **₹31,220cr**. This included an expenditure of **₹10,436 cr.** towards **electric traction** (which carries about **two thirds** of total **freight** and about **50%** of **passenger traffic**), **₹18,586 cr.** towards diesel traction (which carries balance **one third** of freight and about **50%** of **passenger traffic**) and **₹2,198** cr. towards supply of electrical energy to various offices, workshops and railways stations etc.

IR has been procuring electricity as an **ordinary consumer** for its traction applications despite being the **largest single user** of energy in the country. Accordingly, it has been paying higher tariffs for energy duly taking the burden of **distribution losses**, **cross subsidy** and **other surcharges** of Power Distribution Companies (DISCOMs). The Electricity Act 2003 conferred **Deemed Licensee** status on IR due to its involvement in **generation**, **transmission** & **distribution** of **energy from the time electricity came to India**. Accordingly, IR had been working to get this provision of Electricity Act operational. However, due to various factors, it was not happening. Being the **architect** of **Electricity Act 2003, Shri Suresh P. Prabhu, Hon'ble Minister of Railways,** took up this task with fresh **impetus** and under his **stewardship, a strategy was drawn.**

In line with this, Central Electricity Regulatory Commission (**CERC**) was requested for issue of necessary guidelines to all State Transmission Utilities (**STUs**) and State Load Dispatch Centers (**SLDCs**) to facilitate **Open Access** to Indian Railways on existing transmission network as **Deemed Licensee**. This was made to enable Indian Railways to procure energy from any generating unit, including captive generating plants, traders, or through power exchange up to the interconnection point of railway network in terms of specific provisions of Railway Act.

In its historic **judgment** on **5th Nov.'15**, CERC ordered that:

Indian Railways is an authorized entity under the Railways Act to undertake transmission and distribution activities in connection with the working of the railways, independent of its status under the Electricity Act.

Indian Railways is a deemed Licensee under third proviso to Section 14 of the Electricity Act and no separate declaration to that effect is required from the Appropriate Commission.

All concerned RLDCs, State Transmission Utilities and SLDCs are directed to facilitate long term access and medium term access in terms of Connectivity Regulations from the generating stations or other sources to the facilities and network of Indian Railways.

Finally, IR's vision of drawing electrical energy as deemed licensee was realized on **26th Nov.'15** when it started drawing about **200 MW power** on Central Railway from **Ratnagiri Gas Power Pvt. Ltd**. {**RGPPL** - A Govt. owned (gas based power plant)} PSU in Maharashtra. This was for the **first** time that IR had drawn energy under open access as a distribution licensee using state distribution network. IR contracted about **500 MW** from RGPPL for consumption in the states of **Maharashtra**, **Gujarat**, **M.P.,** and **Jharkhand for** meeting its electric traction power requirement. The flow of power in all these four States was completed by **22nd Jan.'16**. Further, IR also contracted **50 MW** through open tender for taking on its own transmission network for Dadri to Kanpur which started flowing from **1stDec.'15**. With these actions, average cost of energy for electric traction in these states has come down from **₹7.70** to **₹4.61/unit** thereby giving an **annualized saving** of about **₹1,300 cr**.

This is a **classic** example of **co-operation** between **Centre** and **States** where they had worked shoulder to shoulder to implement provisions of Electricity Act 2003 and improve efficacy of key public services. While reduction in input costs will improve **resilience** of IR, at the same time, energy released can be used by States for powering their energy deficit areas. The availability of energy at low price will enable IR to keep its freight tariff under check and reduce inflationary impact on prices in general. In long run, this would increase share of railways in freight traffic by making rail tariff more competitive. This would also reduce pressure on state highways.

With this action, an important **Budget announcement** of **2015-'16** to **reduce input cost** to **IR** by **₹3,000 cr.** could be realized. This document enumerates immediate benefits that will accrue to Indian Railways by procuring energy as a distribution licensee, and its impact in improving financial performance of IR. The estimated savings on these accounts indicates that in **next ten years** (**2015-'25**), these initiatives can generate a cumulative **saving** of about **₹41,000 cr.** in **electric traction bill.**

In addition to procuring energy at competitive rates, special emphasis has been laid by **Hon'ble Minister of Railways** towards **efficient utilization** of energy. Indian Railways have been taking various energy efficiency **measures**, and as per estimates of **Bureau of Energy Efficiency (BEE)**, these measures have **reduced energy consumption** by more than **3%** in **electric traction** and by about **2.8%** in **non-traction** applications on year to year basis. These initiatives have given a financial **saving** of about **₹400 cr.** in financial year **2015-'16** alone. This document has a chapter on Railways' achievements and its future plans in

Contents

1. Overview of Indian Railways 2

1.1 Ordinary Working Expenses of Indian Railways 3

2. Energy Use on IR 4

3. Traction System on IR 6

3.1 Electric Traction: Journey of Innovation 6

3.2 Evolution of Electric Locomotive 6

3.3 Evolution of Speed Potential 7 of Electric Locomotives

3.4 Advantages of Electric Traction 7

4. IR's Traction Power Network 8

4.1 Indian Grid 8

4.2 Traction Power System & Connectivity with National Grid 9

5. Electricity Use on IR 11

5.1 Growth Pattern of Energy requirement 11

5.2 Traction Electricity Cost 12

6. New Paradigm: Deemed Licensee 14

6.1 Deemed Distribution Licensee status of IR 14

6.2 Operationalization of Deemed Distribution Licensee 14

6.3 Challenges faced 15

7. Implications of New Traction Power Procurement Strategy 16

7.1 Strategy for Traction Power Procurement 16

7.2 Current Status 17

7.3 Savings Projected 17

7.4 Key take away 18

7.5 Way ahead 18

8. Integrated Rail Energy Management 19

8.1 Objective 19

8.2 Goals 19

8.3 Command & Control (C&C) Structure 19

8.4 Forecasting System 20

8.5 Human Resources 20

9. Transmission Line Network of IR 21

9.1 Developing an integrated transmission network 21

9.2 Way Ahead 21

10. Energy Conservation Initiatives 22

10.1 Efficient utilization of energy 22

10.2 Electric Traction 23

10.2.1 Electric Locomotives 23

10.2.2 EMU and Air Conditioned coaches 23

10.2.3 Traction Sub-Stations 24

10.2.4 Head on Generation (HOG) 24

10.2.5 Conversion of Trains from Diesel Traction: 25

10.3 Diesel Traction 25

10.3.1 Operational improvements 25

10.3.2 Diesel Locomotive 25

10.3.3 Alternate fuels 26

10.3.4 Diesel Procurement System 27

11. Vision for Non-Traction Energy 28

11.1 Strategy for Sustainable Savings 28

11.2 Action Plan for Improved Energy Efficiency 29

11.3 Energy Conservation Measures 29

11.4 LED Lighting in Stations 30

11.4 IR- United Nations Development Programme (UNDP) - Global Environment Facility (GEF) Project 31

12. Decarbonizing IR's Energy Needs 33

12.1 Why Decarbonise 33

12.2 Why Electrified Transport 33

13. Renewables in IR 34

13.1 Solar Energy 34

13.2 Harnessing Solar Power 37

13.3 Harnessing Wind Power for Railways 37

14. Designed and Made in India 38

15. Conclusion 39

this respect as well. It is expected that energy savings due to induction of **latest generation 12000 HP locomotives** and **electric multiple units** (**EMUs**) having **regeneration** capability can **save** more than **25%** of energy.

IR is committed to contribute towards improvement of environment. In this direction, it is focusing on environmental friendly measures like changing energy mix from fossil fuel base to renewable energy base which include use of **wind**, **solar**, **waste-to-energy** etc. Keeping in line with vision of Hon'ble Prime Minister, IR has recently installed **26 MW wind plant** in **Jaisalmer**. This has taken IR's installed capacity of renewable energy to about **50 MW**. Further, IR has planned to increase its **installed capacity** of **solar power** plants to **1000 MW** and of **wind mill plants** to about **200 MW** by year **2020**. In addition, Indian Railways are working to develop a long term decarbonization strategy by sourcing almost **100%** of its energy from **renewable sources**. This document has a chapter on action plan towards changing energy mix for making IR as the **first 100% decarbonized** transport system in the **world**.

With success in reducing electric traction bill substantially, **mission** of bringing down operational cost of Railways has already started taking shape. In due course of time, this will also give shape to the directive of **Hon'ble Prime Minister** that Railways should play a dominant role in meeting transport needs of the nation in an economical manner, de-congest highways, create more jobs with expansion of rail network and reduce India's dependence on imported fuel. This humble beginning with cutting input costs will **strengthen financial resilience** of IR, improve its **resource mobilization**, and enable **shifting** of **traffic** from **road** to **rail** by making it more attractive. Making these savings happen by **2025** will be a real tribute to Indian Railways when it will be celebrating its **centenary year** of **electric traction** on Indian Railways. However, implementation of all these programs will require **modernization** of some of **IR's assets** to safeguard and insulate its operations from grid imbalances etc. Further, Indian Railways have to gear itself for integration of **higher level** of **renewable energy** through induction of new generation grid balancing technologies.

Indian Railways has also embarked upon mission **Electrification** with an aim to reduce dependence on imported fuel & rationalise the cost of energy for Railways. In light of these developments, **90%** of Railway routes have been **planned** for **electrification** in coming years.

♦♦♦

List of Abbreviations

AP	Andhra Pradesh
BAU	Business as Usual
CERC	Central Electricity Regulatory Commission
CTU	Central Transmission Utility
DELP	Domestic Efficient Lighting Programme
DFCCIL	Dedicated Freight Corridor Corporation of India Ltd.
DISCOMs	Power Distribution Companies
EMU	Electrical Multiple Unit
GTKM	Gross Tonne Kilometre
HOG	Head on Generation
IR	Indian Railways
IREMS	Integrated Rail Energy Management System
kWp	Kilowatt peak
MP	Madhya Pradesh
MW	Megawatt
MWp	Megawatt peak
NOC	No Objection Certificate
OWE	Ordinary Working Expenses
RCD	Railway Consumer Depots
REMCL	Rail Energy Management Company Limited
Rkm	Route kilometre
RVNL	Rail Vikas Nigam Limited
SCADA	Supervisory Control and Data Acquisition
SEC	Specific Energy Consumption
SLDC	State Load Dispatch Centre
SLTPDC	State Level Traction Power Dispatch Centre
STU	State Transmission Utility
TN	Tamil Nadu
Tr.D	Traction Distribution
TSS	Traction Substations
U.P.	Uttar Pradesh

1 Overview of Indian Railways

Indian Railways (IR) network is spread over **66,030 route kilometre (90,803 track km)** connecting **7,137 stations** and serving people of this nation since **1853**. Indian Railways is the **fourth largest** railway system in the world. In 2014-'15, Indian Railways transported **8.22 billion passengers** to their destinations, i.e. **22.5 million passengers** a **day**, and **1.1 billion tons** of freight across **length** and **breadth** of the country. IR acts as a vehicle of ***inclusive growth*** connecting regions, communities, ports; and centers of industry, commerce, tourism and pilgrimage across the country.

Indian Railways, along with national highways and ports, is backbone of India's transport infrastructure. Currently, about **30%** of **total freight traffic** (in terms of **ton-kilometers**) of the country moves on rail. Further, share of Indian Railways in certain **core infrastructure sectors** such as coal, power, steel, cement and in other critical sectors like fertilizer is as high as **70%**. The reach and access of its services are continuously expanding with continuous improvement through its committed team of about **1.30 million employees** and use of cutting-edge technologies. The assets of IR as on 31st Mar.'15 are given in Table 1 below:

Table 1: Assets of Indian Railways (As on 31st Mar.'15)

SN	Details	Numbers
1	**Rolling Stock- Locomotives**	
i)	Steam	43
ii)	Diesel	5,714
iii)	Electric	5,016
2	**Passenger Coaches**	
i)	EMU coaches	8,475
ii)	Conventional coaches (including Rail Cars)	51,833
iii)	Other coaching vehicles	7,000
3	**Freight Cars/ Wagons**	
i)	Broad Gauge	250,711
ii)	Meter Gauge	3,139
4	**Route Kilometers (Rkm)**	
i)	Broad Gauge	58,825
ii)	Meter Gauge	4,908
iii)	Total Rkm (incl. Narrow Gauge)	66,030
5	**Details of electrification**	
i)	Rkm electrified	22,224
ii)	Rkm electrified (% age)	33.6
6	**Personnel -**Total staff (in lacs)	13.26

Source: Statistical Summary of Indian Railways, 2014-15

Railways, being one of the most energy efficient transport systems, have an edge over other modes of transport. Indian Railways accordingly endeavor to provide **efficient**, **affordable**, **customer-focused** and **environmentally sustainable integrated transportation** solution. Further, it aims at acting as an economic driver in the country through modernization and providing high speed rail networks.

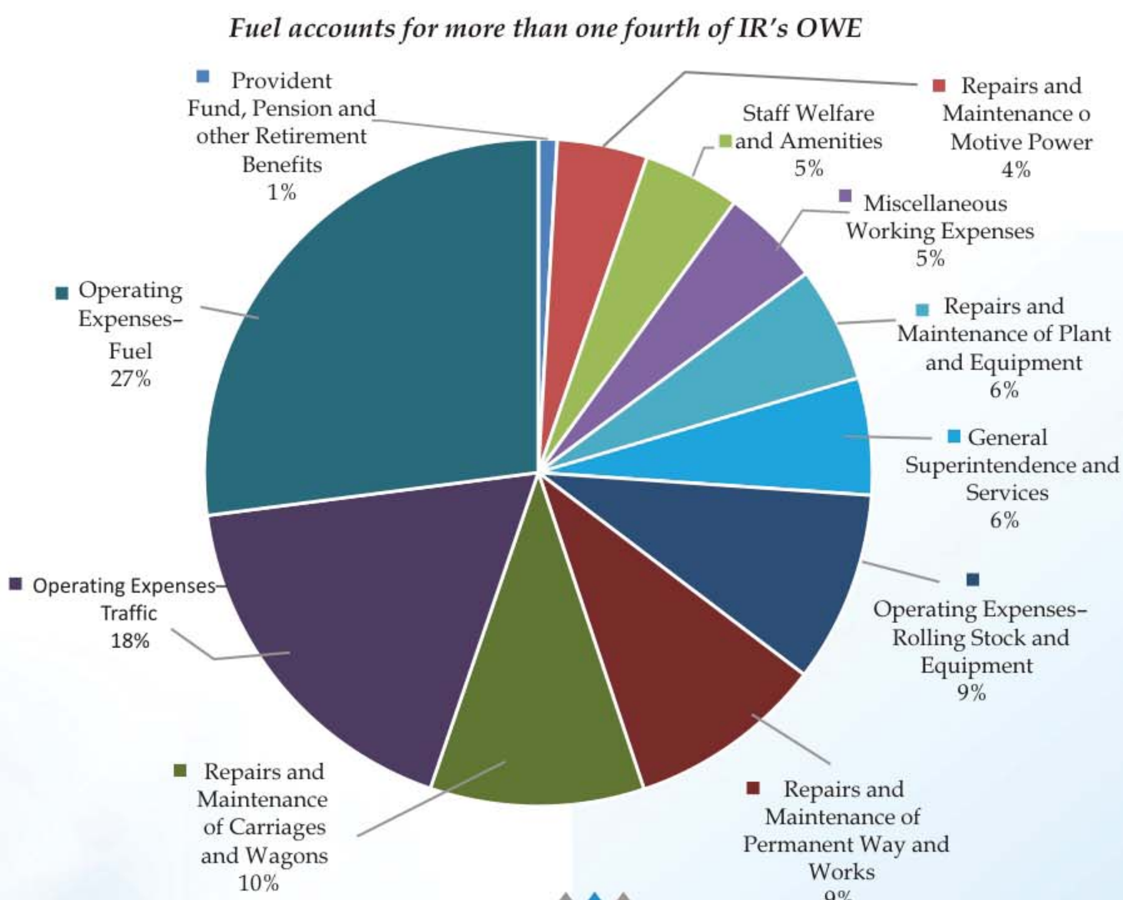
1.1 Ordinary Working Expenses of Indian Railways:

In 2014-'15, total Ordinary Working Expenses (OWE) of IR stood at **₹1.06 lac cr.** with **fuel for traction** accounting for the **single largest component** at **₹29,022 cr.** Expenditure under different heads as a percentage of total OWE are shown in Fig. 1 below:

Above fuel expenditure comprises **₹10,436 cr.** For **electric traction, ₹18,586 cr.** For diesel traction. In addition, an expenditure of **₹2,198 cr.** was made towards supply of electrical energy to various offices, workshops, railways stations etc.

Electric traction accounting for just **36%** of **total fuel expenditure** carries about **two thirds of total freight** and about **half** of **total passenger** traffic. **Due to various initiatives taken, & procurement of electricity under open access, electric traction bill for 2015-'16 got reduced to ₹10,200. Further,** due to subdued diesel prices & various initiatives taken in improving fuel efficiency, diesel traction bill got reduced to about **₹16,483 cr**.

Fig .1: Ordinary Working Expense under different heads, 2014-'15

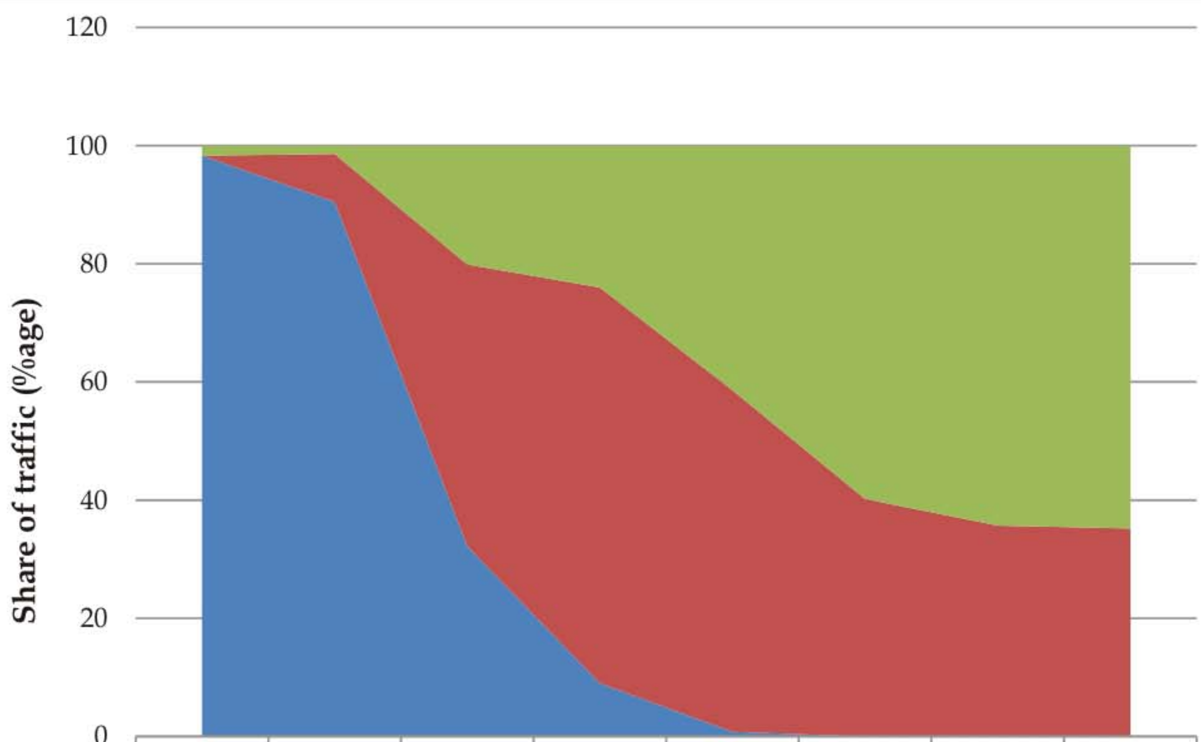


2 Energy Use on IR

Over the period, Indian Railways has seen a shift in usage of energy source from coal to diesel and later to electricity for its propulsion requirements. This shift in use of energy source mirrors global trends in shifting from coal and diesel towards electricity for traction applications. This is more visible in recent trend in Indian Railways which has seen a distinct increase in traffic hauled by electric traction (Fig. 2).

Fig. 2: Share of Traffic by type of Traction for Freight & Passenger

Freight Traffic

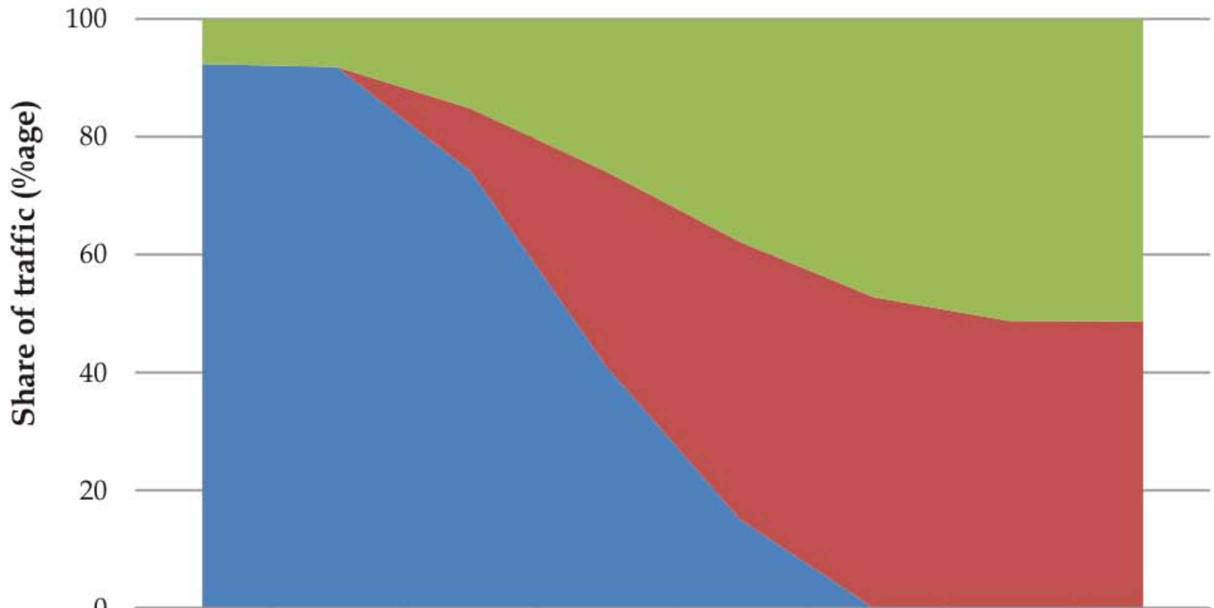


	1950-'51	1960-'61	1970-'71	1980-'81	1990-'91	2000-'01	2010-'11	2014-'15
Electric	1.7	1.4	20.1	24	41.4	59.8	64.3	64.8
Diesel	0	8.1	47.7	67	57.8	40.2	35.7	35.2
Steam	98.3	90.5	32.2	9	0.8	0	0	0

Year

Steam Diesel Electric

Passenger Traffic



	1950-'51	1960-'61	1970-'71	1980-'81	1990-'91	2000-'01	2010-'11	2014-'15
Electric	7.6	8.1	15.2	25.8	37.8	47.2	51.2	51.3
Diesel	0	0	10.7	33	47.1	52.8	48.8	48.7
Steam	92.4	91.9	74.1	41.2	15.1	0	0	0

Year ■ Steam ■ Diesel ■ Electric

3 Traction System on IR

On date Indian Railways primarily uses electricity and diesel for traction applications. Electric traction which is spread over about **28,000 route km** carries about **67%** of **total freight** and more than **50%** of total **passenger traffic** while diesel traction carries balance 33% of freight and about 50% of passenger traffic. Indian Railways **consume** around **1.8%** of **total electrical energy generated in the country** and around **3%** of total **diesel consumed** in the country for its traction applications. Being the largest consumer of energy in the country, Indian Railways has always been conscious about the way energy is utilized. It has a long history of taking actions in reducing its cost of energy through efficient utilization of energy and continued up-gradation of technology. Looking at cost and environmental benefits, lately, emphasis has shifted from diesel to electric traction, and in recent past, IR has decided to speed up this process further to take it to **90%** by **2022**.

3.1 Electric Traction: Journey of Innovation

Recognizing benefits of electrical multiple units for suburban areas, **electric traction** was **first introduced** in **India** on **Feb. 03, 1925** in Mumbai. **First Train** on **electric traction** worked on **1500 V DC** System from **Bombay Victoria Terminus** to **Kurla Harbour**. This was the turning point in development of railways and also in growth of sub-urban transport system for Mumbai and for other metropolitan cities in India. Chennai got electric traction on **May 11, 1931** and became the **second metro city** to get the same. India had **388 km** of electrified rail network at the time of **independence**. Keeping in line with international developments in traction systems, Indian Railways had decided to adopt **25 kV AC electric traction system**. However, the thrust on use of electric traction began only in **1961** with introduction of **2900 HP** capacity locomotives capable of running at a maximum speed of **80 kmph**. French National Railways (**SNCF**) provided initial technical assistance and consultancy for adoption of **25 kV AC**, **50 Hz single phase electrification system** over **Indian Railways**.

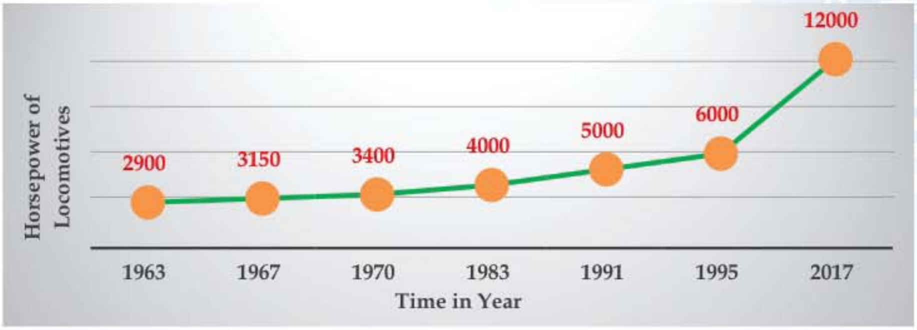
Today, Indian Railways is not only the **largest institutional consumer** of electrical energy but also unique in a sense that it has extensive generation, transmission and traction distribution systems, renewable energy assets, domestic and industrial distribution systems.

3.2 Evolution of Electric Locomotive

Indian Railways took up indigenous production of electric locomotives at Chittaranjan Locomotive Works (**CLW**) in **1960,** and the **first 1500 VDC** electric **locomotive** for Bombay area, '**Lokmanya**', was flagged off on **October 14, 1961**. The capacity of electric locomotive has since then been steadily increasing with improved technology and development of in-house production capabilities.

Indian Railways currently has **6000 HP** capacity **3 phase electric locomotives** having **regeneration** capability and capacity to run passenger trains at **160 kmph** and haul freight trains with **5,000 ton** load. Further, Indian Railways have decided to go for **doubling** the power of its freight locomotives from **6000 HP** to **12000 HP** which will soon be produced in country with latest technology. The growth of locomotive power with time is shown in fig. 3 below.

Fig.3: Power of Electric Locomotive in IR



3.3 Evolution of Speed Potential of Electric Locomotives

The speed potential of electric locomotive also steadily increased with time from **80 kmph** in **1963** to **160 kmph** in **1995**. **WAP$_5$** locomotive certified for **160 kmph** is hauling the **fastest passenger train** in **India, Gatiman from New Delhi to Agra.** Further, this locomotive has design capability to run at **200 kmph** for which necessary modifications in its driving system are currently under progress. The growing speed potential with time is brought out in fig. 4.

3.4 Advantages of Electric Traction

The fundamental advantage of electric traction over other forms of traction is that it is not dependent on a particular form of primary energy. Thus, electric traction can make use of energy generated from coal, natural gas, biogas, solar, wind etc. Electrification of transportation system per se is now seen as a basic need of modern life. Electrification of rail transport is now a global priority and a stated goal of the Government of India also.

Electric traction offers **regenerative braking** where kinetic energy of train is converted into electrical energy thereby resulting in **saving** of **energy** by around **20%** in **locomotives** and around **30%** in **electric multiple units**. This saved energy was hitherto wasted as heat energy in conventional brakes. Further, regenerative braking does not lead to any **attrition** and is also **safe** and **effective**.

Fig.4: Speed potential of Electric Locomotive in IR

* Though the locomotive was tested for 160 kmph but train at 160 kmph was started in **2016 (Gatiman).**

4 IR's Traction Power Network

On Indian Railways, electric traction energy is delivered to locomotive at **25 kV AC**, **50 Hz** on **single phase**. This energy is distributed though 25kV fed copper conductor system with transfer of energy through a sliding contact to locomotive (pantograph). The traction distribution network of Indian Railways is generally connected with transmission network of state power grid through **Traction Substations** (**TSS**).

4.1 Indian Grid[1]

Indian Power system is divided into five regional grids for planning and operational purposes. Integration of regional grids, and thereby, establishment of National Grid, was conceptualized in early nineties. Integration of regional grids which began with asynchronous **high-voltage, direct current** (**HVDC**) back-to-back inter-regional links facilitating limited exchange of regulated energy was subsequently graduated to high capacity **synchronous links** between regions. Synchronization of all regional grids will help in **optimal utilization** of resources by transfer of energy from resource centric regions to load centric regions. Further, it shall pave way for establishment of a vibrant electricity market for trading of power across regions.

Fig. 5: Five Regional Grids, Integrated Synchronously

[1] http://www.powergridindia.com/_layouts/PowerGrid/User/ContentPage.aspx?PId=78&LangID=english

4.2 Traction Power Distribution System

Indian Railways are generally connected at **132 kV level** with state grid system (in few places at **66 kV, 110kV** and **220 kV** level) and utilizes power at 25 kV AC, 50 Hz on single phase. This energy is distributed though overhead electric wire network on railway tracks which transfer energy to the traction powering units. In a way, railway system is connected directly to **State Transmission Utility** (**STU**) and energy is consumed irrespective of State boundaries.

The various zones of Indian Railways are not coterminous with boundaries of States. The regional grid wise distribution of Indian Railways' traction distribution network (Tr.D) and its number of TSS over is indicated in Fig. 6 & 7 below.

Nearly **60%** of IR's present **traction power network** is in **Western** and **Eastern regions**. **Electrification** of railway tracks in North Eastern States served by **North Frontier Railway** is currently in progress, thereby absence of TSS in North Eastern Region.

Fig.6: Traction Distribution Network, Region wise

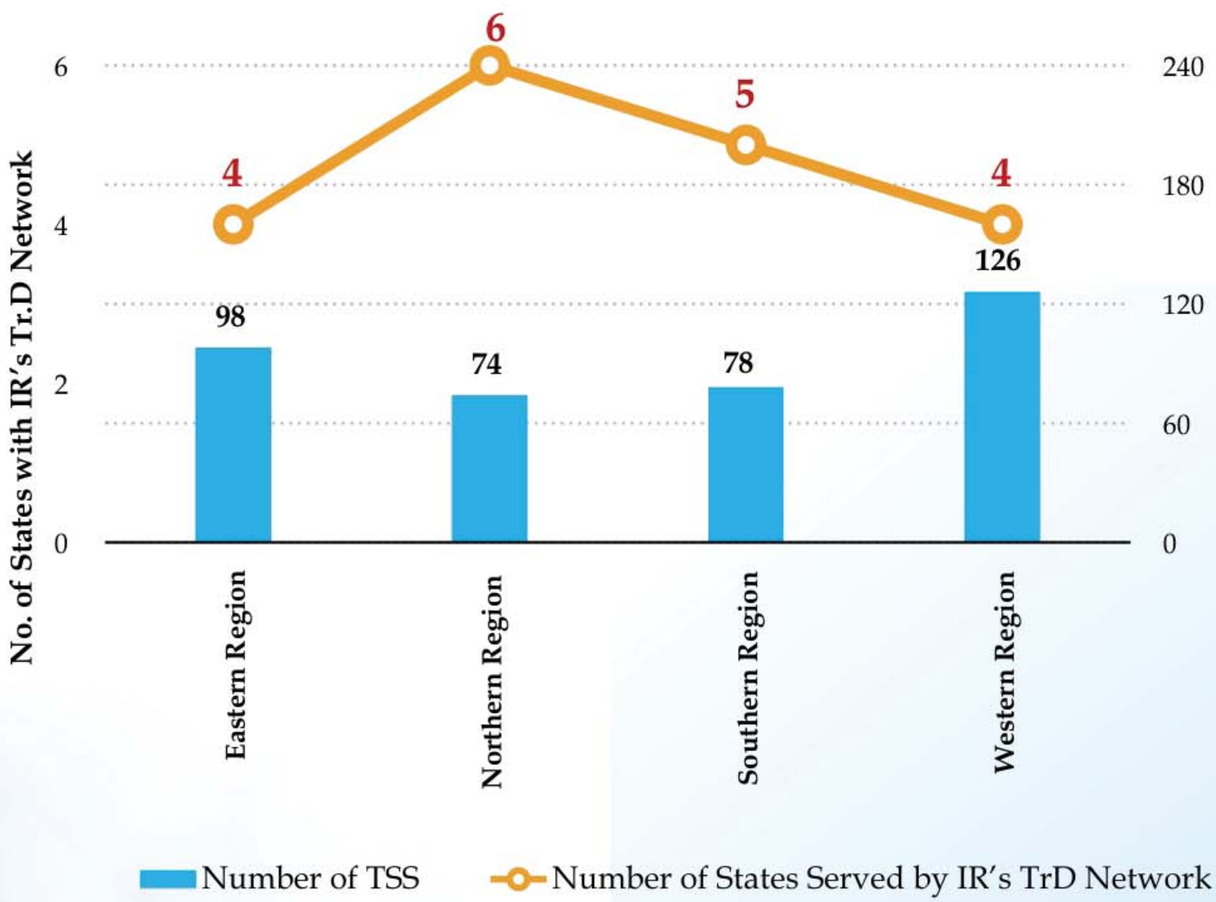


Fig.7: IR's Traction Sub Stations & their supply system Network

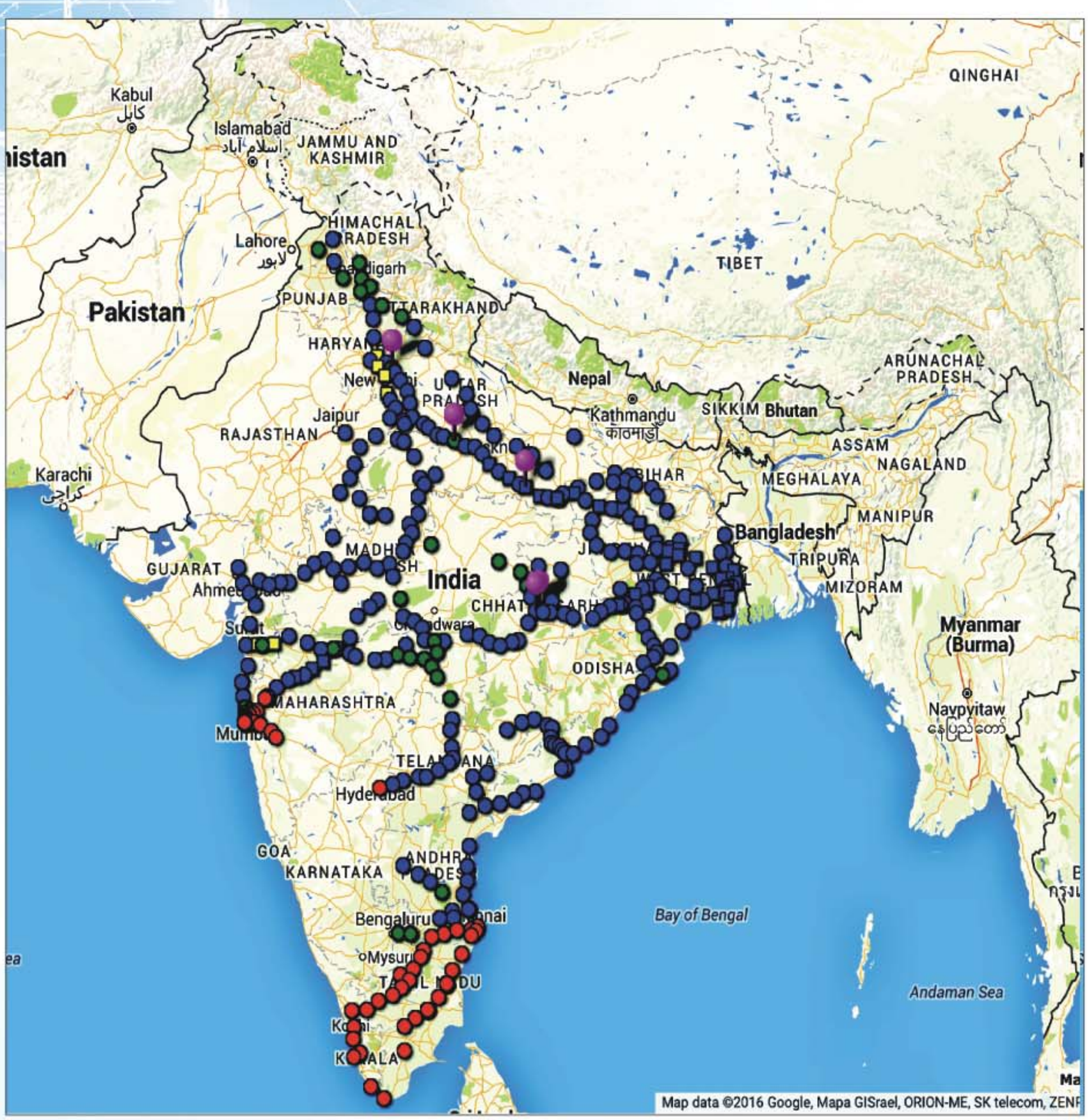


Table 2: Legend

Symbol	Colour	Voltage Level (kV)
Circle	Red	110
Circle	Blue	132
Circle	Green	220
Square	Blue	25
Square	Yellow	66
Pin	Violet	220/ 132

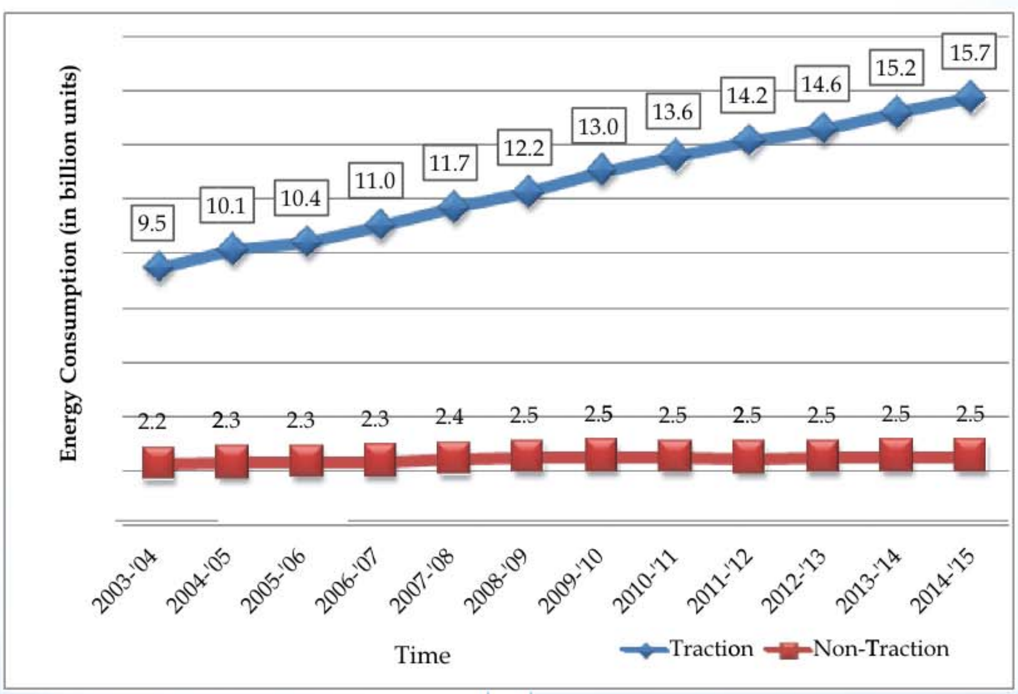
5 Electricity Use on IR

5.1 Growth Pattern of Electricity requirement

Indian Railways consumed over **18.25 billion units** of electrical energy for its traction and non-traction applications during 2014-'15 which is about **1.8%** of **total electrical energy generated** in the **country**. The total energy bill paid for consuming this energy was about **₹12,635 cr.** which includes **₹10,436 cr.** for traction applications and **₹2,199 cr.** for non-traction applications. Indian Railways has been consistently working towards controlling its energy bill. On traction side, it has been working on multi-pronged strategies including procuring energy from open market, introduction of latest energy efficient locomotives, etc. Similarly, on non-traction front, it has developed a long-term energy efficiency and conversation programme by progressively introducing energy conservation mechanism and adopting energy efficient technologies. Through these energy conservation measures, **saving** of **15% energy** by 2020 is targeted. The energy requirement for electric traction which constitute around 85%of electrical energy consumption on IR has been growing at a **compound annual growth rate** (**CAGR**) of **4%** over last decade due to continuous increase in share of 'Electric traction'.

The growth rate of electrical energy requirements for non-traction applications is mostly static, an indication of efficacy of energy conservation efforts of Indian Railways (Fig. 8).

Fig. 8: Energy Consumption for Traction and Non-Traction applications



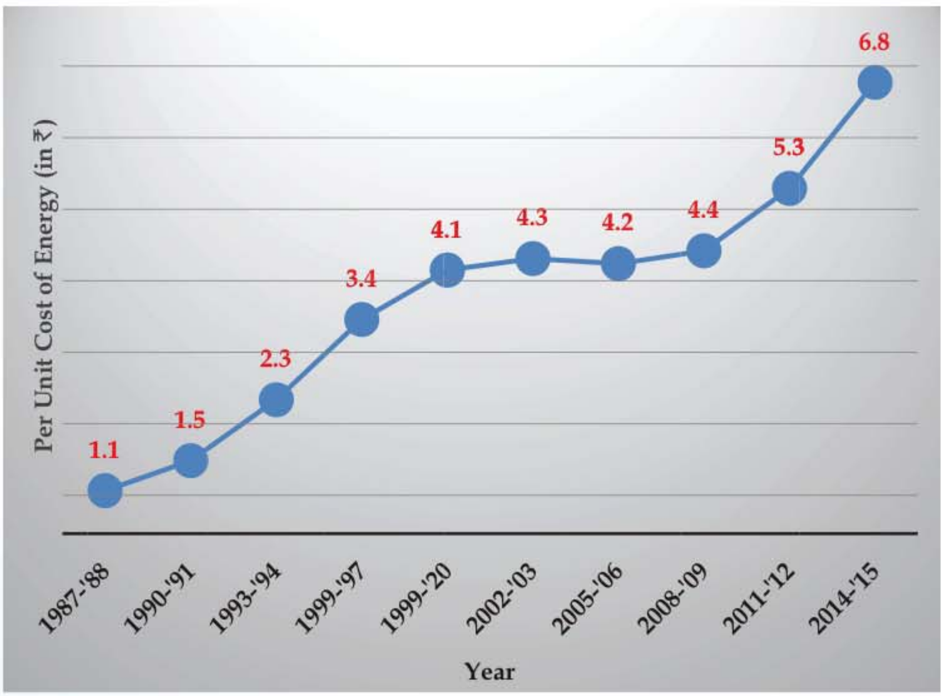
5.2 Traction Electricity Cost

The **cost** of **electrical energy** procured by Indian Railways for its traction applications has increased at a CAGR of **7%** between **1987** and **2015** (Fig. 9). While increase in the cost between years 2000 and 2006 was moderate, increase from **2006** to **2015** was high. This was primarily due to cross subsidy burden and increasing distribution and transmission losses of DISCOMs which were passed on to by charging higher tariff for traction energy.

Post Electricity Act 2003, entire power sector has been restructured. Unbundling of generation, transmission and distribution, creation of single synchronous grid, power trading exchanges were some of major reforms undertaken in Indian power sector. Further, to invite private capital into power sector, several institutional changes have been made with the objective of giving quality power at reasonable price to all.

While the Electricity Act 2003 has saved the Railways Act and has given Deemed Licensee

Fig.9: Cost of Energy for Electric Traction, 1987-2015



Though Indian Railways were connected with state grids mostly at 132 kV level, it was treated as ordinary consumer by DISCOMs and were forced to pay high tariffs. In the process, it was made to carry double burden of social responsibilities on account of Government of India's commitment to provide cost effective transport system and also of State Governments to provide subsidized power to target groups. This has resulted in substantial increase in traction energy bill for IR.

status to Railways, due to various reasons, these provisions remained non-operational. The concerted efforts made since then brought in **clarification** in **May, 2014** from Ministry of Power that Indian Railways is a **Distribution Licensee**.

Prior to this, Indian Railways had successfully implemented a transmission line for carrying energy from Dadri to Kanpur. In this regard, **Hon'ble Supreme Court**, in its **Judgment** in **2012** had **upheld Indian Railway's Deemed**

Licensee status for transmission of power for its own use. This transmission line was an effort to devise methods to reduce cost of energy as in this case IR was drawing energy directly from power generator through Central Transmission Unit (CTU) network.

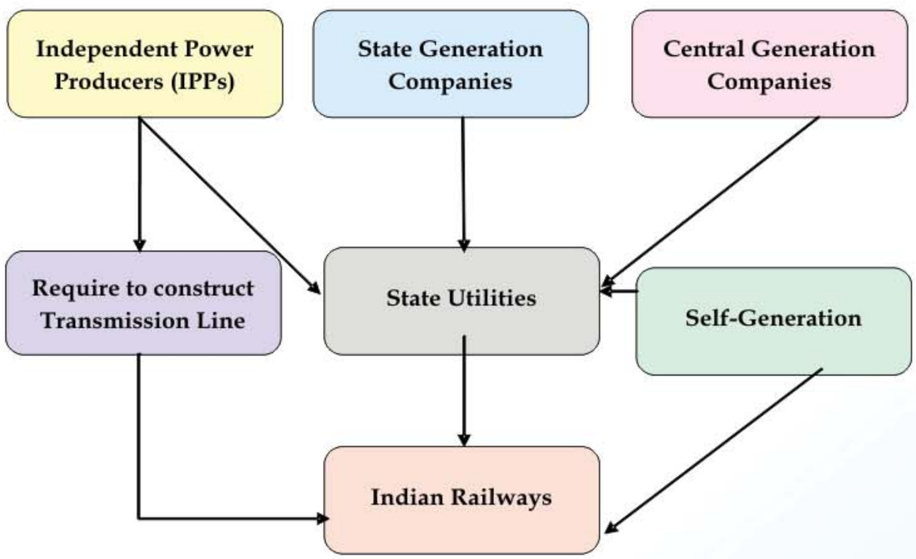
However, Railways could not replicate same across the country due to various reasons including funds constraint and thereby continued to procure electricity for its traction power by paying high tariffs. DISCOMs charged a premium in passing this energy to railways which consisted of:

- Cross subsidy component,
- High transmission and distribution losses,
- Administrative costs towards dispatch and forecast duties,
- Cost to maintain compliance with connectivity requirements,
- Handling contingencies, etc.

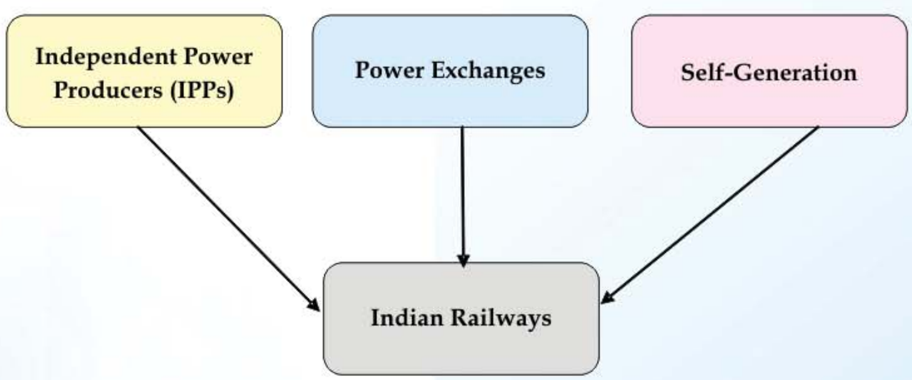
Due to substantial increase in electric traction charges, there was a case to vigorously workout methods to bring down this traction energy cost as it has substantial impact on IR's financial health.

Fig.10: IR in power sector: (i) as a consumer of DISCOMs and (ii) as deemed Licensee

(i) IR as Consumer of State Utilities



(ii) IR is deemed Licence



6 New Paradigm: Deemed Licensee

6.1 Deemed Licensee status of IR

Although Indian Railways is a bulk consumer, it used to pay extremely **high charges** for drawl of energy for its **traction** applications. Being a dominant national bulk carrier, IR has to find ways and means to draw most economical energy available in the country and at the same time leverage its needs for meeting national objective of decarbonizing transport sector.

Deemed Licensee status enables Indian Railways to directly buy content (energy) from generators by paying haulage (wheeling) charges to central and state transmission systems under Open Access. Realizing potential towards reducing traction energy bill through deemed licensee status, **operationalization** of **deemed licensee** status for Indian Railways was taken up as a challenge.

Having done exhaustive background work, promise and enthusiasm was shared by **Hon'ble Minister for Railways** in his **Budget Speech**, 2015:

It is proposed to procure power through the bidding process at economical tariff from generating companies, power exchanges, and bilateral arrangements. This initiative is likely to result in substantial savings of at least ₹3,000 cr. in next few years.

Despite apprehensions, under able guidance of Hon'ble Minister for Railways, an initiative was taken by signing a power purchase agreement with **generation companies** of **Gujarat** for consumption of power in Maharashtra by invoking Indian Railways' deemed licensee status. **No Objection Certificate** (NOC) was applied to State Load Dispatch Centre (SLDC) in Maharashtra in Jan.'15. However, Maharashtra raised issues regarding distribution licensee status of IR. Central Electricity Regulatory Commission (CERC) was then approached to get these issues clarified. In a historic order, CERC, duly taking into account all existing orders and looking at the fact that Railways Act has been duly saved in the Electricity Act 2003, **clarified** on **5th Nov.'15** that **Ministry of Railways** have the **status** of **deemed licensee** and it can arrange power for its own use as a distribution company.

6.2 Operationalization of Deemed Distribution Licensee

Based on the above clarification from CERC, Indian Railways contracted about **500 MW** from **RGPPL** for consuming it in states of **Maharashtra**, **Gujarat**, **M.P.** and **Jharkhand**. On the basis of above order, fresh NOC application was made in Maharashtra for drawing about **200 MW** at **47 Traction Substation (TSS)** duly covering Central and Western Railways. With power from this contract started flowing from **26th Nov.'15**, in Maharashtra, Indian Railways' long dream to avail power as Deemed Licensee saw light of the day. This was the first time that Indian Railways has drawn power under open access as deemed licensee using State transmission network. **This drawl of 200 MW in Maharashtra saved about ₹600 cr./year (saving of about ₹3.5/unit for about 1.8 billion units).** After success in Maharashtra, NOC applications were made in three other states i.e., MP, Gujarat & Jharkhand and same were duly provided by SLDCs of these states. Based on these NOCs, **power** started **flowing** in these states from **22nd Jan.'16** which included flow of **200 MW** in **MP**, **90 MW** in **Gujarat** and **80MW** in **Jharkhand.**

In addition, **50 MW of power** has been **contracted** @ **₹3.69/unit** through Railway Energy Management Company Limited (REMCL) using **Case-1 bidding document** of Ministry of Power over its CTU connected transmission network from Dadri to Kanpur in U.P. This power has started flowing from **1st Dec.'15**. This was probably the **first time** that any organisation contracted power using **Case 1 bidding document** of **Ministry of Power**.

With these actions, **average cost** of energy for electric traction has **come down** to **₹4.61 / unit** from earlier average of **₹7.70 / unit** in these five States. This has started giving a **saving** of about **₹1,300 cr.** on annualized basis. Further, this has also reversed trend of regular increase in energy costs with expenditure on electric traction getting reduced to **₹10,200 cr.** in 2015-'16 from **₹10,436 cr.** in 2014-'15.

With this, a **major step** was taken towards **fulfilling** an important announcement of **Budget 2015-'16** to reduce input costs to Indian Railways by **₹3,000 cr**. This is also a classic example of **co-operation** between **Central** and **State** agencies where they have worked shoulder to shoulder.

6.3 Challenges faced

Getting connected as Deemed Distribution Licensee was a real challenge for IR as process of getting No-Objection Certificates was not easy. However, due to collective efforts by **Ministry of Power** and **Ministry of Railways,** substantial progress could be made in this direction thereby resulting in substantial cost reduction to IR. Some of the main hurdles faced in obtaining NOCs for drawing power as Distribution Licensee from these states despite clear orders of CERC were:

i. Provisioning of **ABT** (Availability Based Tariff) **meters**.

ii. Ensuring CT/PT (Current transformer/ Potential transformer) of correct class and accuracy.

iii. Obtaining **clearances from DISCOMs** who were concerned in losing high value customer.

iv. Convincing SLDC that all TSS should be considered as **clubbed load**.

v. Working out **deviation settlement mechanism** (DSM).

vi. Sorting out issues related to provision of **backup power.**

vii. Developing a reasonable accurate day ahead **load forecasting** mechanism looking at variable energy demand from Railways. This is very important as large variations in load forecasting can result into paying extra amount and leading to increased tariff.

viii. Convincing Railways team that any **disruption** of **power** will **not affect Railways' operation** as in that case power will be available from grid.

ix. Convincing the State governments that in long term it would be a **win-win situation**.

7 Implications of New Traction Power Procurement Strategy

7.1 Strategy for Traction Power Procurement

After success in procurement of power through open access in 2015-'16, **Hon'ble MR** in Budget Speech, 2016 had announced:

In my Budget Speech last year, I had promised annualized savings of ₹3,000 crore to be achieved by third year. It is about 30% of total traction supply cost. I am happy to announce that the target will be achieved in next financial year itself, a year earlier than envisaged. For the first time, IR has leveraged provisions of the Electricity Act to procure power directly at competitive rates, using its status as Deemed Distribution Licensee. Power Procurement Contracts already signed and implemented will mean an annualized saving of ₹1,300 crore. Further actions to source power, already initiated, will deliver annualized savings of ₹1,700 crore during coming year, taking the total to ₹3,000 crore. In addition, the saving of ₹300 crore is being targeted through demand side management and energy efficiency measures.

Operationalization of deemed licensee status has given an unprecedented opportunity to Indian Railways to address the **high cost** of **traction energy** which is a **key variable cost**. Its reduction has wide implications on financial performance of Railways. After **successfully** availing traction energy through open access mechanism in **Maharashtra**, **Gujarat**, **M.P.**,**Jharkhand** and **U.P.** (partly), it has been established that there is a great potential for substantial savings through this route. Accordingly, Indian Railways, through REMCL, had tied-up about **585 MW** from for consumption in **Orissa**, **Bihar**, **U.P.**, **Punjab**, **Haryana**, **Delhi**, **Rajasthan** and **Chhattisgarh** at an average rate of around **₹4.00/unit** at Railway consumption point (i.e. TSS). In addition, about **400 MW** has been tied up at an average rate of about **₹5.00/unit** for consumption in **Southern** states (**Andhra Pradesh**, **Tamil Naidu**, **Kerala**, **Telangana** and **Karnataka**).

Indian Railways' captive power plant at **Nabinagar** being developed by **Bharatiya Rail Bijlee Company Limited** (**BRBCL**) is also taking shape with its **first unit commissioned** on **30th Mar.'16**. The first unit of this **1000 MW** plant is expected to provide **firm power** to Indian Railways by Jan 2017, **90%** of total power so generated by this plant will be available to IR and balance **10%** will be taken by Bihar State.

> *Paraphrasing JFK when he announced intent to go on the moon, setting a ten year target-* ***We want to do it, not because it is easy, but because it is difficult.*** *The target was beaten.*

The above initiatives when fully implemented are likely to provide a **saving** of about **₹3,000 cr./year** in traction energy bill. These savings will appear much higher when compared with **business as usual** (**BAU**) mode where traction tariff would have continued to grow at about **5% per annum**. However, with adoption of market driven strategies along with availing Deemed Licensee status, energy cost has come down substantially.

7.2 Current Status

The details of targeted saving of **₹3,000 cr.** for **2016-'17** are as below:

i. **Saving of ₹1,300 cr./year** has already been achieved with drawl of **680 MW** from RGPPL (reduction in energy cost from **₹7.07** to **₹4.61/unit**- saving of **₹2.46/unit**). This power covered 100% power requirement in **four** states (**Maharashtra**, **Gujarat**, **Madhya Pradesh** and **Jharkhand** - **580 MW** at **114 TSS**) & CTUs connected network in UP (**100 MW** at **14 TSS**).

ii. Additional **585 MW** has been tied up which will **save ₹1,100 cr. /year** (reduction in energy cost from **₹6.5** to **₹3.7/unit-** saving of **₹2.8/unit**). It will cover **141 TSS** in states of **Orissa**, **Bihar**, **UP**, **Haryana**, **Punjab**, **Delhi**, **Rajasthan**, **Chhattisgarh**, and **West Bengal**.

iii. Further, **425 MW** has been contracted for states of **Tamil Nadu**, **Telangana**, **Kerala**, **Andhra Pradesh, & Karnataka** which is expected to save **₹400 cr./year** (reduction in energy cost from **₹6.5** to **₹4.9/unit-** saving of **₹1.6/unit**) covering **87 TSS**.

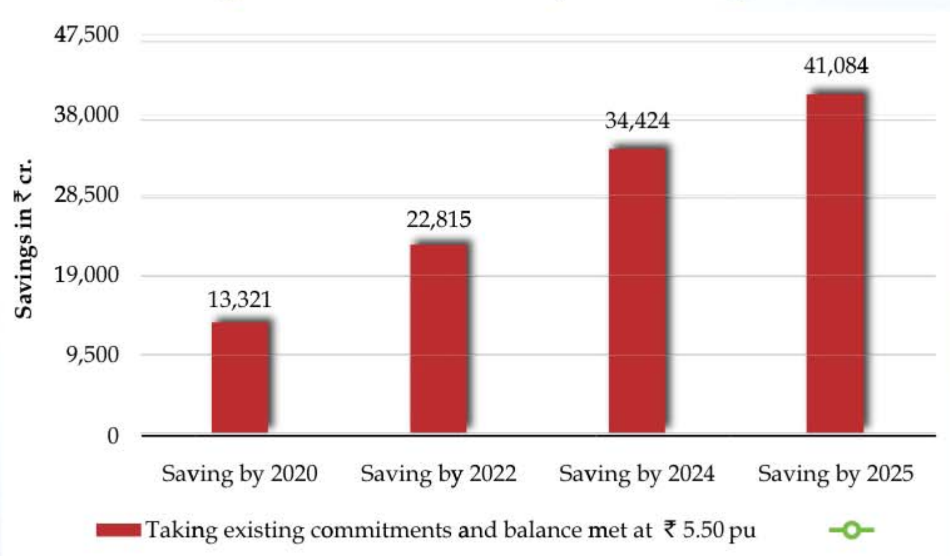
iv. Further, power from Railways' captive power plant at Nabinagar is expected to save **₹200 cr. /year.** First unit of Nabinagar plant covers **26 TSS'** in West Bengal.

The above initiatives are expected to result in saving of **₹4,000 cr./year** by **2017-'18** against business as usual mode. In addition, speedy electrification of existing tracks and commissioning of Dedicated Freight Corridor Corporation of India Ltd. (DFCCIL) network in next few years will further increase savings for IR. Further, savings will also accrue with improvement in **Specific Energy Consumption** (**SEC**) and induction of energy efficient locomotives capable of regenerative braking.

7.3 Savings Projected

Considering drawl of electrical energy for traction applications through open access at an average cost of **₹5.50/unit**, an estimate of savings up to year 2025 has been brought out in Fig. 11. These savings have been arrived at considering business as usual mode where the traction tariff would have otherwise grown at a rate of around **5%**. These savings are expected to increase further once DFCCIL is operationalized as envisaged.

Figure 11: Scenario of Projected Savings



The above savings have taken into account the expected upward pressure on thermal electricity with new emission norms coming into force. It can safely be said that by 2025, with these actions to procure power directly from market, Indian Railways will be able to save more than **₹41,000 cr.** During **2015-'25** on cumulative basis. It is expected that with induction of more number of locomotives and EMUs having regeneration capability, energy savings would further increase.

Table 3: Break up of Projected Financial Savings of ₹41,000 cr.

All figures are in ₹ cr.

Year	Payment in BAU mode	Payment in new paradigm	Total Savings	Cumulative Savings
2015-'16	10598	10200	397	397
2016-'17	11462	9000	2462	2860
2017-'18	12398	8491	3058	5918
2018-'19	13667	9270	3470	9388
2019-'20	15067	10121	3934	13321
2020-'21	16609	11050	4454	17776
2021-'22	18310	12064	5039	22815
2022-'23	19614	12799	5535	28350
2023-'24	21010	13579	6074	34424
2024-'25	22506	14406	6660	41084

7.4 Key take away

Limited runs of new strategy for procurement of electrical energy from market as deemed distribution licensee has shown path towards substantially bringing down cost of energy for electric traction in Indian Railways. By adopting this method of procurement of power, Indian Railways have broken business as usual mode and have entered into a new era in meeting its power requirement. It has opened various vistas to IR to manage power requirement in a dynamic fashion taking benefit of low cost power available through power exchange, short term contracts etc. This has brought in factor of innovation in power procurement in Railways and will change the way of working in Railways. This innovation will expose Indian Railways to power sector, a dynamic world, and enable it change energy mix from conventional to renewable sources in due course of time. It indicates that the new mechanism is indeed a proven method to reduce cost of traction electricity and merits its wider implementation. It can be readily seen that deployment of **Wind**, **Water (Hydro)**, **Solar** (**WWS**) based electricity cannot be done gainfully unless mechanism of open access is exercised wherein electricity is evacuated from **WWS** surplus zones to other regions.

7.5 Way ahead

Having come thus far, lessons have been learnt and are being internalized. Use of market mechanisms can be a double edged sword. To fully utilize benefits available and save against risks, there is a need to have **elaborate technology platform** to give confidence to grid operators that IR's connectivity system conforms to all statutory requirements of the Indian Electricity Grid Code 2010. A well designed system will deliver consistent and optimized savings. Accordingly, there is a **need** to have **robust nationwide Command, Control** and **Forecasting system** supported by Supervisory Control and Data Acquisition (**SCADA**) systems that are **highly optimized** for **real-time control** and **monitoring** with energy management functionality.

8 Integrated Rail Energy Management

To achieve this mission, **savings** of **₹41,000 cr.** by **2025**, a comprehensive Integrated Rail Energy Management System (IREMS) has been developed.

8.1 Objective

The objective of creating Integrated Rail Energy Management System (I-REMS) is to Improve viability of Indian Railways through an integrated approach towards optimized utilization of energy resources.

8.2 Goals

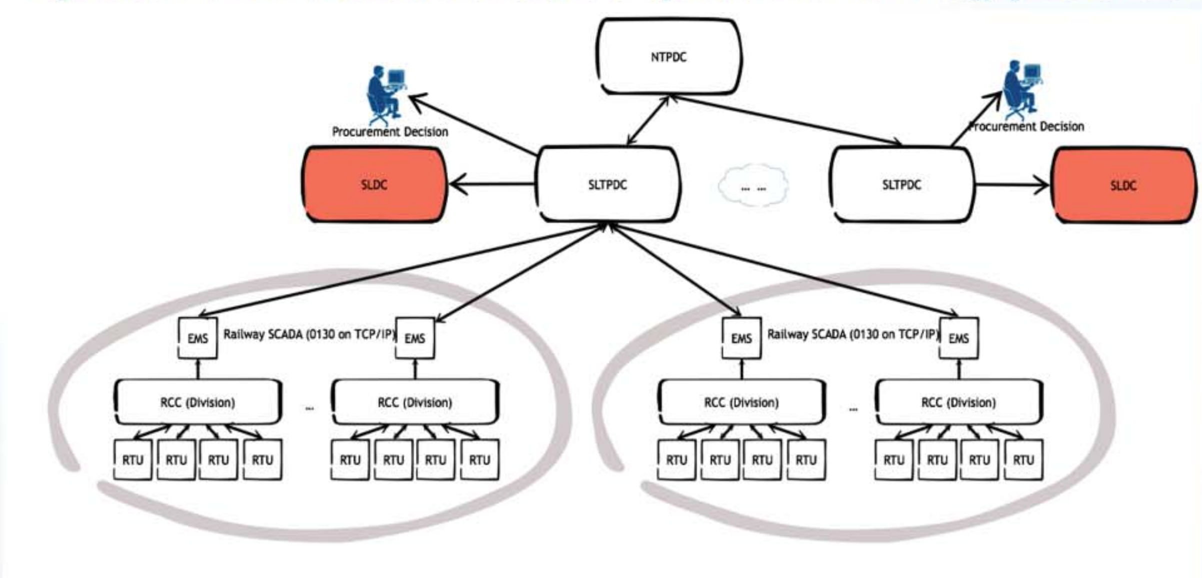
- **Operationalizing distribution licensee** status in all States by 2017-'18.
- **Changing energy mix** towards environmentally friendly and sustainable energy basket for traction & non-traction applications.
- **Capacity building** and improving **skill sets** of railway staff.
- **Integrate** power **distribution system of** Indian Railways.
- Develop **structures** for **sustained savings** in future.
- Induct **energy efficient technologies**.
- Take global leadership in decarbonizing.

To create a robust mechanism to sustain savings, there is a need to create visibility of entire network and capture traffic flows to generate more accurate forecasts.

8.3 Command & Control (C&C) Structure

To meet requirements of Indian Electricity Grid Code 2010, a real-time system needs to be created which would straddle on Indian Railway's SCADA systems (fig. 12).

Fig.12: Command and Control architecture to operationalize new energy procurement



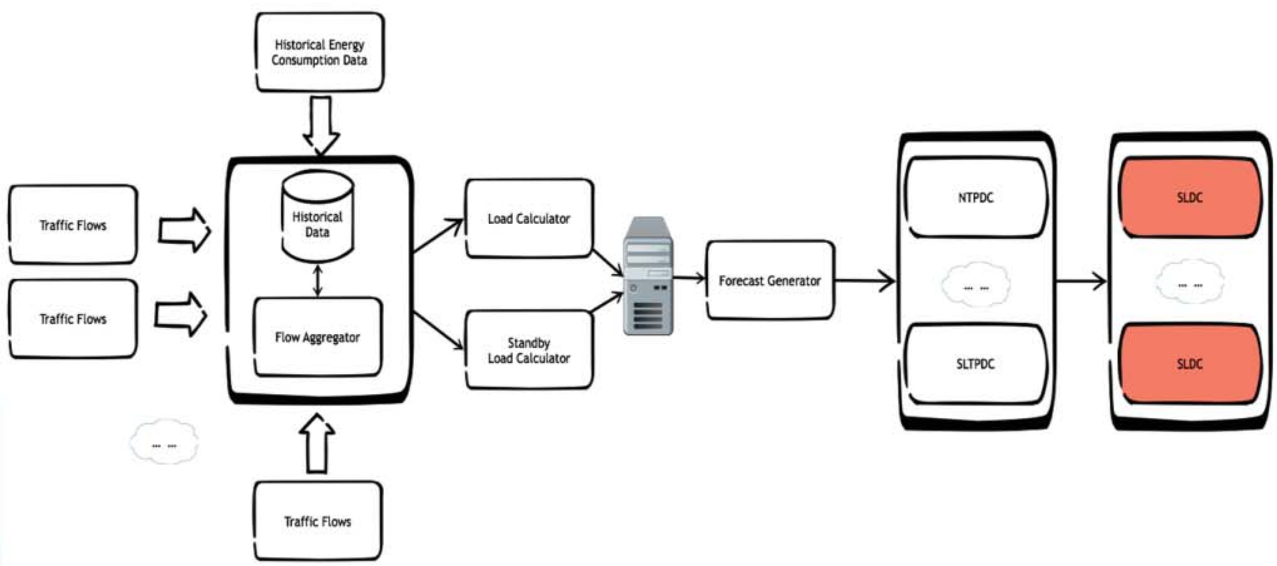
As boundaries of Zonal Railways are not coterminous with State boundaries, there is a need to create a **State Level Traction Power Dispatch Centre** (**SLTPDC**) which would aggregate parameters needed for connectivity compliance for onward transmission to State Load Dispatch Centers (SLDCs) which are under the control of State Governments.

SLTPDC would also function as state level network monitor and participate in handling grid level interaction at the advice of SLDC. Such capability is needed to give confidence to grid operators for faster reconnection of railway loads following major grid level disturbances.

Load forecasting would need industry grade load flow solver, which would be customized to handle traction loads. The calculator would take in section details and network availability and section particulars (new speed restrictions, blocks etc.) from SLTPDC.

Given criticality of load estimation (energy procurement plan for next day and corrections needed arising from blocks, restrictions and unusual), and high skill sets needed to run it several times in a day, it is proposed to create **National Load Forecasting Centre with facilities at two different locations.**

Fig.13: Load forecast calculator & National Load Forecasting Facility



8.4 Forecasting System

As IR would now be connected as another utility to grid, role of energy forecast and planning has to be shouldered by it. To start with, consumption data would be stored in a database which would help generate a datum need for day-ahead forecast. However, for more accurate forecast, traffic flows would need to be incorporated in a forecast calculator.

8.5 Human Resources

The entire command & control (C&C) structure is to be highly automated. However, highly specialized nature of this project require 24x7 manning of various levels of C&C structure as shown in Fig. 12.

Forecasting of power requirement being a highly involved exercise requires specialized tools and well trained manpower to perform this activity. Accordingly, it would require skill development by continuous training and up gradation of skills.

9 Transmission Line Network of IR

9.1 Developing an integrated transmission network

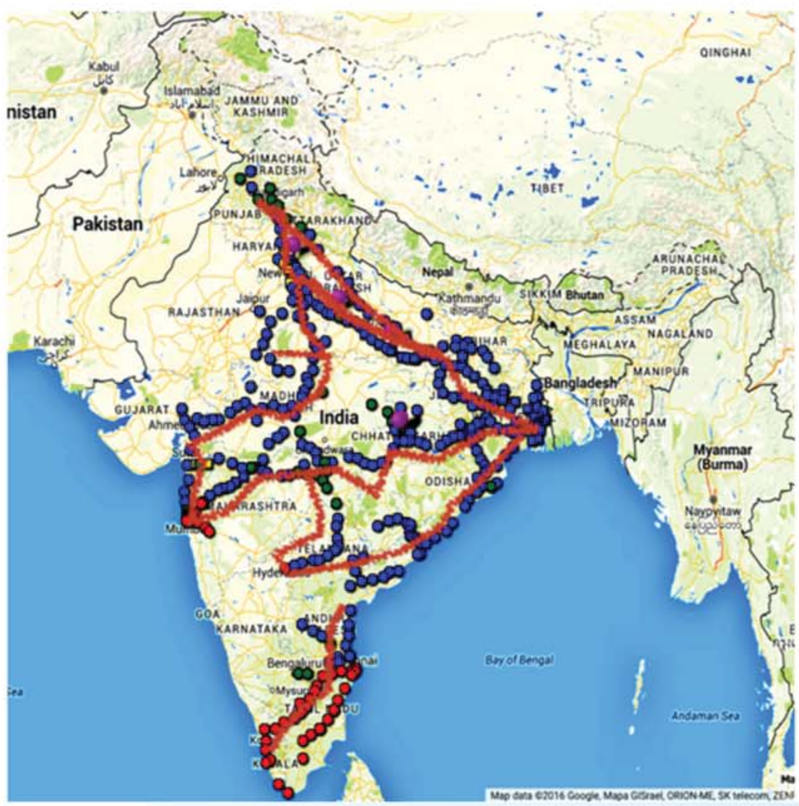
9.1.1 From long term perspective and for **improved reliability** of **power**, there is a need to have a **dedicated transmission line network** for **Railways** to ensure supply of electrical energy at reasonable cost to IR and for improved reliability of power supply. This aspect has become important due to IR's plans to develop high speed and dedicated freight networks across the country. Indian Railways currently have a transmission network of about 400 km from Dadri to Kanpur which has further been extended up to Allahabad. In addition, work has been sanctioned to take it further up to Somnagar via. Mugalsarai. Another work for developing 500 km length transmission network has been sanctioned in South East Central Railway to be executed by Rail Vikas Nigam Limited (RVNL).

9.1.2 In light of this, Indian Railways will develop an integrated transmission network to carry electrical energy for its traction applications. It is estimated that under phase-I, about **8,000 km** of **transmission line** would be required to give much needed **resilience** and supply security for **golden quadrilateral**. This network will also meet energy requirements of DFCCIL and high speed rail network. A tentative network of IR's transmission line for direct connection to CTU is shown in Fig. 14 (red line).

9.2 Way Ahead

9.2.1 A techno-economic study has been conducted by RVNL which indicates that developing a transmission network is a viable option and should be pursued from long term perspective of energy security to IR and to control the cost of energy for traction applications.

Fig.14: Tentative transmission line architecture



The transmission line network shown in **red color**

The traction substations are shown in **blue color**

10 Energy Conservation Initiatives

10.1 Efficient utilization of energy

Indian Railways have been very conscious about saving energy. It is said that **energy saved is energy generated**. From efficient energy utilization perspective, electric traction offers a unique feature of **regenerative braking** where kinetic energy of a train is converted into electrical energy can be fed back to electric grid. This feature has been successfully incorporated in **WAG_9**, **WAP_7** and **WAP_5** class of locomotives with potential for energy **saving 20%**, and in all new **EMUs** with potential for **saving** of **energy** upto **30%**. In addition to saving energy, regeneration increases life of rolling stock wheels and improves their availability for running trains thereby making electric traction more economical.

Over last **six** years, Indian Railways have been able to improve its Specific Energy Consumption (SEC) by about **13%** through various energy conservation initiatives. This in effect means a **saving** of about **₹2,600 cr.**

Fig.15: Regeneration of energy in three-phase electric rolling stock

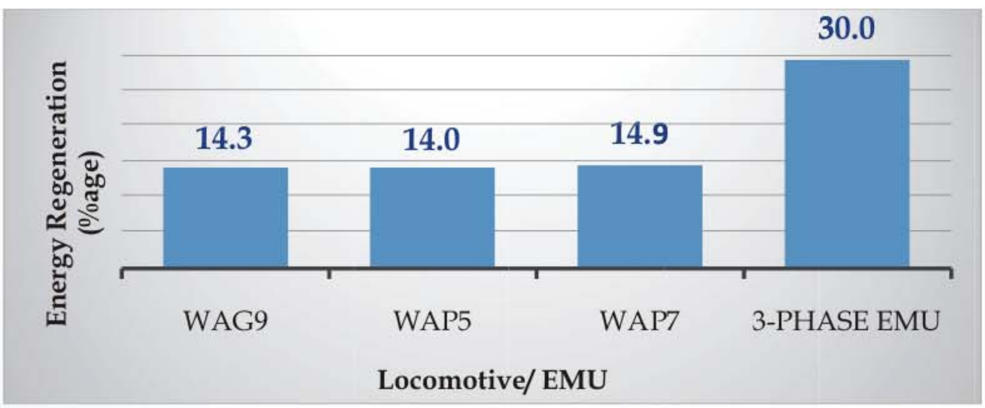


Table 4: Details of SEC over last six years

(in kWh/'000 GTKMs)

SN	Year	Specific Energy Consumption			
		Passenger	% age Reduction	Goods	% age Reduction
1	2010-'11	19.4	1.02	6.79	6.85
2	2011-'12	19.0	2.06	6.43	5.30
3	2012-'13	18.9	0.52	6.13	4.66
4	2013-'14	18.8	0.53	6.08	2.12
5	2014-'15	18.9	0	6.86	0
6	2015-'16	18.6	1.59	6.31	8.02
Improvement in last six years			**5.1**		**13.0**

As per Bureau of Energy Efficiency assessment for the year 2014-'15, an **improvement** of 3.3% over previous year was achieved in use of energy for **traction** application. In addition, for non traction power application, Indian Railways bagged **114 national energy conservation awards (NECA)** in last few years (Table 5).

vi). **Switching off** of trailing locomotives in case of multiple locomotive units when carrying light load.

vii). **Benchmarking** of energy consumption through use of microprocessor based energy meters in electric locomotives.

Table 5: Awards received for Railways in NECA over last three years

SN	Year	National Energy Conservation Awards received
1	2014	22
2	2015	23
3	2016	27

10.2 Initiative taken to improve energy utilization

10.2.0 Electric Traction

10.2.1 Electric Locomotives

i). With effect from 1st **Apr.'16, all new electric locomotives** are being produced with **three phase technology** having **regeneration** capability.

ii). **High efficiency 12000 HP** new generation locomotives will be produced by 2018.

iii). Regular counselling of **loco pilots** for **effective** use of **coasting** and **regenerative breaking**.

iv). Minimizing **idling** of electric locomotives in sheds and in yards.

v). Regular **counselling** of **loco pilots** for switching **OFF** of blower in case yard detention is more than **15 minutes**.

10.2.2 EMU and Air Conditioned coaches:

i). All new **EMUs** will be produced with **three phase** technology having **regeneration** capability

ii). Provision of EMU specific coasting boards and powering boards.

iii). **189nos.** of **energy efficient rakes** provided with 3 Phase **insulated-gate bipolar transistor** (IGBT) propulsion system have been introduced in **Mumbai Suburban** area since 2007. These rakes have given a saving of around **₹1cr./rake/year**.

iv). Capacitor banks have been provided for improvement of power factor and to reduce feeder current in End-on-Generation (EOG) AC coaches and Power cars.

v). Energy efficient LED lighting is being provided in all Railway coaches (picture 1).

Picture 1: Coach fitted with LED lighting

10.2.3 Traction Sub-Stations

i). Over **0.95 power factor** is to be maintained in traction sub-stations.

ii). Switching off of standby transformer which saves about 0.3-0.5% of total annual traction energy consumption.

iii). Regular **energy audit** of TSS.

10.2.4 Head on Generation (HOG)

i). HOG System: Presently, in many trains including Rajdhani, Shatabdi, Duronto etc., air-conditioning, lighting and other electrical loads of passenger coaches are powered by diesel engine driven Alternators in generator cars available at both ends of a train, which is **End on Generation (EOG)** system. Indian Railways have planned to replace this EOG system with **Head on Generation (HOG)** system wherein the above electrical loads of passenger coaches would be fed directly from electric power drawn by locomotive from grid. It would result in releasing the space occupied by existing generator cars for additional passenger accommodation. Accordingly, HOG system is expected to result in:

a) **Savings in energy bill** as electricity from DG set is far costlier;

b) **Increased revenue** to IR due to additional passenger carrying capacity; **Savings in foreign exchange** due to reduced diesel consumption;

c) **Zero noise** pollution; and

d) **Reduction in CO_2** emission by about **350 tons/rake/year.**

HOG system has already been provided in **ten trains (14 rakes)** and very soon **60 trains** will be taken up on this system. Further, CLW shall produce **all WAP_7** locomotives duly equipped with HOG system.

ii). **Savings in energy bill & additional revenue :** As per field calculations done for train no. 12951 (Mumbai Rajdhani) rake, **HOG** system would result in **net savings** of about **₹ 2.8 cr./rake/year** when compared to EOG system of operation. If electrical energy charges under the present agreements under open access are considered, these savings would further increase to **₹3.2** cr./rake/year. Further, considering that if the space released by the existing power cars is provided with passenger accommodation of three-tier AC, additional revenue for train no. 12951 would be **₹3.4 cr./rake/year.**

iii). **Financial benefit to IR:** Taking into account both fuel savings due to conversion into HOG system and also increased revenue from additional passenger accommodation, additional revenue to IR would be around **₹ 6.2cr./rake/year** with **BAU approach and ₹ 6.6 cr.** With **power under open access.** Additionally, conversion of these rakes with HOG system would further result in **reduction** in **diesel consumption** thereby saving in **foreign exchange.**

10.2.5 Conversion of Trains from Diesel Traction to Electric Traction:

Considering the financial benefits with running of trains on electric traction, **172 trains** have been taken over from diesel traction to electric traction during the period Aug.'16 to Dec.'16 with an estimated financial saving of **₹ 352.6 cr./year**. Further, **104** more **trains** are planned for conversion with potential for an additional savings of **₹ 223cr./year.**

10.3 Diesel Traction

10.3.1 Operational improvements

i). **Rationalization of fuelling pattern:** Considering variation in price of diesel procured in various **Railway Consumer Depots** (**RCDs**), tank fuelling has been planned to be done in RCDs having the lowest price. Each Railway has made a set of 4-5 RCDs which are cheaper and maximum fuelling is being done from these RCDs.

ii). **Diesel Electric Multiple Unit (DEMU):** DEMU Diesel power cars (DPCs) have smaller engines in comparison to a diesel locomotive and thereby consume less fuel. Replacing **short distance passenger trains** (having **5-10 coaches**) with **DEMUs** will give fuel **saving** of approximately **10%**.

10.3.2 Diesel Locomotive

i). **Locomotive with multiple generator sets:** Research Designs and Standards Organisation (RDSO) and Diesel Loco Modernisation Works (DMW) in collaboration with National Railway Equipment Company (NREC), USA have developed a technology wherein a locomotive would be provided with three smaller engines in place of a single large engine. The switching on/ off of these engines would be carried out by an on-board computer based on the power requirement. Two such locomotives have so far been turned out by DMW, Patiala. This arrangement has shown a fuel saving of up to **17%** for passenger operations. In addition to fuel saving, reduction in NOx as well as particulate emissions by **85-90%** has been noted.

ii). **Auxiliary Power Unit (APU):** APU is being provided in diesel locomotives to save fuel during **idling** of locomotives. APU is a self-contained unit containing a small diesel engine coupled to a compressor for charging brake pipe and to an alternator for charging battery. When a locomotive **idles** for **more** than **ten minutes**, main engine of locomotive shuts down and APU with a small **25 hp engine** comes into operation. A locomotive provided with APU consumes only **three litres** of **diesel per hour** compared to **25 litres otherwise.** Besides fuel saving, there would be a reduction in **lubricating oil** consumption, **wear** and **tear** of the **main engine**, CO_2 emission and emissions of other pollutants like **hydrocarbon** (**HC**), **nitrogen oxide** (**NOx**), **carbon monoxide** (**CO**) etc. APU system is expected to save **₹9 lacs/ year** on account of savings in fuel oil alone. The **payback** period for APU system is just **one** to **two** years. It costs **₹10 lacs** for providing in each new locomotive and between **₹10** to **20 lacs** for providing in each existing locomotive based on its design. Indian Railways have planned to roll out all its new diesel locomotives duly fitted with APU.

iii). **Common Rail Electronic Direct Injection (CReDI):** This system ensures optimal supply of fuel, complete combustion, reduction in emission and optimizing power output and is expected to reduce fuel consumption by**3-5%**. IR plans to introduce CReDI gradually in its fleet of diesel locos which is being developed for diesel locos by RDSO, a first on large diesel engines.

iv). **Miller Cycle Turbocharger:** Miller cycle turbocharger increases **power density** of engine **without exceeding** the **thermal** and **mechanical** limits. Miller Cycle turbocharger is designed to provide high boost pressure (**> 3.5 bar**) and is used with a modified cam shaft to suit Miller cycle timings. It gives a **reduction** in **fuel consumption** of around **2%**, **NOx** emissions by around **20%**, and **exhaust gas temperature** by up to **50°C**.

10.3.3 Alternate fuels

i). **Biodiesel: Indian** Railways have started **five percent** blending of biodiesel in high speed diesel (HSD) for traction purpose in line with directions laid down in **World Environment Day Charter**. Progressively, orders are being placed and coverage of bio-diesel is being increased. Indian Railways consumed around 5000 kilolitres of biodiesel during financial year 2015-'16. Second phase procurement of biodiesel has commenced. A total of **51**

RCDs have been identified for implementation of **5%** biodiesel during the second phase. This will take total number of RCDs using biodiesel to **87** in next **six months**.

ii). **Compressed Natural Gas (CNG):** IR has already started running CNG based DEMUs on Northern Railway and has plans to convert about **100** more DEMUs to run on dual fuel i.e., CNG and diesel.

iii). **Liquefied Natural Gas (LNG):** IR is working towards developing locomotives that can run on LNG.

10.3.4 Diesel Procurement System

As a snowball effect, diesel procurement system is also being revamped by procuring crude oil directly which has the potential for saving about **₹1,500 cr./year in coming years.** All these actions will make it possible for Indian Railways to become a modern high speed passenger friendly mode of transport.

11 Vision for Non-Traction Energy

11.1 Strategy for Sustainable Savings

Indian Railways consume around **2.5 billion units** of electricity for its non-traction usage. The consumption of non-traction energy has largely been static from 2008 onwards, which is an indication of efficacy of energy conservation efforts of Indian Railways (Fig.16)

Non-traction energy feeds the electrical loads of manufacturing units, workshops, maintenance depots, residential complexes, station area, platforms etc. Savings in consumption of electrical energy for non-traction applications can be achieved by replacing end use equipment with their energy efficient equivalents. However, for sustainable savings, a three pronged strategy forming a triad needs to be drawn which include **economy** in **end use**, **economy** in **procurement**, and having a **control & monitoring system** (fig. 17).

Fig.16: Energy Consumption for Non-Traction Applications

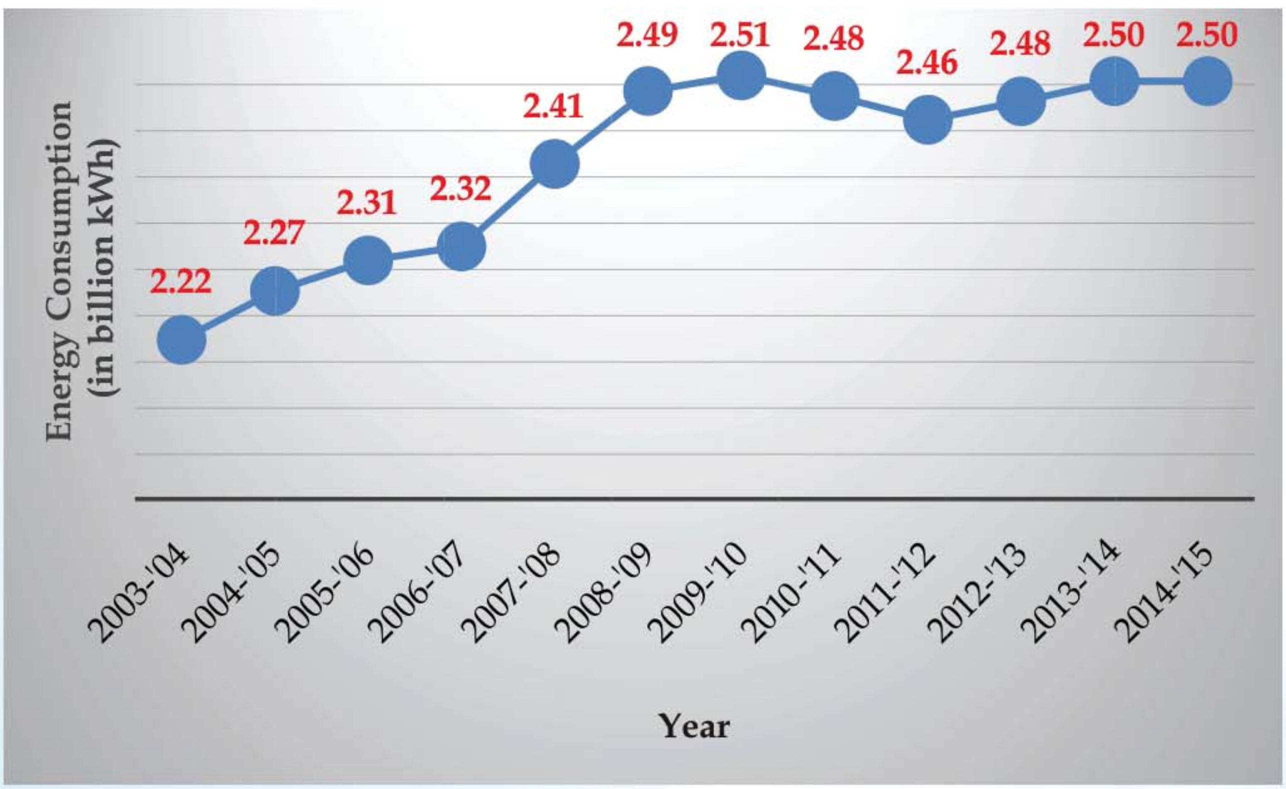
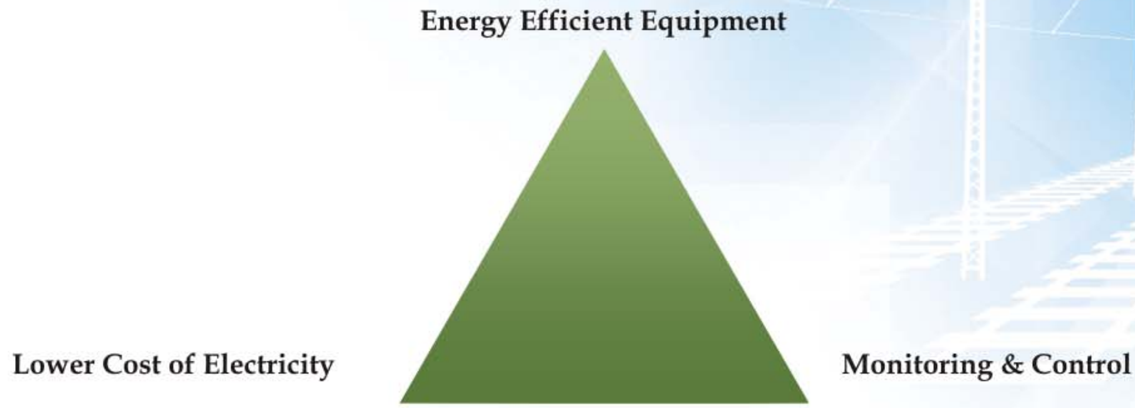


Fig.17: Triad for Sustainable Energy Savings



Economy in end use has a key focus point with progressive deployment of LED based lighting and energy efficient machines.

11.2 Action Plan for Improved Energy Efficiency

To further improve upon energy efficiency in non-traction field, following initiatives are being taken up:

- **Energy audits** of large load centres to assess demand profile and actual end use for mapping energy consumption pattern;
- Implementation of **utility SCADA** for better supervision and control of utility grid;
- Creation of a **viable funding** model whereby **improvements** are **cost neutral** to IR;
- Introduction of **Smart grid technologies**;
- Building an **automation** and **control** system; and
- Introduction of **smart metering**.

Keeping in line with above philosophy, **energy consumption** in **non-traction** category has been **mostly static** over last **five years** despite **increase** in **connected load** by around 15% which became possible due to a number of energy conservation initiatives undertaken. However, considering energy efficiency opportunities available and upcoming expansion, it is felt that there is an immense scope to further improve upon this by adopting use of innovative energy efficiency technologies, solutions, and best proven international practices.

11.3 Energy Conservation Measures

Indian Railways have started energy conservation journey much earlier and at every stage took benefit of best available technologies including replacement of **T-8 fluorescent** tube lights (FTL) by energy efficient **T-5 lights** and **compact florescent lamps (CFL)**, provision of light-emitting diode (LED) lights, energy efficient ceiling fans, occupancy sensors, use of star rated equipment etc. As per assessment made by Bureau of Energy Efficiency for non-traction applications, these initiatives have resulted in a **saving** of about **2% on year to year basis** energy during last three years despite about **5% increase** in **connected load**. These efforts have been regularly recognized at national level and IR has received several prestigious awards. Till 2016, IR has bagged **114 energy conservation awards and in 2016,** Indian Railways have bagged **27 National Energy Conservation Awards** instituted by Bureau of Energy Efficiency, which is the **highest number** of **National Energy Conservation Awards** received by Indian Railways during last **decade**.

As a part of energy conservation drive, Indian Railways have carried out **energy audit** of **448 facilities** till Mar.'15, and during 2015-'16, energy audit of **195 facilities** has been carried out. For moving ahead on energy conservation, IR has signed memorandum of understandings (MOUs) with Ministry of Power and BEE for co-operation in improving energy conservation over IR. These were signed in presence of **Shri Suresh Prabhakar Prabhu, Hon'ble Minister of Railways** and **Shri Piyush Goyal, Minister of State, Independent Charge for Power, Coal and New & Renewable Energy**, underscoring the importance accorded to energy in national decision making. Additionally, an **MOU** was also signed between **REMCL** and **Energy Efficiency Services Limited** (**EESL**) for implementation of energy conservation projects over Indian Railways with an aim to provide a frame work for **promoting future solutions** and facilitate Indian Railways to bring a **change** in its **energy mix**.

As part of capacity building of staff on energy efficiency, an **international summit on Energy Efficient Technologies in Railways** was held in New Delhi to share several energy efficient technologies adopted by various railways across different countries. Further, to emphasize on energy management system in Zonal Railways, *Centre for Railway Information Systems* (CRIS) has developed **Indian Railways Green Energy** (**IRGREENRI**) portal to disseminate green initiatives adopted over Indian Railways.

Ministry of Railways has issued directives to Zonal Railways to utilize LED tube light fittings under **Domestic Efficient Lighting Programme** (DELP) Scheme. About **ten lac LED luminaries** have been distributed to railway staff till Nov.'16. In addition, **2 lac LED luminaries** were installed by Zonal Railways so far.

Some important measures implemented on non-traction side for energy conservation are:

i. Replacement of **florescent tube lights** with **LED tube lights**.

ii. Replacement of **90 W ceiling fans** with energy efficient **ceiling fans**.

iii. Automation of Pumps with Global System for Mobile communication (**GSM**) **based techniques**.

iv. Use of **energy efficient star rated pumps**.

v. Micro-controller based **Automatic Platform Lighting Management System** with segregation of **70/ 30%** circuits.

vi. Use of **3 star** and **above** labelled electrical equipment.

vii. **Solar based LED lighting** system for **level crossing gates**.

viii. Use of **solar water heater** in place of **electric geyser**.

ix. Use of **occupancy sensors** in **offices**.

x. Become part of **Perform, Achieve and Trade** (**PAT**) scheme of Bureau of Energy Efficiency (BEE). Under this, **22 Designated Consumers** have been declared (**16 Zonal Railways** and **6 Railway Production Units**).

11.4 LED Lighting in Stations

To take forward the mission of efficient utilization of energy, Budget 2016-'17 had pronounced to cover all railway stations with LED luminaries in next two to three years and to obtain star rating for various railway installations. As part of this, about **350 railway stations** have already been **provided** with **100% LED lighting**. **To take ahead provision of LED lights at all stations, Energy Service Company (ESCO)** mode is also being pursued. A policy directive in this reference has been formulated and issued by Ministry of Railways.

Picture 2: LED Facade lighting at Mumbai CST station

The difference in energy efficiencies has consequences both for the fuel used and for the CO_2 emissions. In regions where rail is electrified and electricity generation emits few GHGs, such as European Union, rail can offer significant CO_2 benefits over road transport. All regions could achieve large CO_2 savings through a combined strategy of shifting freight from road to rail, electrify their railways and decarbonize their power generation.

Electrification: Switching from diesel to electricity allows a gain in efficiency close to 15% on a life-cycle basis because of the lower energy losses occurring in power plants compared to ICEs and added regenerative braking.

Picture 3: LED lights installed in Railway stations

11.4 IR- United Nations Development Programme (UNDP)- Global Environment Facility (GEF) Project

To support Indian Railways, a project on **Improving Energy Efficiency in Indian Railway System** was taken up in collaboration with **GEF** & **Energy and Environment Unit** of **UNDP**. Objective of the project is to speed up energy conservation measures in Indian Railways by introduction of latest energy efficient technologies.

Some of the pilot projects taken up under this programme are as below:

I. **Optimal light control** system over **Delhi Division,** Northern Railway (NR).

II. **Smart sense & smart grid system** at **Baroda House, New Delhi.**

III. **Automation** of **light & fan** control for **New Delhi Railway Station.**

IV. Implementation of SCADA in New Delhi Railway Station.

V. **Automation** of **pumping arrangement** at **Ghaziabad,** Northern Railway (NR).

VI. **Bay lighting** in **workshops & loco sheds.**

VII. Provision of **200 super energy efficient fans (**about **35 watt).**

VIII. Provision of **Solar pumps** over Delhi division, NR.

IX. Supply, fixing, testing & commissioning of **retro-fitment** of **LED lights** in **150 non-AC** self-generating second-class 3-tier sleeper **(GSCN)** coaches of Coaching Depot in Delhi division, NR.

X. **Energy efficient automation system** for **pumping installations** for **stations, workshops, hospitals, railway offices** and **colonies** at **Jaipur,** North Western Railway **(NWR).**

XI. Provision of **building management** system for **stations** and **railway offices** for **implementing energy efficiency measures** at **Dadar station,** Central Railway.

XII. Installation of **variable voltage variable frequency** (VVVF) drives for **lifts.**

XIII. Strengthened the institutional capacity of Indian Railways by creating a **Centre of Excellence (COE)** on energy efficiency technologies and solutions at Indian Railway Institute of Electrical Engineering (IREEN), Nasik, Maharashtra.

XIV. Under the institutional capacities and technical training component, more than 1000 Railway officers / supervisors were provided training on Computer Based Training (CBT) module and practical training on improving the energy efficiency of electrical appliances / equipments at Indian Railway Institute of Electrical Engineering (IREEN), Nasik, Maharashtra (picture 4) and at National Academy of Indian Railways (NAIR), Vadodara, Gujarat.

Picture 4: Motor & Pump training facility at IRIEEN, Nasik

12 Decarbonizing IR's Energy Needs

12.1 Why Decarbonise

Climate change mitigating action rests in reducing carbon footprint of economic activities. The twenty-first session of the **Conference of the Parties** (**COP21**) concluded in **Dec.'15** has brought together **195 countries** with objective of containing global warming which is attributed to emissions of **greenhouse gases** (**GHG**). There is an increasing pressure on all countries to reduce emissions while maintaining their levels of economic growth. Developing countries like India face pressure to increase economic activity and create employment for improving the quality of life of millions of people while at same time reduce emissions.

Hence, there is a need to reduce energy intensity (indicator of energy needed to support a unit of GDP) and reduce carbon footprint of our economic activities as well.

12.2 Why Electrified Transport

Globally, **transport sector** accounted for **27 %** of final **energy use** and **6.7 Gt CO_2 direct emissions** in 2010, with baseline CO_2 emissions projected to approximately **double** by **2050**[2]. Accordingly, for reduction in **GHGs,** transport sector needs to adopt **environment friendly** technologies.

It is a settled fact that decarbonization of electrical energy demand is comparatively straight forward than decarbonizing non-electrical energy demand. This is due to **electrical energy** being **neutral** to **primary** energy **source**. Electrical energy demand can be **decarbonized** using clean power sources such as **solar**, **wind**, **hydro**, and **waste-to-energy**. Further, decarbonized electricity is a key thrust area of government with **renewable energy** on top of **Hon'ble Prime Minister's agenda**.

While **two-thirds** of **freight** and **more than half** of **passenger traffic** of IR move on electric traction, **road transport** is continuing its **dependence** on **imported liquid fuels**. Hence, there is a major scope for switching transport towards Rail from the road sector and to reduce GHG emissions. This would improve the quality of urban environment in a big way.

[2] https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/drafts/fgd/ipcc_wg3_ar5_summary-for-policymakers_approved.pdf

13 Renewables in IR

While railway operations are energy intensive, provisions of the Electricity Act 2003 has given possibilities for decarbonizing energy basket. Indian Railways have already taken initiatives towards decarbonizing its energy envelop. These include installation of **36.5 MW** of **wind generation** and **14 MW** of **solar power plants** which are in operation and supply power to Indian Railways. In addition, **50 MW** of solar rooftop power plants are under **different stages** of commissioning. Indian Railways is working towards taking installed capacity of solar plants to **1000 MW** by **2020**.

By their very nature, railway stations, maintenance facilities and office buildings have sufficient untapped space to implement solar generation. The released passenger coach batteries also offer storage solutions for smaller locations to avoid use of Diesel Generating (DG) sets.

13.1 Solar Energy

As part of Indian Railways Solar mission to reduce dependence on fossil fuels and keeping in line with Budget 2015-'16 announcement of **Hon'ble MR**, Indian Railways has plans to set up **1000 MW solar power plant** in next five years. As part of this, IR will setup solar power plant on **rooftops** of **railway stations, buildings** and on **railway land** as per following:

- **500 MW solar plants** on **roof tops** of **railway buildings** through **developer mode** with power purchase agreement (PPA) by Indian Railways which will be used for meeting non-traction loads.
- **500 MW solar plants** to be put up on **land based systems** with **PPAs** to be signed by Indian Railways with **developers**, primarily to meet traction loads.

Indian Railways has started installing solar power plants in 2014-'15 on administrative buildings, stations and hospitals. Harnessing of solar energy was enhanced in following years taking total capacity to about **10 MW** by **2015-'16**. This includes **one megawatt** solar power plant on rooftop of **Katra Railway station**. Further to it, order for **6.5 MW** solar plants (**Five** locations **each** of **500 kWp, 20 locations** each of **100 kWp, 200 locations** each of **10 kWp**) was issued. These plants have started getting commissioned and this will take total installed capacity of solar power plants to **17 MWp**. Under the net metering provision, this power can be consumed in railway grid thereby paving way for steady decarbonization of Indian Railways. **The pictures of solar power plants set up by various Zonal Railways are as under:**

"India has now graduated from megawatts to gigawatts in terms of renewable energy production"
Hon'ble Prime Minister Shri Narendra Modi

Picture 5: 1.0 MW Rooftop Solar Power Plant at Katra Railway Station

Picture 6: 500 kWp Solar Rooftop Power Plant at Varanasi Railway Station

Picture 7: 500 kWp grid connected Solar Rooftop Power Plant at Secunderabad station

Picture 8: Solar Rooftop Power Plant at Jaipur Station

13.2 Harnessing Solar Power

To harness solar energy on a large scale, Zonal Railways have been allocated installation of **50 MW** capacity under phase-I for which open tenders have been issued. These plants will start getting **installed** from **July'17 onwards**. Further, Zonal Railways have identified additional capacity for installing 100 MW solar power on rooftops. REMCL has invited tenders for the same. For all these **rooftop installations**, **Viability Gap Fund** (**VGF**) from Ministry of New Renewable Energy (MNRE) has been obtained. Further tenders for rooftop installations will be floated in a phased manner for **350 MW** under the MNRE's incentive scheme for which consultancy has been awarded to **M/s. Central Electronics Limited** (**CEL**) for assessing capacity. The total installed capacity of rooftop solar power plants on railway buildings is projected at **500 MW** by **2018-'19**.

Following actions have been taken for installation of 500 MW solar plants on land systems:

i). **50 MW** is being set up through **Reva Ultra Mega Solar Limited** (**RUMS**) in M.P.

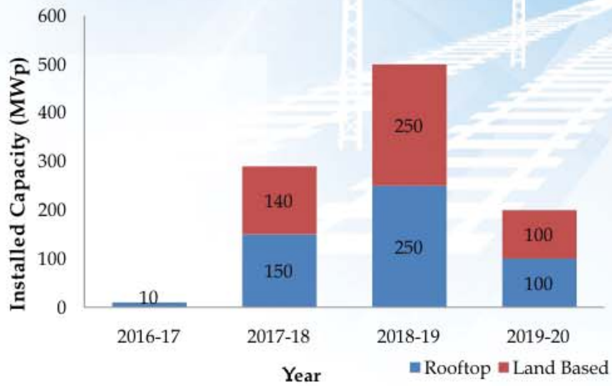
ii). **40 MW** will be setup through **Solar Energy Corporation India** (**SECI**) for traction load with **battery backup** (**30 minutes**) as per MNRE special scheme.

iii). **150 MW** Solar power plant will be setup through SECI for meeting non traction power requirement.

iv). For balance about **250 MW**, REMCL is working out various options.

The year wise projections for setting up of solar power plants over IR are in Fig. 18:

Fig. 18: Projected installed Capacity of Solar Power Plants



13.3 Harnessing Wind Power for Railways

Indian Railways have targeted to increase its installed capacity of wind power to about **200** MW. Of this, **10.5 MW** capacity **wind mill plant** was set up in **Tirunelveli** district in Tamil Nadu for meeting energy requirements of Integral Coach Factory (**ICF**), Chennai which has generated **138.4 million units** till **Mar.'16**. Further, **26 MW windmill** power plant was commissioned in Oct.'15 in **Jaisalmer**, Rajasthan which has generated more than **60 lac units**. Further to it, installation of balance capacity is planned through tariff based bidding and partly through investment by Railways through REMCL.

These capacities will be created based on requirement of non-solar **Renewable Purchase Obligation** (RPO) obligation in various states. IR *is **planning** to install **56MW wind mill** through **tariff based bidding** for meeting non-traction loads in **Maharashtra**, **Andhra Pradesh**, **Tamil Nadu** and **Madhya Pradesh**. Further, REMCL shall set up* **100 MW** capacity **wind mill plants**.

14 Design and Made in India

Electrified economy creates more quality jobs in country as primary resources are from within country where complete value chain of energy transformation rests in the country(from primary energy harvesting to consumption). Possibility of diversified primary energy sources makes electrified activity inherently supportive of variety of jobs and gives better linkage to economic activities. For creating sustainable handling of waste on IR's network, waste-to-energy is a real possibility.

The ambitious **Swachh Bharat Mission** launched by **Hon'ble Prime Minister** has embedded in it creation of sustainable model of waste disposal. **Waste-to-energy**can be an interesting activity to address waste disposal in a sustainable manner. Electricity so generated can be deployed on IR's grid.

As Indian Railways embarks on Mission 41k, following activities would create quality jobs:

- **Rail Energy Management System**
  - **Creation of Command & Control system for Traction Energy**: For monitoring and controlling traction energy flows in accordance with statutory requirements and functional needs of IR.
  - **Creation of Monitoring and Control system of non-Traction Energy**: For control and supervision of electricity flows on IR's utility grid.
- **Renewable Energy opportunities**

  Railways are committed and poised to induct about **1.2 GW** of **renewable energy**. Globally, it has been accepted that renewable energy generation creates quality and sustainable employment.
- **Creation of Indian Railway Transmission Line Network**: This would serve to give resilience to IR's traction network and reduce its dependence on STUs.
- Instead of just aiming at saving of costs by a mercantile approach, the complete technical architecture would be designed under leadership and guidance of in-house resources. Indian enterprises would engineer products and deliver complete structure.
- By **association** with **academic institutes**, young minds would be exposed to best engineering practices, engineering economics, and energy systems, and give sufficient practical challenges to R&D labs to take mantle of global leadership in power systems.
- As Rail Energy Management System gets more integrated, possibilities of further optimization would grow. Thus, by highly selective system up gradation, network level energy flows can be better visualized, monitored and hence controlled.

15 Conclusion

To **improve financial performance of Indian Railways, reversing** the **increasing trend** in **fuel expenditure** is an **important** area as it constituted around 27% of its **ordinary working expenses.** In this regard, operationalizing the deemed licensee status available to Indian Railways was the first land mark achievement towards reducing the energy bill of electric traction. In 2015-'16, these initiatives have resulted in an **annualized savings** of **₹1,300 cr.,** and it is expected that these actions would take annualized savings of about **₹3,000 cr.** In **few years.**

The impact of procuring power as a Licensee will bring in savings of more than **₹4,000 cr./year** against BAU. Its effect on Indian Railways' finances over **next ten years** will be more than **₹41,000 cr.** and will add to making Indian Railways a more customer friendly mode of transport. As a **snowball** effect, **diesel procurement system** is also being **revamped** by procuring **crude oil directly** which has the potential for saving of about **₹1,500 cr./year.**

Equally important is introduction of latest generation **energy efficient technologies** which have been successfully done by deciding to produce only **3 phase locomotives** and **EMUs having regeneration capacity,** and also to take up manufacturing of new electric locomotives of **12000 HP** capacity.

India currently stands at a moment of opportunity in which it is evident that **transition** to a **low-carbon system** can bring about **economic growth.** The falling costs of renewable energy, ambitious government plans for rapid deployment of renewable energy, and increasing financial support from international agencies, governments and investors indicate that transition to a low-carbon economy is not only possible but also already underway. Since Indian Railways is the single largest consumer of electricity in India by consuming about **18 TWh/year, prioritizing decarbonisation** of Indian Railways could help India achieve its 2030 emission reduction goals as well as improve energy security by reducing fossil fuel imports. Targeting **100% decarbonisation** of IR is a strategic example for transportation sector as well as to Indian industry as a whole. As part of this strategy, IR has planned to set up **1000 MW solar power** plants and about **200 MW of wind power** plants in next few years across various Zonal Railways & productions units.

Waste-to-Energy: Swachh Bharat Mission aims at sustainable methods of maintaining cleanliness. By careful choice of technology, IR can convert waste to electricity. This energy can be deployed on IR's electric grid.


दरे
आरपीएम
डब्ल्यू एपी-7
30391
INDIAN RAILWAYS
30391

Ministry of Railways

Railway Board

Rail Bhawan, New Delhi