GOVERNMENT OF INDIA (भारत सरकार)
MINISTRY OF RAILWAYS (रेल मंत्रालय)
(RAILWAY BOARD) (रेलवे बोर्ड)

2022/EEM/150/09 New Delhi, Dated: 30.12.2022

General Managers
All Indian Railways &
Production units

Vice Chairman,
Rail Land Development Authority

General Manager(Const)NF Rly., Guwahati
General Manager, CORE, Allahabad

Director General, RDSO, Lucknow
Director General, NAIR, Vadodara
Director General, IRIEEN, Nasik

Sub: Adoption of Energy Efficiency Measures in Non-Traction over Indian Railways
Ref: i) Railway Board Letter No-2016/Elect(G)/150/9 dt-08.03.2018
ii) Railway Board Letter No 2016/Elect(G)/150/9 dt 09.09.2016 and 27.12.16
iii) Railway Board Letter No 2016/Elect(G)/150/9 dt 20.07.2022

Indian Railways has set a target to achieve Net Zero Carbon Emission by 2030. Lowering of energy consumption by adopting energy-efficient measures would be one of the key measures to achieve this ambitious target.

2. Therefore, to adopt energy efficiency measures within Indian Railways a comprehensive policy incorporating various aspects related to energy efficiency in Non-Traction for speedy and effective implementation has been prepared. The policy broadly centered around 05 action points i.e. *Sustainable Buildings, Cloud based data monitoring and management portal, Energy Efficiency in equipment and appliances, Power quality restoration, Capacity building and awareness.*

2.1 In order to implement the different energy efficiency measures mentioned in the policy in a given time-frame, action points along with timelines are mentioned in the chapter-4 of the policy itself.

3. Accordingly, all Zonal Railways are advised to chalk out the action plan to achieve the timelines mentioned in the policy and apprise the Board's office within 15 days of issuing this policy.

The policy is being issued with the approval of Board (MT&RS, MI, MF and Chairman & CEO)

30/12/22

(Manish Gupta)
Executive Director, Electrical Energy Management
Railway Board
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DA: Indian Railways Energy Efficiency action plan and policy.

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Copy to the following for information and necessary action:

1. PCEE's All Zonal Railways & PUs.
2. PCE's All Zonal Railways & PU's.
3. PCEE/CORE, Allahabad.
4. ED/EM, RDSO, Lucknow.
5. Directors, IRICEN/Pune, IRISET/Secunderabad, IRIMEE/Jamalpur.

30/12/22

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Copy also to:

1. EDME(EnHM), ED/GS/Civil-I, EDF(X), ED/SD, ED/L&A for kind information please.
2. DME/C&IS with a request to upload on Railway website under "Circulars" head of EEM Dte.

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INDIAN RAILWAYS: ENERGY-EFFICIENCY ACTION PLAN & POLICY [IREAP]

INTEGRATED ACTION PLAN FOR REDUCING NON-TRACTION ENERGY USE

DECEMBER 30, 2022

INDIAN RAILWAYS ENERGY-EFFICIENCY ACTION PLAN & POLICY [IREAP] INTEGRATED ACTION PLAN FOR REDUCING NON-TRACTION ENERGY USE 1

1 CONTEXT 1

1.1 Energy Efficiency Action Plan 1

2 KEY PROVISIONS OF THE ENERGY-EFFICIENCY POLICY 2

2.1 AP1- Sustainable Buildings 2
2.2 AP2 - Cloud based centralized web-portal for Data Monitoring and Management 2
2.3 AP3- Energy Efficiency in Equipment AND Appliances 3
2.4 AP4 – Power Quality Restoration 3
2.5 AP5 – Capacity Building and Awareness 3

3 PERIODIC EVALUATION OF IMPLEMENTATION PROGRESS AND POLICY UPGRADATION 4

4 DETAILS OF ENERGY-EFFICIENCY ACTION POINTS 5

4.1 AP1- Sustainable Buildings 5
4.2 AP2 - IR NIYANTRAC (cloud-based data monitoring and management portal) 5
4.3 AP3 – Energy Efficiency in Equipment and Appliances 6
4.4 AP4 – Power Quality Restoration 6
4.5 AP5 – Capacity Building and Awareness 7

5 AP1 – SUSTAINABLE BUILDINGS 8

5.1 Compliance of all buildings to BEE Shunya/Shunya+ 8
5.2 Compliance of new and upcoming non -residential buildings to Super ECBC 10
5.3 Compliance of residential buildings to ECO Niwas Samhita 12
5.4 Adoption of ESCO model to implement EE initiatives 13

6 AP2 – CLOUD BASED CENTRALIZED WEB-PORTAL FOR DATA MANAGEMENT, CONTROL AND MONITORING. 17

6.1 Development of cloud-based data management web portal, led by CRIS 17
6.2 IOT devices/smart devices to be installed by Railways which are integrable with CRIS application platform 18

7 AP3- ENERGY EFFICIENCY IN EQUIPMENT AND APPLIANCES 22

7.1 Adoption of Lighting, Fan and AC Controllers 22
7.2 Procurement of BEE 5 star rated appliances 22
7.3 30%-70% platform lighting circuit segregation 23
7.4 Replacement of conventional fans with BLDC fans 24
7.5 Energy efficiency measures in Workshops, Production units, Locomotives including use of VFD drives, energy efficient motors, etc. 24
7.6 Adoption of low carbon cooling systems 25
7.7 Other energy efficiency retrofit 28

8 AP4 – POWER QUALITY COMPENSATORS 29

8.1 Ensure provision of APFCs 29
8.2 Power Quality Restorers should be used as needed 30

9 AP5 – CAPACITY BUILDING AND AWARENESS 31

9.1 Periodic training of the staff of IR 31
9.2 Development of Printed/Digital awareness campaign 31
9.3 Annual energy efficiency (OorjaVir) award 32
9.4 Reporting of Energy Efficiency and Net Zero actions 32

INDIAN RAILWAYS
ENERGY-EFFICIENCY ACTION PLAN & POLICY [IREAP]
INTEGRATED ACTION PLAN FOR REDUCING NON-TRACTION ENERGY USE

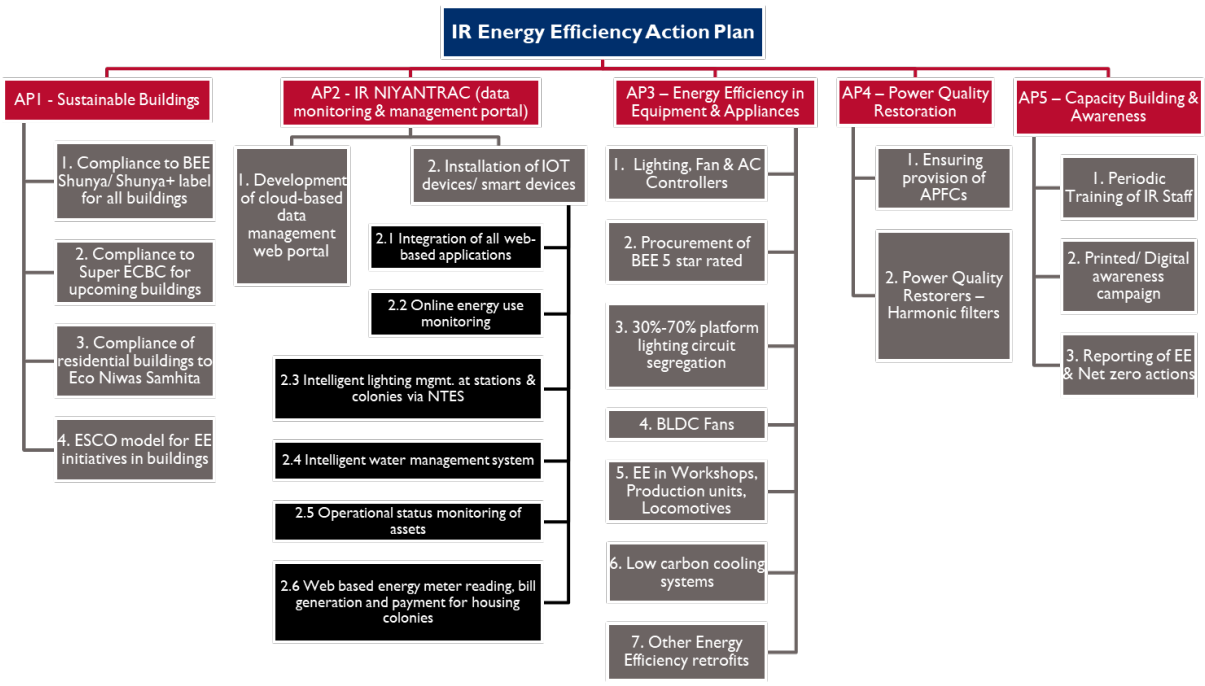
1 CONTEXT

India has made comprehensive climate commitments to achieve Net Zero Emissions and has set ambitious goals for energy efficiency and reduced carbon intensity of the economy. Aligned with this vision, Indian Railways has set a target of Net Zero Carbon Emission by 2030.

Non-Traction end-uses account for over 2,100 GWh of electricity use per year, projected to increase by 30% by 2030 as IR network and infrastructure expands. Achieving the Net Zero Emissions target requires an integrated approach to reducing energy use intensity of existing and future infrastructure along with a shift to renewable energy sources. IR has started work on many of these fronts including energy demand management, shift from diesel to electricity, greening of electricity supply, and offsetting emissions. Lowering of energy consumption by adoption of energy efficient measures would be one of the key measures to achieve this target.

1.1 ENERGY EFFICIENCY ACTION PLAN

IR has formulated an energy efficiency policy with an action plan comprising of five action points (APs) for reducing energy use in non-traction applications. This policy and the action points are based on an integrated approach of life-cycle carbon reduction strategies, with a scalable implementation approach, and continuous measurement and verification through an online system, along with capacity building of IR officers and staff at all levels. The policy includes provision for online monitoring energy use along with a dashboard for tracking progress of the policy action plan. The policy also address the need for training on broad issues of sustainability and carbon reduction, along with specific technical training for energy efficiency.



2 KEY PROVISIONS OF THE ENERGY-EFFICIENCY POLICY

2.1 AP1- SUSTAINABLE BUILDINGS

1. **Compliance of all buildings to BEE Shunya/Shunya+** - All existing buildings (having connected load of more than 30 kW) to be made, as far as possible, BEE Shunya/Shunya+ label including installation of smart meters for energy monitoring.
2. **Compliance of new and upcoming buildings to Super ECBC -** All new buildings having connected load of 30 kW and above shall comply to BEE Super ECBC guideline and for the new buildings having connected load of less than 30 kW, it is highly encouraged to comply with BEE Super ECBC guideline.
3. **Compliance of residential buildings to Eco Niwas Samhita** - All new residential buildings built on plot area of more than 500m^2 shall comply to Eco Niwas Samhita. Code compliance has two parts – Part I, launched in 2018, caters to mostly building envelop requirements and the Part II, launched in 2021, caters to the electromechanical and renewable energy systems.
4. **Adoption of ESCO model to implement EE initiatives -** BEE is preparing guidelines for implementing energy efficiency measures in large commercial buildings through ESCO business model. IR is also participating in the "Promotion of ESCO Model" program initiated by BEE and enrolled ten buildings for the energy efficiency retrofits. In this model, BEE empanelled energy auditors will conduct the Investment Grade Energy Audit (IGEA) to set up the baseline and identification of energy efficiency measures. Once the baseline is set-up, Shared savings model or guaranteed savings model can be adopted for implementing the identified EE retrofit. IR shall also extend ESCO models for procurement of appliances and equipment in buildings as well as Railway Stations e.g., lighting systems. In case of upfront investment ESCO implementation, the payback period of the energy efficient technologies should be less than half of the manufacturer's recommended life cycle.

2.2 AP2 - CLOUD BASED CENTRALIZED WEB-PORTAL FOR DATA MONITORING AND MANAGEMENT

1. **Development of cloud-based data management web portal, led by CRIS -** In order to have standardization, optimal utilization of data collected and security of data, data from smart/IOT devices shall be integrated with IR's own IT application. CRIS shall also develop mobile application for the same for easy accessibility, monitoring and control
2. **Installation of IOT devices/smart devices by Railways which are integrable with CRIS application platform.**

2.1 **Integration of all web-based applications of ZRs to a centralized portal -** Communication between cloud server and smart systems is to be done via standard, common and open-source protocol. It will act as a single bridge for integration with other IR IT application viz Railsaver.

2.2 **Online energy use monitoring -** All energy inflows and outflows are required to be monitored so that the energy baseline consumption is established holistically. Hence, energy monitoring provisions like submetering, diesel consumption records, energy bills via submetering etc. are to be incorporated which can aid to develop energy portfolio of different zonal railways on the basis of which energy consumption reduction plans may be developed.

2.3 **Intelligent lighting management at stations and colonies including 30%-70% platform lighting through NTES–** Integration with centralized portal will lead to automatic/ scheduled control and monitoring of outdoor and infrastructure lighting. 30%-70% lighting of station platforms can be integrated with NTES for automatic switching on/off platform lights based on actual arrival/departure of trains.

2.4 **Intelligent water management system; control and monitoring of pumps and overhead water tanks; and quick watering system at Railway Stations –** Integration of Real time monitoring like continuous water level monitoring in overhead tanks/underground water tanks,

pressure, flow etc. with automatic switching controls. rules/ logics may be defined by user of Railways as per local requirements, e.g., watering system at colonies, quick watering system at stations.

2.5 **Operational status monitoring of escalators and lifts -** Operational monitoring of the assets like lifts, escalators etc. can be done and alert system via SMS or automated calls can also be integrated to intimate service engineers of any failures.

2.6 **Web based energy meter reading, bill generation and payment for housing colonies -** Mobile and web-based solution for data collection, tariff-based bill generation, user reports as well as data exchange capability with iPAS (Integrated Payroll Accounting System). Cost benefit analysis of this initiative would need to be undertaken.

2.3 AP3- ENERGY EFFICIENCY IN EQUIPMENT AND APPLIANCES

1. **Adoption of Lighting, Fan and AC Controllers -** Adoption of occupancy sensor-based controllers at all offices, rest houses, service buildings.
2. **Procurement of BEE 5 star rated appliances –** BEE has issued the list of mandatory and voluntary appliances under star labelling program. It is advised to procure BEE 5-star rated equipment which falls under the purview of star labelling program.
3. **30%-70% platform lighting circuit segregation -** Automatic switching - on/off lights at all stations based on arrival of trains shall be deployed. Circuit segregation for affecting the same needs to be done at all stations.
4. **Replacement of conventional fans with BLDC fans -** Power demand of a BLDC ceiling fan is around 50% of the conventional ceiling fan and it also offers more efficiency when compared to conventional fan. For indoor environments, BLDC fans are suitable to be used in place of conventional fans to achieve energy savings. For external use, reliability and cost benefit analysis to be done.
5. **Energy efficiency measures in Workshops, Production units, Locomotives including use of VFD drives, energy efficient motors, etc. –**Installation of energy efficient motors and pumps, VFDs for cranes, pulleys and other variable loads need to be done. VFDs are to be installed to achieve energy savings wherever part load conditions occur. Total cost of ownership of the equipment will be considered for procurement.
6. **Adoption of low carbon cooling systems -** Low Carbon Cooling Systems such as evaporative cooling, geothermal cooling, solar based cooling shall be explored and implemented subject to the feasibility and cost-benefit analysis.
7. **Other energy efficiency retrofit –** This would include any other equipment or appliance retrofit which will lead to energy savings, under the discretion of zonal railways.

2.4 AP4 – POWER QUALITY RESTORATION

1. **Ensuring provision of APFCs -** Average PF of various railway buildings is either lagging or leading and there is scope for correcting it to near unity (ideal value). Wherever APFCs are installed, it should be ensured that they are in working condition.
2. **Power Quality Restorers should be used as needed–** Maintaining good power quality can avoid occurrences like equipment damage, early ageing etc. Hence, power quality compensators such as Hybrid Harmonic Filters: APFC with passive and active harmonic filters may be adopted by IR.

2.5 AP5 – CAPACITY BUILDING AND AWARENESS

1. **Periodic training of the staff of IR** - Training on sustainability, energy efficiency and renewable energy technology, every 6 months along with involving IRIEEN and other CTIs.
2. **Development of Printed/Digital awareness campaign and energy efficiency awards**– Development of flyers, booklets, pamphlets and banners for media, railway stations, and all IR facilities to create awareness on decarbonization, energy efficiency and sustainability among stakeholders. Establishment of energy efficiency award within Indian Railways for recognizing exemplary contributions

towards energy efficiency. Award will be of two categories a) Individual/ Team category b) Divisional category.

3. **Reporting of Energy Efficiency and Net Zero actions –** Establishment of two-way communication and reporting between various stakeholders, ZRs and Board to ensure reporting on the best practices/innovations.

3 PERIODIC EVALUATION OF IMPLEMENTATION PROGRESS AND POLICY UPGRADATION

The progress on action points shall be evaluated on half-yearly basis by the individual Zonal Railways (ZRs) at the level of General Managers (GM). The Overall progress of various action points may also be put up to railway board on half-yearly basis. Railway board shall also revise the policy recommendation on yearly basis to incorporate the energy efficiency technological advancements. This will pave the way towards the continuous implementation of EE measures over Non-Traction side of the Indian Railways.

4 DETAILS OF ENERGY-EFFICIENCY ACTION POINTS

4.1 AP1- SUSTAINABLE BUILDINGS

Action Points	Timelines
1. All existing buildings (having connected load of 30 kW or more) to be made, as far as possible, BEE Shunya/Shunya+ label including installation of Smart Meters for monitoring	• Shunya/Shunya+ compliance check – T + 4 months (m) • Action Plan to be made by Zonal Railways for implementation
2. All new and upcoming buildings of 30 KW and above to be made SuperECBC compliant	• SuperECBC compliance check – T + 4m • Guidelines to be circulated by Railway Board to ZRs
3. All new residential buildings to be Eco Niwas Samhita compliant	• Eco Niwas Samhita compliance check – T + 4m
4. Adoption of ESCO model to implement EE initiatives in existing buildings.	• Investment Grade Energy Auditing Tender float – by T + 2m ✓ Tender Award – by T + 5m ✓ Conduct of Audit – T + 8m ✓ For Central AC Buildings – T + 10m • ESCO contracting – from T + 10m

4.2 AP2 - IR NIYANTRAC (CLOUD-BASED DATA MONITORING AND MANAGEMENT PORTAL)

Action Points	Timelines
1. Development of cloud-based data management web portal, led by CRIS.	• Development of application platform by CRIS –T + 12m

2. Installation of IOT devices/smart devices by Railways which are integrable with CRIS application platform. 2.1 Integration of all web-based applications of ZRs to a centralized portal. 2.2 Online energy use monitoring 2.3 Intelligent lighting management at stations and colonies including 30%-70% platform lighting through NTES 2.4 Intelligent water management system, control & monitoring of valves, pumps and overhead water tanks. 2.5 Operational status monitoring of escalators and lifts. 2.6 Web based energy meter reading, bill generation and payment for housing colonies	• Proof of Concept – December 2022 • Pilot project on IOT devices by a ZR by T + 12m. • Sanction of an Umbrella work for Zonal Railways in 2023-24.

4.3 AP3 – ENERGY EFFICIENCY IN EQUIPMENT AND APPLIANCES

Action Points	Timelines
1. Procurement of BEE 5 star rated appliances. 2. 30%-70% platform lighting circuit segregation. 3. Replacement of conventional fans with BLDC fans (indoor use). For external use reliability and cost benefit analysis to be done. 4. Energy efficiency measures in Workshops, Production units, Loco sheds including use of VFD drives, energy efficient motors, etc. 5. Adoption of low carbon cooling systems based on local conditions. 6. Adoption of Lighting, Fan, and AC Controllers. 7. Other energy efficiency retrofits.	• Action plan along with work proposals to be finalized by all Zonal Railways by T + 3m

4.4 AP4 – POWER QUALITY RESTORATION

Action Points	Timelines
1. Ensuring provision of APFCs	• Identification of defective APFCs– T+2m • Installation of APFCs – T+9m • Operationalization of defective APFCs - T+9m

2. Power Quality Restorers should be used as needed	• Identification of load centers for Power Quality Audit – T+2m • Installation of Power Quality Restorers - T+9m

4.5 AP5 – CAPACITY BUILDING AND AWARENESS

Action Points	Timelines
1. Periodic training of the IR Officials ✓ Training of Officers, Supervisors and Staff ✓ Hosting training in association with IRIEEN, STC and CTIs ✓ Different batches should be nominated for holistic capacity building ✓ Training course - aligned with IR objective of net zero carbon emissions	• Training of staff -every 6 months (IRIEEN ongoing) • Training module development for others – T+3m
2. Development of Printed/Digital awareness campaign and Framework for Energy Efficiency Awards ✓ Development of content aligning with IR strategies. ✓ Development of presentations, flyers, pamphlets etc. ✓ Development of sustainability-oriented poster for railway stations and office corridors. ✓ Framework development for "Energy Efficiency Awards"	• Development of first set of awareness media content – T + 2m • Framework development for energy efficiency awards – T + 2m
3. Reporting of Energy Efficiency and Net Zero actions ✓ Development of reporting template ✓ Periodic schedule of reporting ✓ Access to information among all stakeholders within IR	• Quarterly reporting by ZR to Railway Board

5 AP1 – SUSTAINABLE BUILDINGS

There is need to focus on reducing the energy consumption of both existing buildings and upcoming/new buildings to realize the net zero carbon emission vision.

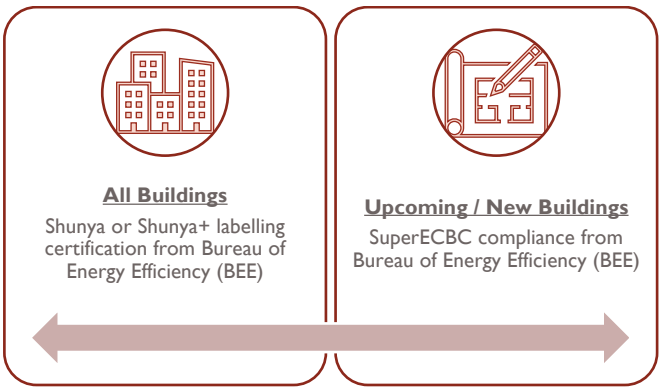


Figure 1 BEE Certification for existing and upcoming buildings

The Indian Railways has already adopted strategies such as green building certification, GreenCo ratings, BEE Star ratings etc. for its buildings and infrastructure.

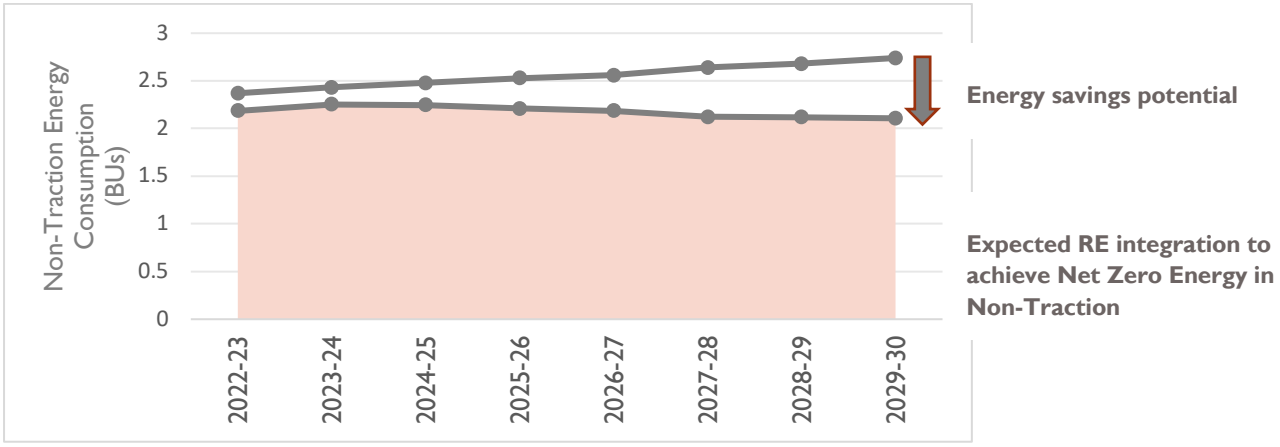


Figure 2 Non-Traction Projected Energy Consumption

Retrofitting existing buildings for enhanced energy efficiency, in combination with SuperECBC compliance for upcoming/ new buildings can result in energy savings of **0.63 billion units**[1] in **FY 2029-30**. This translates to **0.51 million tons of CO_{2e} for FY 2029-30**. This would also result in deferring investment required for additional renewable energy to meet the vision of Net Zero Carbon Emission by 2030. In the next section, energy efficiency strategies along with implementation mechanism are discussed for both existing and upcoming buildings.

5.1 COMPLIANCE OF ALL BUILDINGS TO BEE SHUNYA/SHUNYA+

All existing buildings (having connected load of more than 30 kW) shall achieve, as far as possible, **Shunya or Shunya+ labelling certification from Bureau of Energy Efficiency (BEE)**. The initial focus shall be on reducing the energy demand by integrating energy efficiency measures and then substituting the reduced demand

[1]Considering 25% energy savings through retrofitting of 10-15% of existing load every year along with SuperECBC compliance of upcoming buildings

with renewable energy. Increased energy efficiency will drastically reduce the renewable energy requirements and investments. Recommended energy efficiency measures are,

1. **Mandatory energy audit**: Periodic energy audit at least once in three years to assess the building performance and to identify energy savings opportunities.
2. **Energy efficiency retrofits**: Modifications to building systems such as envelope, equipment etc. to reduce the energy consumption or decrease energy demand.
3. **Energy efficient appliances**: Priority to 5-star rated appliance or appliance with highest efficiency.
4. **Renovations/Redevelopment as per SuperECBC**: All the renovation/redevelopment as per SuperECBC Compliance.

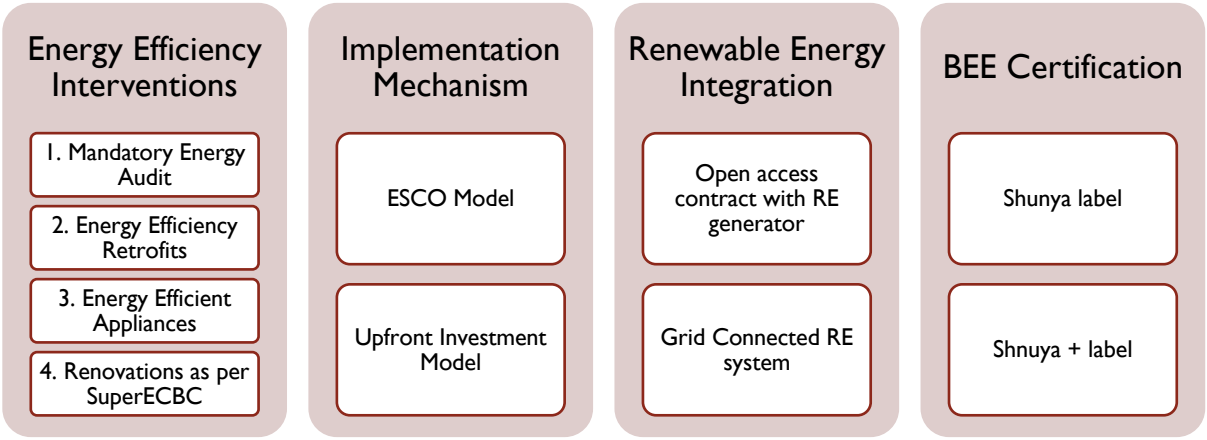


Figure 3 - Components of Shunya/Shunya+ rating

5.1.1 IMPLEMENTATION MECHANISM:

Energy Service Company (ESCO) business model: BEE is preparing guidelines for implementing energy efficiency measures in large commercial buildings through ESCO business model. IR is also participating in the "Promotion of ESCO Model" program initiated by BEE and enrolled ten buildings for the energy efficiency retrofits. In this model, BEE empanelled energy auditors will conduct the Investment Grade Energy Audit (IGEA) to set up the baseline and identification of energy efficiency measures. Once the baseline is set-up, Shared savings model or guaranteed savings model can be adopted for implementing the identified EE retrofit. IR shall make periodic payments to ESCO company as per the measurement and verification report.

Renewable Energy: Once all the measures are implemented, reduced energy demand can be met by renewable energy to achieve Shunya or Shunya+ certification.

After RE integration, building can achieve EPI in the required range (0 ≤ EPI< 10 kWh/m2/Year) and shall apply for Shunya or Shunya+ labelling as per BEE guidelines.

5.1.2 BENEFITS:

Increased energy efficiency in the existing buildings sector can reduce the energy consumption by 20-25 percent which translates into 0.53 billion units' electricity and 0.42 million tons of CO_{2e} considering the current energy consumption.

5.2 COMPLIANCE OF NEW AND UPCOMING NON -RESIDENTIAL BUILDINGS TO SUPER ECBC

All upcoming buildings having connected load of 30 kW and above will be **SuperECBC compliant** and for other new buildings with connected load of less than 30 kW SuperECBC compliance will be endeavoured. Compliance to Super ECBC will be guided via the adoption of following strategies:

1. **Passive design strategies**: Passive design strategies focus on reducing cooling requirement during the summer and heating in the winter through appropriate orientation, external shading, appropriate amount of glazing, use of insulation & cool roof, day lighting, and natural ventilation. These climate specific approaches based on sun, wind, light and micro-climatic considerations shall be integrated to design energy efficient buildings.
2. **Energy efficient comfort systems**: Innovative low energy comfort systems shall be installed for augmenting energy savings. Systems like desiccant cooling systems, three stage evaporative cooling, solar cooling, tri-generation, radiant cooling, ground source heat pumps etc. are some advanced technologies for achieving comfort efficiently.
3. **Energy efficient lighting:** Lighting energy accounts for more than a quarter of total energy consumption in buildings. It is therefore important to optimize lighting energy use to achieve net zero goals. Energy efficient lighting shall be installed. Building form, orientation, and fenestration design must take channel daylight into the building. Daylighting controls as well as occupancy sensors shall be integrated with lighting fixture to further reduce lighting energy use.
4. **Energy efficient electrical system and appliances:** High efficiency rating shall be the primary focus while selecting distribution transformers, power back-up generators, motors, and other appliances such as Geyser, microwave, refrigerators etc.

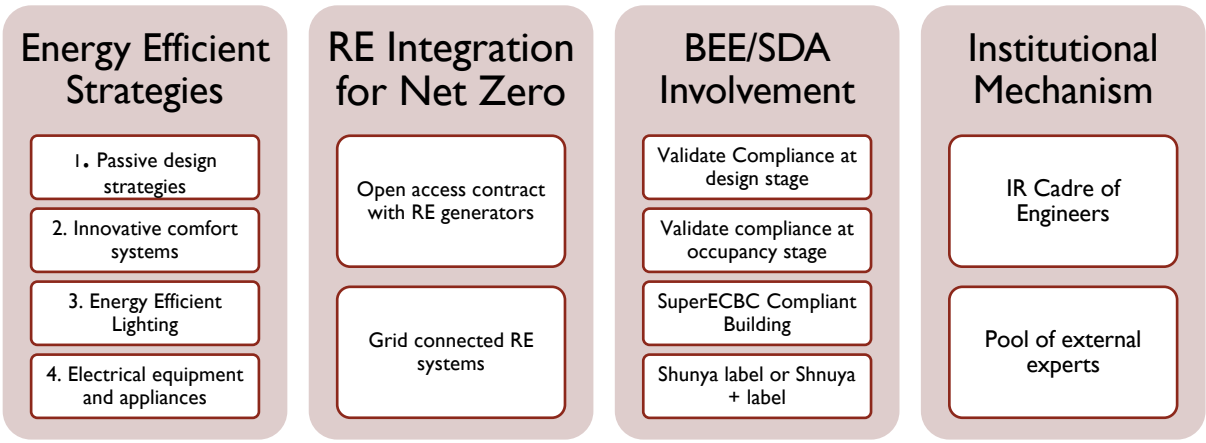


Figure 4 - Components of Super ECBC rating

5.2.1 IMPLEMENTATION MECHANISM:

Tenders of all new buildings shall incorporate SuperECBC specification in the concerned schedules and in the general conditions of the Engineering, Procurement and Construction (EPC) document as well. Latest CPWD Schedule of Rates (SoR) for SuperECBC items, whenever updated, can also be adopted for general civil works. As a reference, SuperECBC specification of an office building in composite climate zone is mentioned below for reference. Same can be referred to modify and update the specifications depending upon the building typologies and climate zone.

Table 1 - Specifications for Office building in composite climate zone

Building envelope			
Daylighting	60%	UDI	
Roof insulation	0.2	W/m2K	In all climatic zones
Wall insulation	0.22	W/m2K	In all climatic zones
Vertical Fenestration			
Solar Heat Gain Coefficient	0.27		
U Value	3	W/m2K	
Visual Light Transmittance	0.27		
Comfort Systems and Controls			
Chiller (Water Cooled)	BEE 5-Star rated		
Fan efficiency	70%		
Motor Efficiency	IE4		
Chilled Water Pump (Primary and Secondary)	14.9	W/ kWr with VFD on secondary pump	
Condenser Water Pump	14.6	W/ kWr	
Pump Efficiency	85%		
Cooling tower	0.017	kW/kWr	
Alternately, system efficiency	0.2	kW/ kWr	
Mandatory piping and ducting insulation	As per Section 5.2.4 of ECBC 2017		
Lighting and Controls			
Use of LEDs	Lighting power density requirement is 50% more efficiency compared to ECBC level		
Use of lighting controls	As per Section 6.2.1 of ECBC 2017		
Electrical and Renewable Systems			
Most energy efficient transformers	Oil Transformer BEE 5 Star rated Dry Type Transformer as per IS 1180		
Motor efficiency	IE4		
DG set	5 Star BEE star rated		
Power factor correction	0.99		
Power distribution loss	1%		
RE generation	4%		

5.2.2 BENEFITS:

Incremental cost for SuperECBC compliant building is 3-5% over and it offers 50 percent energy use reduction compared to conventional building. Opting for SuperECBC compliant buildings will not only decrease the dependency on grid energy but also cut down the investment required for RE installations to achieve net zero energy.

5.3 COMPLIANCE OF RESIDENTIAL BUILDINGS TO ECO NIWAS SAMHITA

The ECO Niwas Samhita Code and Part II (ENS-C&2) will be applicable to all upcoming residential buildings built on a plot area of ≥ 500 m^2 and residential part of mixed land-use building projects, built on a plot area of ≥ 500 m^2. This code is also applicable for all additions and alterations made to existing residential buildings where the existing building exceeds the threshold defined for plot area.

Table 2 - Eco Niwas Samhita Part I and Part II

Part I – Building Envelope (2018)	**Part II – Electromechanical and Renewable Energy Systems (2021)**
• Building Orientation and envelope insulation • Window-floor area ratio • Glazing • Shading • Natural ventilation • Daylight	• Common are and exterior lighting • Elevators • Pumps • Ceiling Fans • On site renewable energy generation

For electro-mechanical systems used in building services (such as common area and exterior lighting, elevators, pumps, basement ventilation, transformers, power distribution losses, power factor correction, electrical vehicle supply equipment, etc.), renewable energy systems (Solar hot water requirements and Solar Photovoltaic) integration and indoor electrical end-use (such as indoor lighting, comfort systems, service hot water, etc.), the ENS-C&2 establishes minimum requirements.

5.3.1 IMPLEMENTATION MECHANISM

To comply with ENS-C&2, building shall meet all of the mandatory requirements and either of the prescriptive approach or points-based system approach. The mandatory requirements include compliance to building envelope of ENS Part 1, power factor correction, energy monitoring, electric vehicle charging system infrastructure and electrical system with distribution losses not exceeding 3% of the total power usage.

The mandatory requirements for compliance to ENS-C&2

Table 3 - Mandatory requirements of ENS-C&2

<table>
<tr><th>Category</th><th>Mandatory Requirements</th></tr>
<tr><td>Window-to-Floor Area Ratio (WFR_{op})</td><td>≥12.5% for composite, ≥10% for hot-dry, ≥16.66% for warm-humid, ≥12.5% for Temperate and ≥ 8.33 % for cold</td></tr>
<tr><td>Visible Light Transmittance (VLT)</td><td><table><tr><td>WWR</td><td>Minimum VLT</td></tr><tr><td>0-0.30</td><td>0.27</td></tr><tr><td>0.31-0.40</td><td>0.20</td></tr><tr><td>0.41-0.50</td><td>0.16</td></tr></table></td></tr>
</table>

	0.51-0.60	0.13
	0.61-0.70	0.11
Thermal Transmittance of Roof (U_{roof})	<1.2 W/m²K	
Residential Envelope Transmittance Value (RETV) of the building envelope (Except roof)	<15 W/m² (composite climate, hot dry climate, warm-humid climate, and temperate climate)	
Thermal transmittance of building envelope (except roof) for cold climate	< 1.8 W/m².K	
Power Factor	All three phase shall maintain the power factor of 0.97 at the point of connection	
Energy Monitoring	Digital log of electricity consumption at building level and applicable end uses at an interval of minimum 15 minutes; Metering shall display current, voltage and total harmonic distortion in case of transformers	
Electrical Systems	Distribution losses < 3% of total power usage; Voltage drop < 2% for feeders and voltage drop < 3% for branch circuit.	
Electric Vehicle Charging System	If charging infrastructure is set up, it should comply to the guidelines of Ministry of Power for Charging Infrastructure	

Table 4 - Minimum ENS score for compliance

Project Category	**Minimum ENS Score for compliance**
Low rise buildings	47
Affordable Housing	70
High rise buildings	100

5.3.2 BENEFITS:

Compliance to ENS-C&2 will cut down the energy consumption of residential complexes of Indian Railways. This code's early implementation would enhance the design and construction of the upcoming residential building stock, reducing the estimated energy demand for comfort cooling in the future.

5.4 ADOPTION OF ESCO MODEL TO IMPLEMENT EE INITIATIVES

Existing buildings of Indian Railways offers a tremendous untapped potential of energy savings. Along with retrofitting of electrical equipment in existing buildings, feasible standalone solution such as implementation of cool roof should also be explored for air-conditioned buildings to minimize the heat gain through the exposed roof of the buildings.

While the EE retrofit will be in implementation phase, building level energy metering and sub-metering of major energy loads shall be done. These meters shall have the ability to communicate as per standard protocols (IS 16444: 2015 and IS 15959 part 2: 2016). Sub-metering of major end uses like air-conditioning, lighting, process energy (motors, compressor systems, escalators etc.) must be done as far as possible with minor changes in circuit.

India Budget FY 2022-23, focusing on transition towards carbon neutrality, called for large commercial buildings to be retrofitted through Energy Service Company (ESCO) models. The Ministry of Power (MoP) taking cognizance of the Ministry of Finance's directives, requested all public and government entities to identify pilot projects under the "Promotion of ESCO Model" program, including IR via BEE letter no 17/05/ESCO/2022-23 dt 22.08.2022

To validate ESCO model of implementation, MoP through BEE is undertaking pilot project in 50 Government buildings (Which include 10 buildings of IR) to identify and implement energy efficiency measures through ESCO mode. The implementation of Energy Efficiency projects will be preceded by Investment Grade Energy Audit (IGEA) to be undertaken by the Facility Owners. These buildings will be the first ones in the country to be showcased as energy efficiency upgrades through the "Promotion of ESCO model" program initiated by the Ministry of Power in accordance with the introduction of ESCO business model in India's budget FY 2022-23.

5.4.1 IMPLEMENTATION MECHANISM OF IGEA

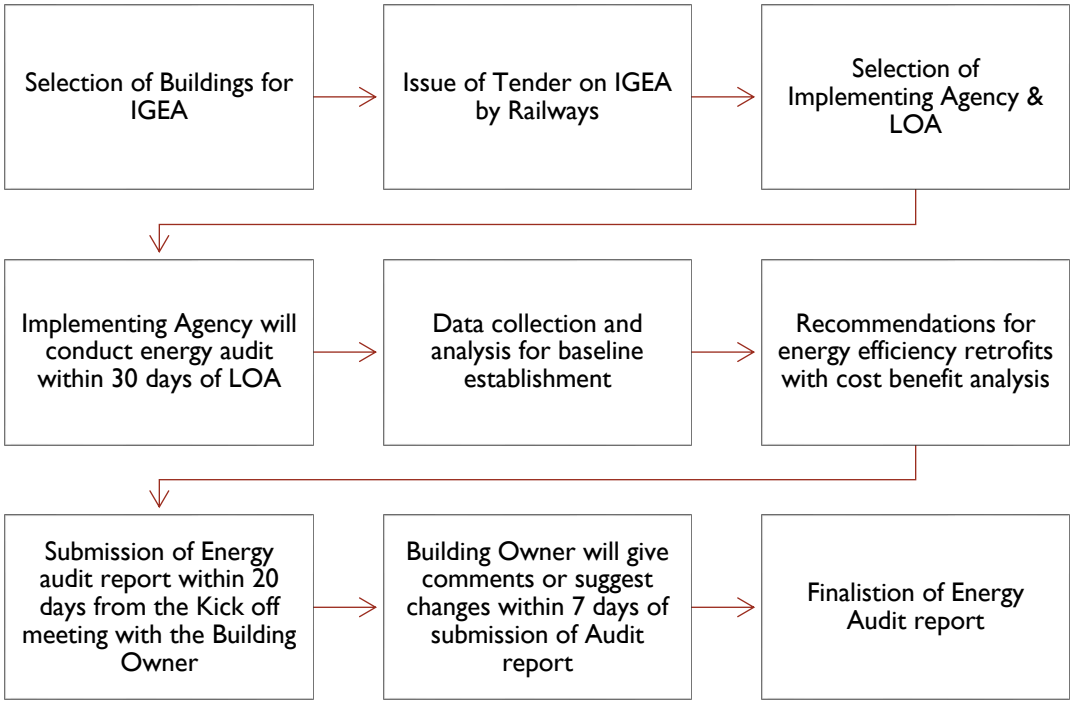


Figure 5 IGEA implementation mechanism

5.4.2 OBJECTIVES AND GOALS OF IGEA

a) IGEA will conduct a base line study and develop a detailed feasibility study including financials and appropriate structure for the energy efficiency project
b) Identification of EE retrofit to reduce energy consumption
c) Establishing detailed project requirement and execution plan, Repair & Maintenance costs, reduction in O&M costs, estimated project cost, technical specifications, performance parameters, facilities required e.g., infrastructure, estimated revenue stream.

5.4.3 IMPLEMENTATION MECHANISM OF ESCO MODEL

Once the baseline is in place by IGEA, Shared savings model or guaranteed savings model can be adopted for implementing the identified EE retrofit. However, it should be examined on cases by case basis to evaluate the

appropriate/beneficial model of IR buildings. BEE empanelled ESCOs with higher grades (Grade I and II) will implement energy efficient retrofit in existing building to lower energy consumption.

a. Shared Savings Model

Under this model. ESCO services undertakes financing, designing, engineering, installation, commissioning, operation and maintenance of the EE retrofitted equipment as per mutually agreed conditions in Energy Service Performance Contract (ESPC). ESCO also provides training to operation and maintenance staff for sustaining the energy savings post completion of the contract. ESCO takes the performance risk, and the cost savings are divided between the ESCO and Indian Railways at a prearranged percentage for an agreed length of time. However, it required a dedicated energy monitoring system for the implemented EE measures to calculate the exact energy savings achieved. The following figure illustrates the shared savings model:

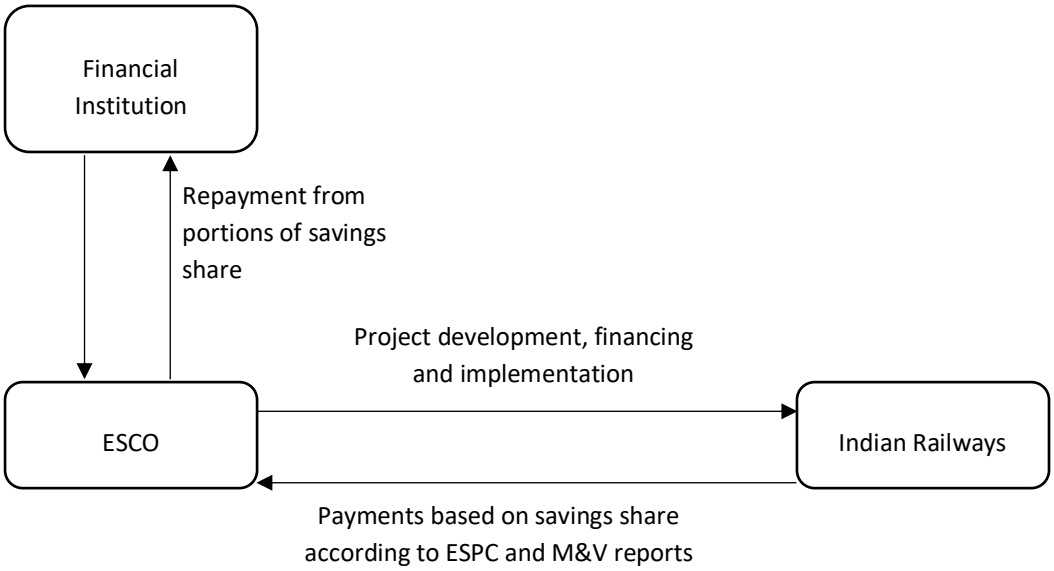


Figure 6 Shared savings model

b. Guaranteed Savings Model

Guaranteed savings model through performance contracting can be adopted for the small as well as large scale EE measure implementation in which ECSO takes the project risk and guarantees the energy savings for certain period depending on the contract condition. However, necessary CAPEX would need to be put in by IR.

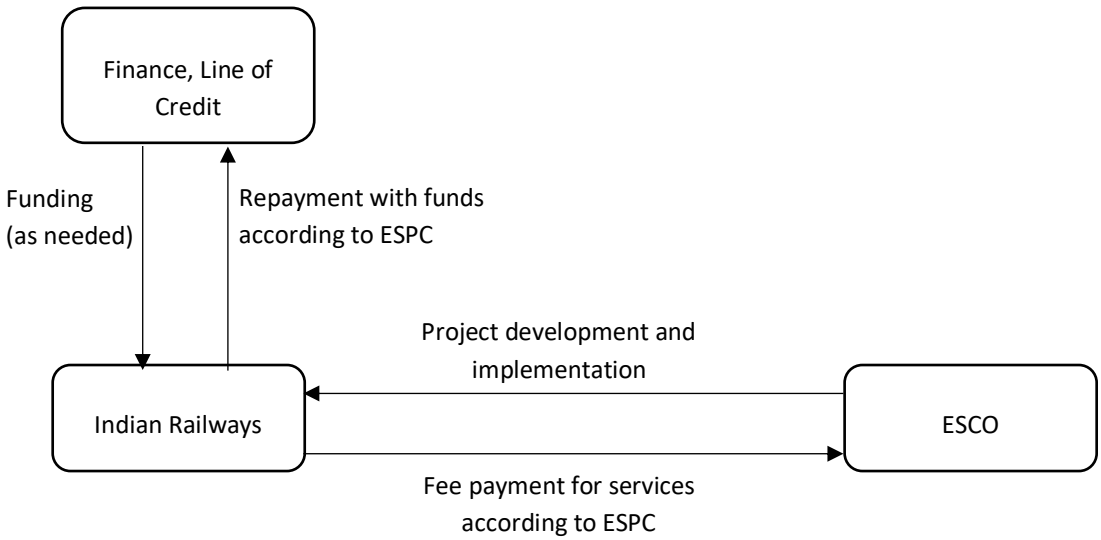


Figure 7 Guaranteed savings model

comparative analysis between shared savings and guaranteed savings ESCO model can help in decision making while selecting the ESCO model for EE measure implementation:

Table 5 - Comparative analysis of Shared savings ESCO model and Guaranteed savings ESCO model

ESCO Models / Parameters	Actual Savings, Shared Savings	Upfront Investment, Guaranteed Savings
Model Description	Upfront costs for the project are borne by ESCO. Monetary Savings generated from the project pays off the project cost incurred to ESCO and shared in a pre-agreed ratio with client. Clients thus earn a 'nominal income' on the energy savings project.	Upfront costs for the project are borne by the client. Technical assistance and performance guarantee for project savings is agreed by ESCO via legal contract.
Monetary Savings	Shared between ESCO and Client at a prearranged percentage	Client
Monitoring & Verification	Extensive monitoring & verification required to pay ESCO EMI which may be cumbersome for IR.	Routine verification by ESCO/third party organization may suffice performance claims by ESCO
Performance Risk	ESCO	ESCO
Investment Risk	ESCO	Client

5.4.4 BENEFITS

a) IGEA will produce the energy audit report which will recommend energy efficiency measures to improve building performance for the building owners.
b) Techno-commercial analysis of recommended EE measures will aid in decision making.
c) Building owners are sometimes constrained by finance, implementing in ESCO model will overcome this barrier as building owner may payback in EMIs.
d) ESCO will provide technical assistance to building owners.

6 AP2 – CLOUD BASED CENTRALIZED WEB-PORTAL FOR DATA MANAGEMENT, CONTROL AND MONITORING

A cloud based centralized web portal to host data from smart systems will ease data compilation for Indian Railways and obviate the need to rely on private vendors for data servers. Any smart devices sending out data (energy consumption data, switching information, controllers etc.) over the internet will communicate with the data servers of Indian Railways.

In IR, presently operations and maintenance of major electrical assets, monitoring of electrical energy is mostly manual and wherever IT applications are being used, they are in disintegrated form, i.e., division and vendor specific and are short lived as there is no centralized monitoring. Consequently, integration of data and its analysis is not being done. There is no centralized collation of data with proper information system for taking coordinated decisions based on historical data analysis and future performance benchmarking.

Few automation initiatives that have been undertaken in the past are done is silos without any centralized approach. The solutions deployed by various agencies are not integrated and all the information collected is lost. It is imperative that IR should have its own central data management application platform wherein there is standard and secure way of getting data from various divisions / zones for real time as well as historical data analysis and future performance benchmarking.

6.1 DEVELOPMENT OF CLOUD-BASED DATA MANAGEMENT WEB PORTAL, LED BY CRIS

In order to have standardization, optimal utilization of data collected, security as well privacy of data, it is important that data from smart devices is transported securely and directly to IR own IT application developed by Centre for Railway Information Systems (CRIS) in association with Zonal Railways and Railway Board.

The centralized web portal shall be a complete application platform that monitoring and control of electrical assets and energy. Besides mapping existing assets, the web portal shall have capability for addition of new assets with different sensor types that can be integrated with diverse types of instruments which are installed from time to time in various electrical assets of Indian Railways.

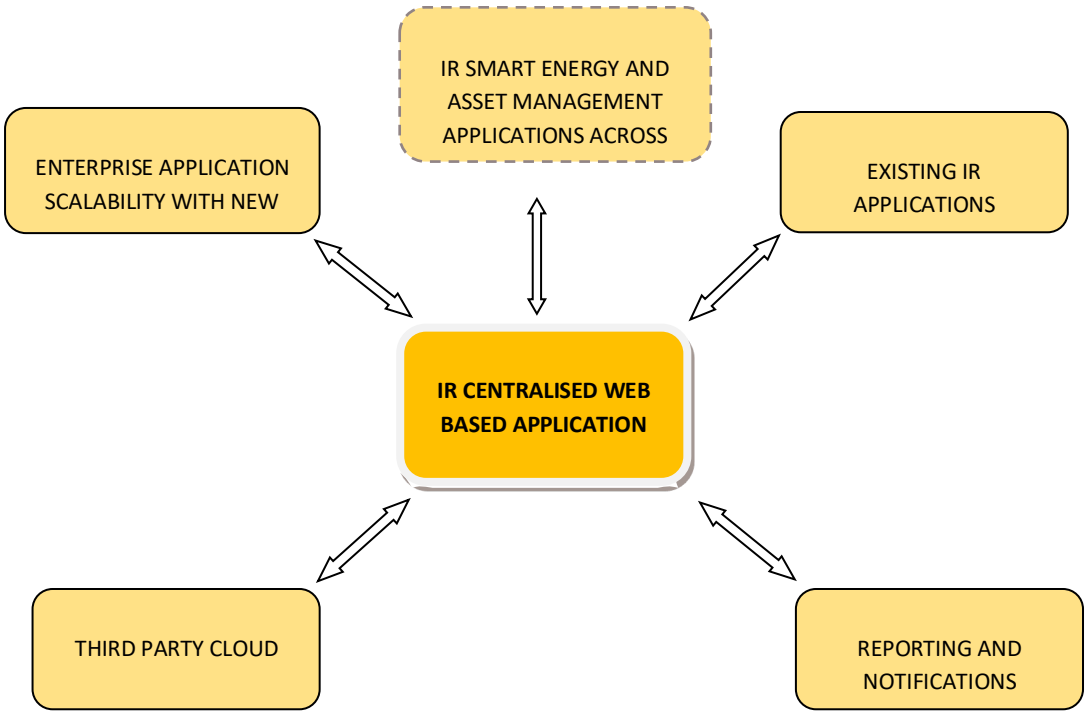


Figure 8 Block diagram of centralized web-based portal

6.2 IOT DEVICES/SMART DEVICES TO BE INSTALLED BY RAILWAYS WHICH ARE INTEGRABLE WITH CRIS APPLICATION PLATFORM.

6.2.1 INTEGRATION OF ALL WEB-BASED APPLICATIONS OF ZRS TO THE CENTRALIZED PORTAL

The centralized web platform will be one stop solution for hosting all data arising from the smart system integrations within IR irrespective of geographical locations and will enable Indian Railways to not only efficiently monitor its real time energy usage across various zones / divisions in a standardized way but also provide a unified data analysis platform for identifying wastages, setting new targets, and monitoring performance with predictive analysis. This web-based platform will also enable Indian Railways to have a central asset repository system, rather than automation and digitalization in disconnected silos as this System will be hosted in CRIS Data Centre.

Salient features of the centralized portal would include integration of the following

a) All energy inflows and outflows are required to be monitored so that the energy consumption is established holistically. Hence here should be smart IOT based energy sub metering at all major Electrical distribution points.
b) Real time monitoring and control of pumps with sensor monitoring like continuous water level monitoring in OHTs/UGTs, pressure, Flow, etc.
c) Operational status, energy consumption and/or health parameters of the assets like lifts, escalators.
d) Automated internet-based monitoring and control of street light feeder pillars and High Masts.
e) 30%-70% lighting control at stations which shall be integrated with NTES system for automatic switching on/off lights based on train arrival and departure.

Once such platform is deployed, this will also act as bridge for data management, data cleansing and data sharing with various other existing IT applications like Railsaver.

6.2.2 ONLINE ENERGY USE MONITORING

All energy inflows and outflows are required to be monitored so that the energy consumption is established holistically. Energy monitoring provisions like submetering, diesel consumption records, energy bills etc. are to be incorporated which can aid to develop energy portfolio of different zonal / divisional railways on the basis of which energy consumption reduction plans may be developed as well as continuously monitored for efficacy and efficiency of various energy management measures that are being undertaken.

Energy sub metering at all key distribution points is essential to assess the actual energy consumption, highlight wastages, implement energy efficiency measures and finally continuously monitoring the efficacy of implemented measures. Today, either there is no sub metering at key distribution points, or it is only known through State Power Utility Bills. Even if there is manual recording in registers at Section(s) / Division(s) level, or by partial manual feeding of data in IT applications, it is not being effectively utilized for data analysis and improvement. It is imperative that there should smart IOT based technical intervention with IR common IT infrastructure.

There should be smart IOT based energy sub metering at all major Electrical distribution points such as Substations / Distribution Transformers / Incoming & Outgoing Feeders / Zonal, Divisional and Section Offices / Major Stations / Production Units / Workshops and Loco Sheds etc. with breaker On/Off/Trip status monitoring etc. The ultimate goal of Energy Monitoring is to reduce energy costs through improved energy efficiency and management.

6.2.3 INTELLIGENT LIGHTING MANAGEMENT AT STATIONS AND COLONIES INCLUDING 30%-70% PLATFORM LIGHTING THROUGH NTES

Currently, the Street Lighting Operation & Maintenance is completely manual and heavily dependent on the operators that requires dedicated staff for the operation (on/off) as well as Efficiency monitoring. There is lack of proper control over On/Off timing of streetlights. While at some places there are timer-based operations, but its failure rate is very high and so light may turn ON in daytime and turn OFF in nighttime. In the existing system, many times critical information may miss due to some negligence or poor data logging and reporting process. There is no visibility of working and non-working lamps on citywide level.

It is being proposed that distributed street light feeder pillars shall be automated with remote Internet based monitoring and control. The internet-based control system shall operate the lights automatically on user-defined rules and event based astronomical calendar schedules that can be configurable from remote location at anytime from anywhere. The monitoring and control can even be extended to operations of equipment providing thermal comfort to passengers. Overload, Imbalance based alerts and alarms. This complete solution result in adequate efficiency, optimized running hours, protection and preventive maintenance, and optimized manpower. Any alarming condition that may develop at site will be immediately communicated by way of SMS generated by Central Server on the mobile phones of the concerned officer. The officer then can take immediate action to correct the problem resulting in minimum downtime.

6.2.4 30%-70% LIGHTING AT STATIONS BY INTEGRATING WITH NTES

This strategy is aimed at integrating the lighting controllers of the platforms with central web portal and NTES so that no manual intervention is required to switch on the remaining 70% light as per the arrival/ departure time of trains.

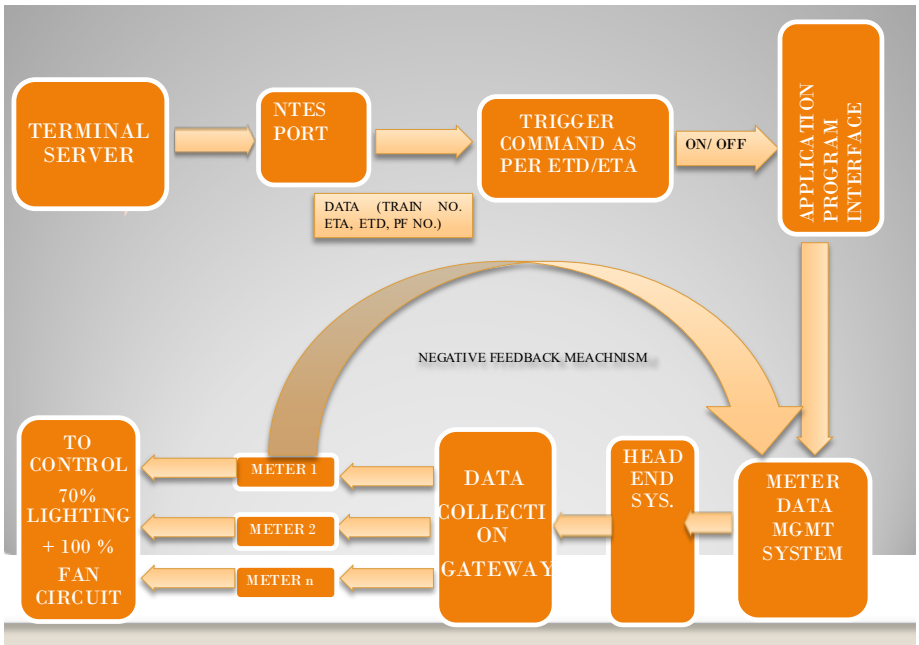


Figure 9 IOT based automation architecture

This intervention pertains to the automation of the controllers and establishing smart connection to regulate the lighting systems of platforms remotely.

6.2.5 INTELLIGENT WATER MANAGEMENT SYSTEM, CONTROL AND MONITORING OF PUMPS, OVERHEAD WATER TANKS AND QUICK WATERING SYSTEM AT STATIONS

At present, the operation of water Network, Pumps are heavily dependent on the operators and requires dedicated operational staff for the operation (on/off) of the Pumps etc. With diversity in pumping station locations and lack of availability of operators causes extra running of pumps, overflow of tanks, wastage of water, water shortage for trains or passengers etc.

The existing geographically distributed Pump Sets will be augmented into intelligent pool of interconnected water supplying equipment by installing and integrating smart controls (with energy meters, sensors, controlling capability) at tube wells, Pumping sites, overhead water tanks and underground reservoirs. Some key parameters which can be remotely monitor and controlled by this system are like On/Off Status of pumps/ valves with time stamping, running hour of pump, water level in the OHTs and UGRs, line and phase voltage in all three phases, power consumption, trip status (Single Phase, Overload, Phase Reversal, Site Power) etc.

All relevant field data can be viewed at the powerful and secure Web Based Application Software hosted at Central Server by all divisions and subdivisions for their meaningful reports and alarms with enhanced aggregation of data at Head office levels. This data can be viewed in the form of meaningful reports, graphs, and bar charts. A complete history of data can be maintained enabling in-depth analysis of the field data for optimization of processes.

6.2.6 OPERATIONAL STATUS MONITORING OF ESCALATORS AND LIFTS

The existing distributed assets like escalators /lifts in IR station will be monitored by installing smart devices which can monitor On/Off/Trip status, energy/health parameters and send energy consumption and operational data to centralized data management web-based portal which can initiate preventive action like alerts to control room operators / IR officials. A complete history of data can be maintained at cloud-based portal, enabling in-depth analysis of the field data. This data can be very helpful in preventive maintenance of the costly field equipment. Continuous monitoring of lifts / escalators in 24×7 near real time over the web across the network and with artificial intelligence can pre-emptively trigger maintenance work to avoid unplanned downtimes/breakdown.

6.2.7 WEB BASED ENERGY METERING AND BILL GENERATION FOR HOUSING COLONIES

In order to bring efficiency into the Railways billing and collection process of electricity bills from the housing colonies, it is envisaged to introduce mobile and web-based solution for data collection, tariff engine-based bill generation, generate user reports having data exchange capability with various other IT Applications like IR IPAS etc. as required. Smart energy meters are to be installed in houses which can transmit energy consumption data to the central server, which will facilitate IR to generate bills and may even accept bill payments via payment gateway. Based on the location and tariff category, the bill for the user will be automatically generated and sent via Email / App Notification / SMS etc. as required. The divisional electrical office can schedule billing cycle and periods. Implementation of this strategy could be done based on cost benefit analysis for that location.

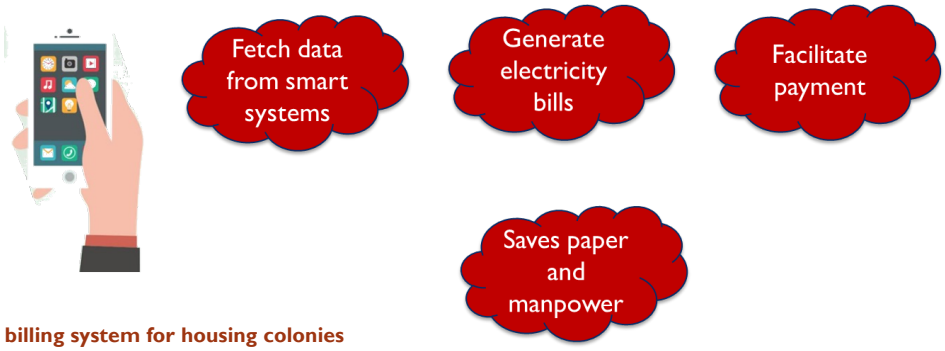


Figure 10 Smart billing system for housing colonies

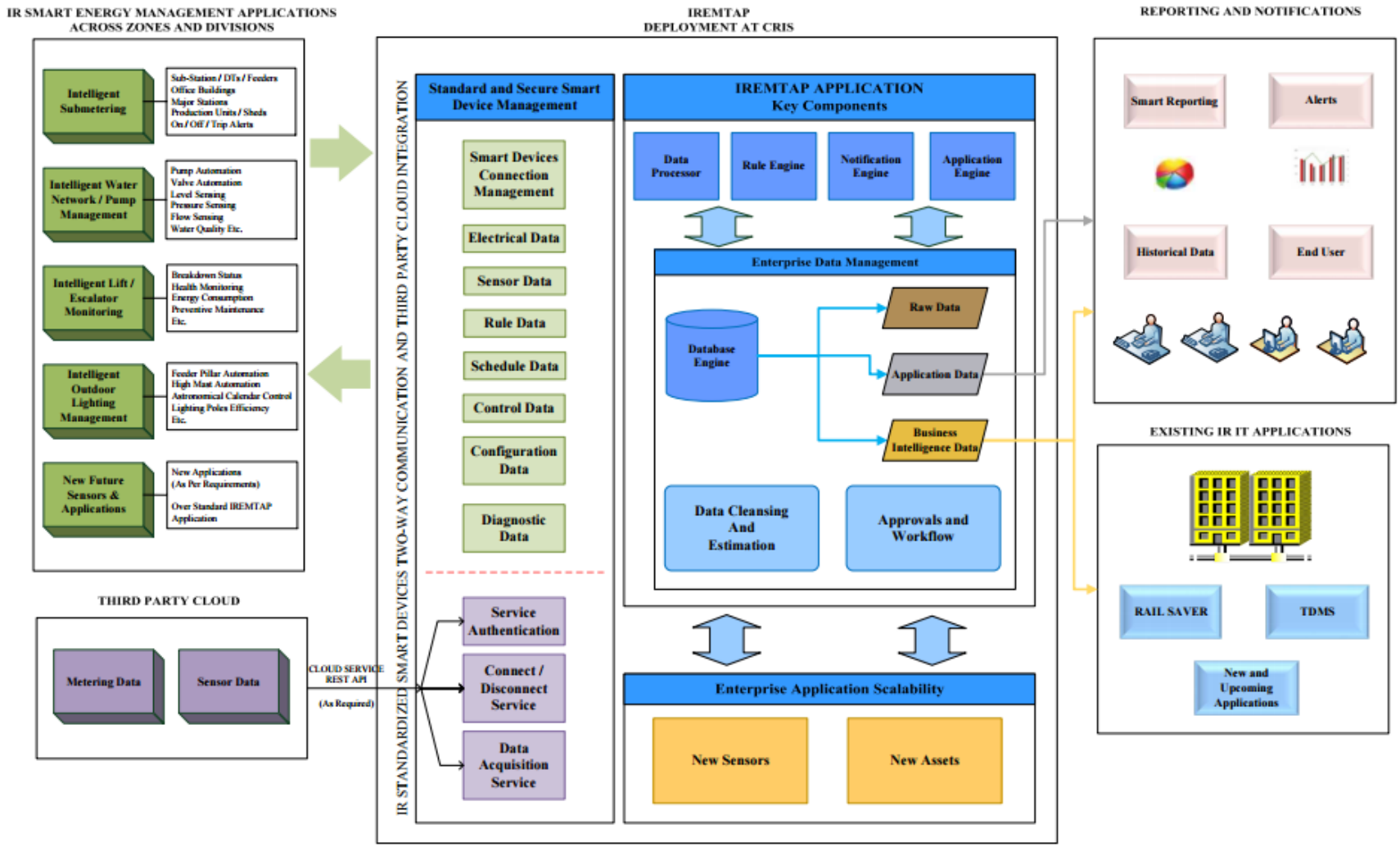


Figure 11 Architecture of IR Energy data management and monitoring application

7 AP3- ENERGY EFFICIENCY IN EQUIPMENT AND APPLIANCES

This action is aimed at decarbonizing the installed equipment and appliances by inducing energy efficiency and reducing energy consumption.

7.1 ADOPTION OF LIGHTING, FAN AND AC CONTROLLERS

This strategy is aimed at installing sensors which will detect occupants of a space based on which the operations of the lighting, fans and room air conditioners will be regulated. The idea behind this strategy is to save energy as it is a common practice in commercial buildings to leave the appliances switched on even when there are no occupants. A lot of energy is wasted especially after working hours as the lights, ACs and fans are in operation until the guard switches them off, which could take at least an hour.

The lighting fixtures may be clubbed together and similar technique may be adopted for fans and AC, as per a study combining AC and fan will optimize energy utilization for thermal comfort.

7.1.1 IMPLEMENTATION MECHANISM

a) Identification of commercial building space where energy is being wasted due to low/no occupancy
b) Integration of lights, fans and ACs with the Infra-red based occupancy sensor in the identified commercial spaces
c) Schedule based regulations of fans, ACs and lights could also be integrated
d) These controllers can be installed under ESCO model if building is opting for large scale EE retrofit.

7.1.2 BENEFITS

a) Energy and cost savings
b) Increase in operational life of equipment

7.2 PROCUREMENT OF BEE 5 STAR RATED APPLIANCES

BEE star labels provide informed choices to the consumers about the energy consumption of appliances and equipment. Each star label rates an appliance/ equipment from a scale of 1 to 5 star with 5 star being the most efficient. The most efficient equipment should be installed to maximize energy savings.

Under star labelling regime of BEE, following equipment have been rated depending upon their performance parameters

Mandatory appliances

a) Frost Free (No-Frost) Refrigerator
b) Tubular Fluorescent Lamps
c) Room Air Conditioners (Fixed speed)
d) Distribution Transformers
e) Room Air Conditioners (Cassette, Floor Standing Tower, Ceiling, Corner AC)
f) Direct Cool Refrigerator
g) Electric Geysers
h) Color TV
i) Room Air Conditioners (Inverter type)
j) LED lamps
k) Ceiling Fans

Voluntary appliances

a) Induction Motors (General purpose industrial motor)
b) Liquefied Petroleum Gas (LPG) Stoves
c) Washing machine
d) Computer (Notebook/Laptops)
e) Ballast (Electronic/Magnetic)
f) Office automation products (Printer, Copier, Scanner, MFD's)
g) Diesel Engine Driven Monoset Pumps for Agricultural Purposes
h) Solid State Inventor
i) Diesel Generator
j) Chillers
k) Microwave Ovens
l) Deep Freezers
m) Light Commercial Air Conditioners (LCAC)
n) Submersible pump set
o) Solar water heater
p) Ultra-high definition television
q) Air compressors
r) Tires/ tyres
s) High Energy Li Battery

It may be noted that energy efficient appliances and equipment have an adverse effect on power quality due to electronic switching control of appliances, hence installation of energy efficient appliances may be followed by monitoring of power quality.

7.2.1 IMPLEMENTATION MECHANISM

BEE 5-Star rated equipment must be procured and the star rating requirement should be lowered till at least three eligible sources/vendors are not available. The equipment BEE star level should be current and must conform as per the values of the latest validity period which BEE revises periodically. Retrofit of the equipment is recommended when payback of the retrofitted equipment/appliances is achieved within half of the equipment prescribed operational life.

7.2.2 BENEFITS

a) Energy and Cost Savings
b) Reduction in carbon emissions

7.3 30%-70% PLATFORM LIGHTING CIRCUIT SEGREGATION

This energy conservation strategy pertains to reduction of lighting load in platforms for railway stations when the train is not present. The illumination of a platform can be reduced by switching off some lights when the train is not stationed in the platform. The lights can be switched back on when the train is about to arrive.

Based on the expected time of arrival of trains, the full illuminating potential of the platform will be switched on before 30 mins of arrival of trains. After the departure of trains, 70% of lighting systems in platforms will be switched off. Automation of 70% lighting circuits at platforms can be integrated with the IR railways website like NTES which keeps a track of the movement of the trains.

7.3.1 IMPLEMENTATION MECHANISM:

a) Switching of lights based on NTES system for detection of train arrival and departure times.
b) The platform of arrival is identified in the NTES system.
c) 15/30 mins can be the additional time to keep the lights on before arrival and after departure for the convenience of the passengers.

7.3.2 BENEFITS:

a) Energy and Cost Savings.
b) Increase in operational life of LEDs installed.
c) Other assets may also be linked with this strategy to reduce energy consumption.

7.4 REPLACEMENT OF CONVENTIONAL FANS WITH BLDC FANS

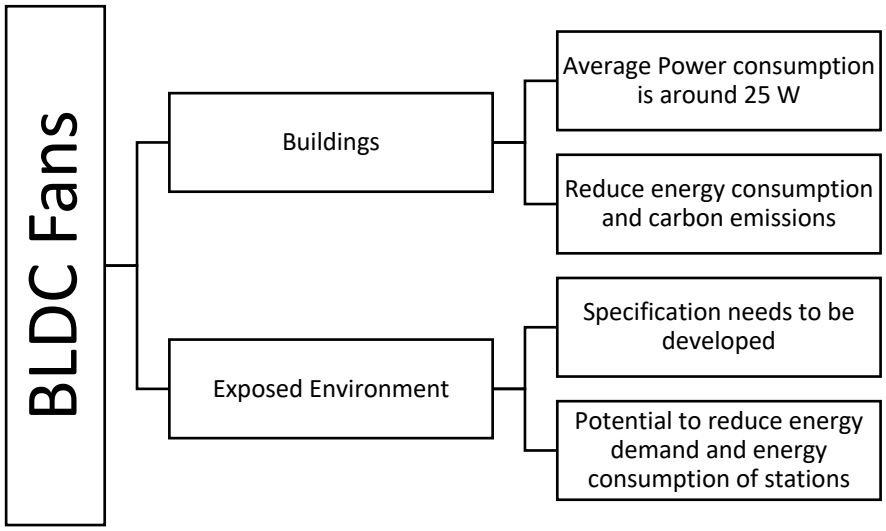


Figure 12 - Adoption of BLDC by IR

7.4.1 IMPLEMENTATION MECHANISM

a) Identification of conventional fans and quantity of replacement
b) Development of specification for Environmental hazard coating for procurement

7.4.2 BENEFITS:

a) Energy and Cost Savings.
b) BLDC may be modified to run on DC power

7.5 ENERGY EFFICIENCY MEASURES IN WORKSHOPS, PRODUCTION UNITS, LOCOMOTIVES INCLUDING USE OF VFD DRIVES, ENERGY EFFICIENT MOTORS, ETC.

During walk through Audit of one of the IR Electric Loco Shed, it was observed that the Cranes and the other variable loads were in operation without VFD, resulting in higher energy consumption and higher maintenance cost. Therefore, it is suggested to install VFD on Cranes and other variable loads for smoothening acceleration and achieving energy saving with low maintenance cost; Energy saving up to 10-15% can be achieved with VFDs.

Similarly, identification of other energy efficiency measures like replacement of existing motors with efficient motors which are of IE5 efficiency can lead to energy savings. Procurement decisions should be based on the total cost of ownership of appliances and equipment which includes the operational cost.

7.5.1 IMPLEMENTATION MECHANISM

a) Identification of equipment running on partial load conditions for significant duration for VFD installation
b) Identification of energy efficiency measures like energy efficiency in motors and pumps
c) Upfront Investment Model: For measures like integrating VFD with cranes, a technical upgrade to the existing equipment and upfront investment model is the best option. In this model, IR can quickly procure VFD for cranes considering the operating hours, amperage etc. of the cranes and achieve energy savings.
d) Equipment based ESCO model - ZRs may identify workshops where VFDs and energy efficient motors/pumps are to be installed and issue tender together for all requirements within a zone on ESCO model, where the upfront cost of the VFD is borne by the ESCO. The energy savings from the VFD will lead on to the return of payments for ESCO.

7.5.2 BENEFITS:

a) Energy and Cost Savings.
b) Smooth acceleration
c) Energy savings and low maintenance cost
d) Reduction in instantaneous higher amperages.

7.6 ADOPTION OF LOW CARBON COOLING SYSTEMS

The current supply mix used to meet cooling demand is dominated by cooling solutions based on vapor compression. These have far higher beginning power requirements than their typical running power usage; these brief surges put additional strain on already overworked electricity systems, resulting in blackouts and burnouts. As the majority of India's power is produced by coal, it also increases the country's energy consumption, which results in indirect GHG emissions. These systems also raise the need for refrigerants, which is linked to GWP (global warming potential) and ODP (ozone depletion potential).

It is essential for India to promote and scale up innovative low carbon cooling solutions as a substitute for conventional appliances using vapor compression to lower mortality rates related with extreme heat events and rising average temperatures, provide thermal comfort to everyone, and ensure sustainable growth.

For example, in order to satisfy its need for cooling, the VIT School of Architecture looked for a low-energy alternative. The school chose structure cooling over the minimum 500TR of air conditioning that its 10,000m^2 space would have required.

7.6.1 TWO STAGE EVAPORATIVE COOLER

Two-stage evaporative cooling system may be explored by IR which does not have refrigerants and it also minimizes the global warming risk associated with refrigerants.

In these coolers, a first-stage indirect evaporative cooler lowers both the dry-bulb temperature (DBT) and WBT of the incoming air. After leaving the indirect stage, the supply air passes through a second stage direct evaporative cooler.

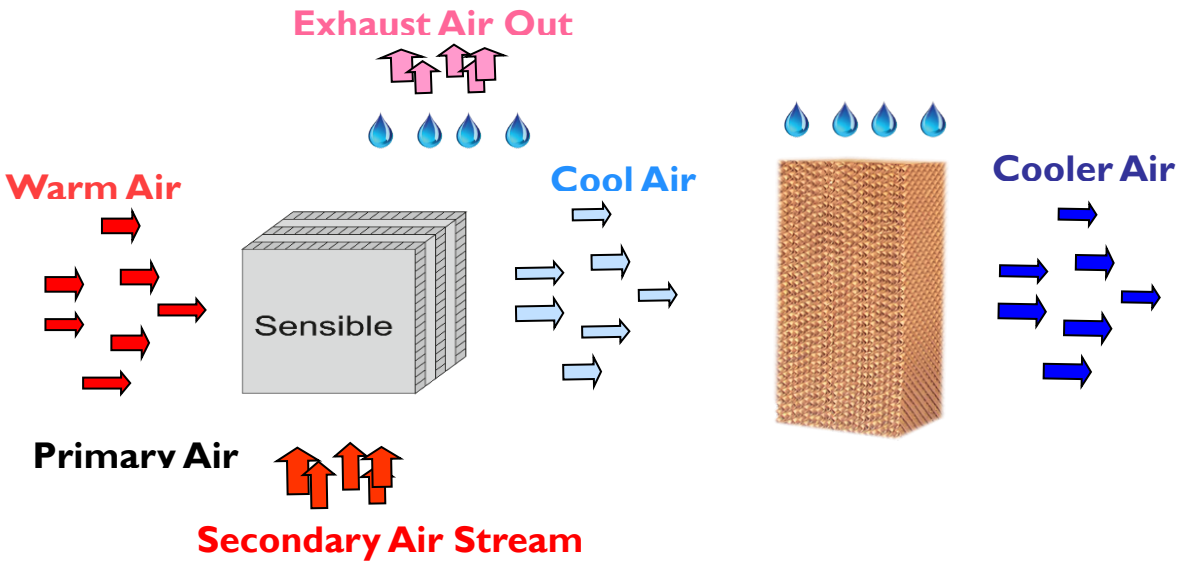


Figure 13 Working mechanism of 2 stage evaporative cooler

Desiccant Rotors International, conducted a temperature analysis to arrive at the temperature difference between outdoor air and supplied air for Delhi's climate (Composite climate zone).

Table 6 - Dry bulb temperature and Wet bulb temperature analysis

City : Delhi			Two Stage Evaporative Cooler	
Outdoor Air			Supply Air	
Month	DBT (° C)	WB (° C)	DBT (° C)	WB (° C)
Jan	25.2	15.7	18.5	13.1
Feb	29.1	16.0	19.9	12.5
March	34.9	19.9	17.6	16.1
April	40.9	21.5	18.4	16.6
May	44.1	21.1	17.1	15
June	44	21.9	18.2	16.2
July	40.5	24.7	22.8	21.4
Aug	37.7	26.1	25.1	24
Sept.	36.9	23.8	22.5	21.2
Oct.	35.6	21.5	19.5	18.2
Nov.	31.5	19.4	17.8	16.5
Dec.	26.1	16.3	19.24	13.75

Analysis demonstrates that with two stage evaporative cooling systems achieving supply air temperature of less than 20 ^{O}C is possible and this system can work effectively in composite climate zone. Prior to implementation, site-specific detailed feasibility study shall be conducted to figure out the challenges linked to this technology.

7.6.2 RADIANT COOLING

Radiant cooling system may be explored by IR. It offers high operational efficiency in comparison to conventional chilling systems. Guiding principle of a conventional air conditioning system is convection whereas in a radiation system, the guiding principle is heat transfer through radiation. Heat transfer predominately occurs through surfaces like floors, ceiling, or wall which in turn are heated or cooled by embedded coils. Radiant systems are installed in combination of large thermal mass to facilitate absorption and radiation. For optimizing performance

of the systems, coils should be installed in floors for heating purposes, and in ceiling for all cooling purposes. Application of radiant systems is limited to areas which have high latent load and chances of air leakage from humid areas are high. Improperly installed systems can lead to condensation on the building structural elements.

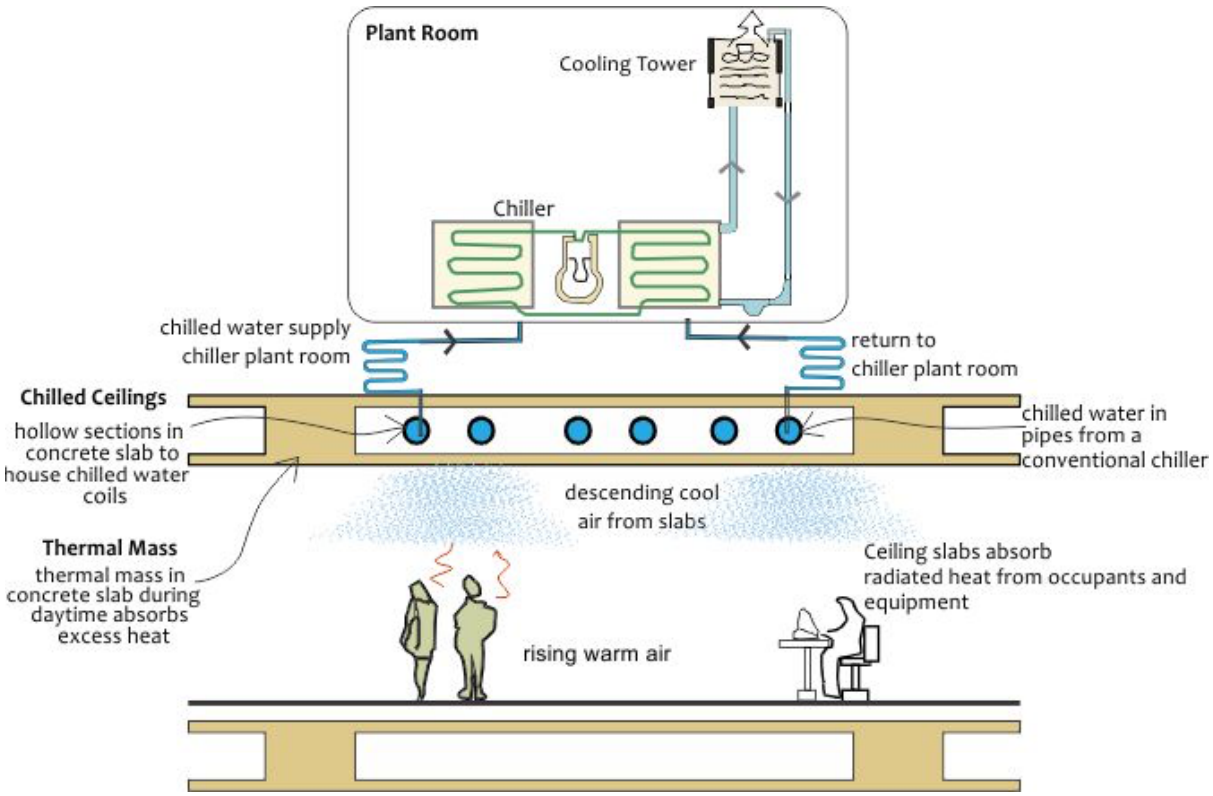


Figure 14 Radiant Cooling System

Types of radiant cooling

a) Chilled slabs: These deliver cooling through the building structure, usually slab, and are also known as thermally activated building systems.
b) Ceiling panels: These deliver cooling through specialized panels.

Systems using concrete slabs are generally cheaper than panel systems and offer advantage of the thermal mass while panel systems offer faster temperature control and flexibility. Capital expenditure of this system is the same as a high efficiency chilled water system; however, operational expenditure is less than the chilled water system.

Radiant cooling systems consist of coils embedded within the structure. These coils carry chilled water generated either through conventional electric chiller systems or low energy chilled water generation systems like absorbent chillers, desiccant chillers. Chilled water in the coils cools down the slab or panels which in turn function as heat sinks for sensible heat loads of internal spaces.

Concrete structures typically used with radiant cooling systems also increase the thermal mass of buildings. This introduces inertia in the structure against temperature fluctuations and allows it to absorb heat from internal spaces.

7.6.3 IMPLEMENTATION MECHANISM

a) Feasibility analysis of low carbon cooling technology
b) Cost benefit analysis
c) Implementation by ESCO for technical and financial assistance

7.6.4 BENEFITS:

a) Reduction/avoiding in the use of refrigerants.
b) Low capital costs and running costs than refrigerant based systems.
c) Possible reduction of peak power demand.
d) Reduction in greenhouse emissions due to reduced energy consumption.
e) Good indoor air quality and 100% fresh air for occupants.

7.7 OTHER ENERGY EFFICIENCY RETROFIT

Apart from the action mentioned above, Zonal Railways may identify energy efficiency retrofit potential which may be unique to their requirements and saving energy which may be crucial to Indian Railways in the process of decarbonization. Such types of energy efficiency pilot implementation need to be documented highlighting the cost and energy saving potential and implementation mechanism. Zonal railway will then share such success stories with Railway board and their counter parts.

7.7.1 IMPLEMENTATION MECHANISM

a) Identification of technology solutions for energy efficiency
b) Feasibility analysis and cost benefit analysis
c) ESCO implementation for technical and financial assistance
d) Development of success story for the benefit and learning of IR

7.7.2 BENEFITS:

a) Opportunity to identify a unique solution with respect to IR
b) Potential to identify crucial decarbonization methods

8 AP4 – POWER QUALITY COMPENSATORS

Problems with power quality are receiving a lot of attention these days because of the financial effects they have on both utilities and customers. The most frequent and serious power quality issues are low power factor and current harmonics.

8.1 ENSURE PROVISION OF APFCS

To maintain the Power factor of electrical systems close to unity, IR should install Automatic Power Factor Controller (APFC) in all major buildings and wherever they have been provided, their health should be monitored. However, facility personnel are operating it manually as APFCs are not operating in automation mode. Moreover, it is also not clear whether all capacitor banks are working effectively and generating the required kVAR as per their rated capacity. In few facilities which were audited by the professionals, leading power factor was observed which indicates that the power factor meter was in faulty condition and was displaying abnormal readings.

So, as a first measure to improve the power quality, wherever APFC is available shall not be bypassed in the electrical circuit and must be operating in automatic mode to maintain a near unity power factor.

APFCs should be installed wherever the need for power factor correction is required. All existing APFCs shall be made functional and undertake any repair and upgrades, if required. Replacement should only be done when repair is not cost effective.

8.1.1 IMPLEMENTATION MECHANISM

a) Identification of workplaces within IR where highly inductive loads are installed and there is a need to correct the power factor.
b) It would be important to conduct power quality audit and accordingly take necessary action for determining the correct specification of the APFC/Power Quality Restorer as the case may be. Mostly, correctly designed APFCs should improve the power quality to a substantial extent. However, Power quality after installation of APFCs should be checked for deciding on the requirement of filters for harmonic suppression.
c) APFC should be 3 CT APFC controller with open-source communication protocol and suitable for working with solar installation (4 quadrant), as required.
d) APFC panel should be with HMI (Human Machine Interface) for ease of diagnosis by maintenance personnel.
e) Available APFCs are to be connected in auto mode. All APFCs should be retrofitted with 14% passive filters and 525V capacitors.
f) Replace the faulty meter to make sure that the meter displays the correct value of power factor.

Troubleshooting guidelines as an aid to users: -

Table 7 Basic methodology for power quality monitoring

Problem	Possible reasons	Action to be taken
Lagging Power Factor	1. Capacitors are derated/single phased 2. Insufficient capacity of APFC panel	1. Check the possible reasons listed below and plan required actions 2. If all capacitors are found Ok, then increase the capacity of APFC panel as required with additional feeders

Leading Power Factor	Excess kVAr compensation by fixed capacitors	Remove fixed capacitors installed at any place below Transformer and APFC panel can be installed with HT sensing APFC relay.
Capacitor drawing less current. (Derated)	Low voltage	Check for mains voltage
	Capacitor got derated (To be understood by checking capacitance values) 1. Voltage and Current harmonics 2.Temperature in panel 3.Insufficient switching delay	1.Check for harmonic over loading and if required install detuned reactors and AHF 2.Suggest changes for proper thermal design 3.Feed required switching delay in APFC relay. (60 seconds while contactor switching)
Single phasing	OPD of 1 phase is operated. Check for Capacitance values. (Either of RY, YB, BR would be zero) 1. Voltage and Current harmonics 2.Insufficient switching delay	1.Check for harmonic over loading and if required install detuned reactors and AHF 2.Feed required switching delay in APFC relay. (60 seconds while contactor switching)

8.1.2 BENEFITS:

a) Cost savings in electricity bills due to reduced demand charges
b) Improved voltage
c) Reduced carbon footprint due to reduced power system losses

8.2 POWER QUALITY RESTORERS SHOULD BE USED AS NEEDED

During site visits, it is observed that along with low power factor, there are harmonics above the specified limits in power system which is deteriorating the power quality and affecting the installed equipment and resulting in higher maintenance costs. Hence, power quality compensators may be installed in places where the power quality is being affected by the type of loads.

8.2.1 IMPLEMENTATION MECHANISM

a) Analysis of harmonics via power quality audit
b) Passive and Active Harmonics filters shall be installed to limit the harmonics in the electrical systems.

8.2.2 BENEFITS

a) No overheating of Cable, transformer, standby generator and other electrical distribution equipment.
b) Harmonic resonance is contained which would otherwise result in high voltage and current surge.
c) Harmonics lead to false branch circuit breakers tripping, which is avoided.
d) Fire hazards in distribution and wiring systems due to harmonics is reduced.

9 AP5 – CAPACITY BUILDING AND AWARENESS

The process of improving an organization's management and governance in order to help it more successfully accomplish its goals and carry out its mission is known as capacity building. Capacity Building and Awareness activities are essential to update and align staff with the overarching vision of Indian Railways.

9.1 PERIODIC TRAINING OF THE STAFF OF IR

It is very important for the Officers, Supervisors, and staff to be aware of the decarbonization strategies in order to implement and identify energy saving potential and avert carbon emissions. USAID SAREP has prepared a training course in collaboration with IRIEEN which covers the Energy Conservation Building Code, its concepts and compliance, etc. This course is designed for engineers of the Indian Railways to incorporate SuperECBC requirements in the tenders and to ensure that building design and construction meets SuperECBC requirements.

9.1.1 IMPLEMENTATION MECHANISM

a) IRIEEN and IRICEN shall develop the training courses for all levels of IR officials.
b) IRIEEN, STC, Zonal Training centers will conduct training on sustainability, energy efficiency and renewable energy.
c) Training will be conducted routinely to keep updated on the latest technologies and solutions to achieve net zero carbon emission. Hands on training will be provided to the supervisors and staff.
d) BEE may be requested to design/assist in making/imparting training modules.
e) STCs should design standard training modules which shall be imparted to supervisor/staff at zones and divisions levels.
f) Managers, engineers, and staff selected for the training has to be an even representation of the ZRs.
g) The trained candidates should initiate and drive the sustainability initiatives in the ZRs

9.1.2 BENEFITS

a) Capacity building of staff on sustainability, energy efficiency and renewable energy
b) Training on various standards and guidelines for compliance

9.2 DEVELOPMENT OF PRINTED/DIGITAL AWARENESS CAMPAIGN

Digital/ Printed media will enable IR to create awareness and focus on circulating the content and intent of IR to transition towards net zero carbon emissions by 2030.

9.2.1 IMPLEMENTATION MECHANISM

a) Development of content aligning with IR strategies.
b) Development of presentations, flyers, pamphlets etc.
c) Development of poster for railway stations and office corridors.
d) Development of modules for hands on training.

9.2.2 BENEFITS

a) Enable more visibility of objectives and approaches towards net zero carbon.
b) Recognition of best practices towards net zero carbon.
c) Creating awareness among all the staff of IR.

9.3 ANNUAL ENERGY EFFICIENCY (OORJAVIR) AWARD

Annual energy efficiency award to recognize exemplary contributions towards energy efficiency and sustainability should be institutionalized. This initiative will create awareness and encourage Indian Railways staff to incorporate best energy efficiency practices. Awards will be presented in two categories:

a) Supervisor/staff within each division
b) Division within each zone

9.3.1 IMPLEMENTATION MECHANISM

a) Development of evaluation methodology for individual/ team and divisional category.
b) Process to record and verify the initiatives of individual/team category.
c) Development of data recording format to award prizes.
d) Cash incentives may be given to individual/team category.
e) The awards will be published in the annual reports of Indian Railways.

9.3.2 BENEFITS

a) Sharing of learnings and success story.
b) Awareness of sustainability and energy efficiency initiatives.
c) Encourage railway peers to achieve similar feats which will drive net zero carbon emission mission.

9.4 REPORTING OF ENERGY EFFICIENCY AND NET ZERO ACTIONS

This strategy is aimed at developing a mechanism to establish a clear guideline to share updates on various activities and at the same share learning experiences. Development of documents to delineate the practices adopted by various ZRs and create a mechanism for reporting and apprising the Railway board

9.4.1 IMPLEMENTATION MECHANISM

a) Development of reporting template
b) Periodic schedule of reporting
c) Access to information among all stakeholders within IR

9.4.2 BENEFITS

a) Sharing of learnings and success story
b) Update on status of net zero mission
c) Information sharing among the Officials of IR