

# ENERGY AUDIT MANUAL FOR INDIAN RAILWAYS



## Table of Content

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Chapter 1.	INTRODUCTION .....	4
Chapter 2.	BACKGROUND.....	7
Chapter 3.	SCOPE .....	9
Chapter 4.	STAKEHOLDER FOR ENERGY AUDIT MANUAL .....	9
4.1	Government Entities .....	9
4.1.1	<i>Planning Commission, Government of India</i> .....	9
4.1.2	<i>Ministry of Environment, Forestry and Climate Change</i> .....	10
4.1.3	<i>Bureau of Energy Efficiency (BEE), MoP</i> .....	10
4.1.4	<i>Ministry of Power (MOP)</i> .....	10
4.1.5	<i>Ministry of Railways</i> .....	10
4.2	Indian Railway Entities .....	10
4.2.1	<i>Indian Railways (IR)</i> .....	10
4.2.2	<i>IR Board and Directorates</i> .....	10
4.2.3	<i>Zonal Railways</i> .....	11
4.2.4	<i>Indian Railway Production Units</i> .....	11
4.2.5	<i>RDSO (Research, Designs and Standards Organisation)</i> .....	11
4.2.6	<i>RITES Ltd</i> .....	11
4.2.7	<i>Central Organisation for Modernisation of Workshops (COFMOW)</i> .....	11
4.2.8	<i>Central Training Institutes, Indian Railways</i> .....	12
4.2.9	<i>Indian Railway Finance Corporation Limited (IRFC)</i> .....	12
4.3	Other organizations.....	12
4.3.1	<i>Manufactures and their associations</i> .....	12
4.3.2	<i>International agencies: UIC, SNCF, etc.</i> .....	12
Chapter 5.	BEE REGULATIONS ON ENERGY AUDIT .....	13
5.1	PAT Rules.....	13
5.1.1	<i>PAT Framework</i> .....	13
5.1.2	<i>Designated Consumers (DCs)</i> .....	14
5.1.3	<i>Phases of PAT scheme</i> .....	16
5.2	BEE-Gazette Notification for Indian Railways .....	17
5.3	Need of Energy Audit.....	17
5.4	Broad Areas of Energy Conservation in Non traction .....	18

5.4.1	<i>  Illumination:</i> .....	18
	<i>  Timer &amp; Sensor:</i> .....	19
	<i>  Automatic Platform Lighting:</i> .....	19
5.4.2	<i>  Pumping</i> .....	19
5.4.3	<i>  Air Conditioning</i> .....	19
5.4.4	<i>  Air Compressor</i> .....	20
5.4.5	<i>  Fan</i> .....	20
5.4.6	<i>  Workshop and Yards</i> .....	20
5.4.7	<i>  Promotion of Renewable Sources of Energy</i> .....	21
5.5	<b>  Type of Energy Audit</b> .....	<b>21</b>
5.4.1	<i>    Preliminary Audit</i> .....	21
5.4.2	<i>    Detailed Energy Audit Methodology</i> .....	22
5.6	<b>  Guidelines for energy audits of non-traction facilities of IR</b> .....	<b>24</b>
5.7	<b>  Post Audit Activities-Implementing Energy Efficiency</b> .....	<b>26</b>
Chapter 6.	<b>  ENERGY AUDIT PROCEDURES</b> .....	<b>27</b>
Chapter 7.	<b>  ENERGY AUDIT TOOLS &amp; INSTRUMENT</b> .....	<b>35</b>
Chapter 8.	<b>  ENERGY CONSERVATION OPPORTUNITIES (ENCON)</b> .....	<b>40</b>
8.1	<b>  Tariff Analysis</b> .....	<b>40</b>
8.2	<b>  Overview</b> .....	<b>41</b>
8.3	<b>  Electricity Tariffs</b> .....	<b>41</b>
8.4	<b>  Applying Tariff Analysis to Energy Audit</b> .....	<b>41</b>
8.5	<b>  Saving Opportunity</b> .....	<b>41</b>

## Chapter 1. INTRODUCTION

India has the world's second largest population with more than 1.2 billion people and continues to grow at 1.4% per year. India's economy has grown with a sustained GDP growth rate of more than 9% during the past decade which has reduced during last few financial year but as per latest report from International funding agency, it will regaining its pace of growth. India's electricity consumption has also increased at an annual rate of about 8-9% in the past years and according to the India's Planning Commission (IEP, 2006) it is expected to continue to grow at similar rates for the next 20 years at a GDP growth rate of 9%. Energy consumption in India is growing and is expected to continue to grow to sustain its economic growth and demand of growing population. If India is to meet this growth target for power availability, its entire requirement cannot come solely from generation / supply augments. A major contribution will have to come from savings through better demand side management and improvement in the end user energy efficiency.

The National Action Plan on Climate Change (NAPCC), released by the Prime Minister on 30th June, 2008, recognizes the need to maintain a high growth rate for increasing living standards of the vast majority of people and reducing their vulnerability to the impacts of climate change. NAPCC outlines a comprehensive policy framework that seeks to protect the poor and vulnerable sections of society through an inclusive growth and sustainable development strategy sensitive to climate change. NAPCC outlines Eight National Missions, representing multi-pronged, long-term and integrated strategies for achieving key goals in the context of climate change which includes horizon, strategies and missions such as National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for a Green India, National Mission for Sustainable Agriculture and National Mission for Strategic Knowledge for Climate Change.

The National Mission for Enhanced Energy Efficiency (NMEEE) is one of the eight national missions under NAPCC with the an objective to promote innovative policy and regulatory regimes, financing mechanisms and business models which not only create, but also sustain, markets for energy efficiency in a transparent manner with clear targets to be achieved in phase wise manner. Achieving national growth objectives & India's commitment towards mitigation of climate change through a qualitative change in direction that enhances ecological sustainability, leading to further mitigation of greenhouse gas emissions, devising efficient and cost-effective strategies for end user Demand Side Management (DSM), deploying appropriate technologies for both adaptation and mitigation of greenhouse gases emissions extensively as well as at an accelerated pace, and engineering new and innovative forms of market, regulatory

and voluntary mechanisms to promote sustainable development are the key strategies of the NAPCC. The Ministry of Power (MOP) and Bureau of Energy Efficiency (BEE) were tasked to prepare the implementation plan for the NMEEE. NMEEE spelt out the four new initiatives to enhance energy efficiency such as Perform Achieve and Trade (PAT), Market Transformation for Energy Efficiency (MTEE) Energy Efficiency Financing Platform (EEFP) and Framework for Energy Efficient Economic Development (FEEED).

India's total energy consumption during 2009 was 449.27 million tonnes of oil equivalent (MTOE) where the residential and industrial sectors consume energy about 38 and 30% respectively. In order to accelerate as well as incentivize energy efficiency, the Perform Achieve and Trade (PAT) mechanism has been designed. PAT is a market based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded. The Ministry of Power (MoP) has specified certain energy intensive industries and other establishments as designated consumers, having annual energy consumption more than their threshold. The identified energy intensive industries and other establishments are Thermal Power Stations, Fertilizer, Cement, Pulp and Paper, Textiles, Chlor-Alkali, Iron & Steel, Aluminum and Railways, 13 Electric traction Sub-stations (TSSs) in each Zonal Railway, 16 Diesel Loco Sheds in each Zonal Railway, All 6 production units i.e. Integral Coach Factory (ICF), Rail Coach Factory (RCF), Chittaranjan Locomotive Works (CLW), Diesel Locomotive Works (DLW), Diesel Component Works (DCW), and Rail Wheel Factory (RWF) and Workshops of Indian Railway has been identified as maximum energy consuming sectors as their annual energy consumption is more than their threshold. The Indian Railway which is one of the designated consumers under PAT scheme is having consumption of 2.4 percent of India's total electricity consumption and hence provides immense opportunities energy efficiency. Further, each identified DCs has to furnish their specific energy consumption to BEE and conduct an energy audit of their installations as per the Notification S.O. 02/11(6)/05-BEE dated 28/04/2010 on a defined interval of time. This Energy Audit Manual has been prepared as a guideline document for Energy Audit to be carried out in Indian Railways Installations i.e. Railway Station, Residential Colonies, Production Units, Workshops, Loco-sheds, Car-sheds, Hospitals, Offices (Divisional, Zonal, etc.), Water pumping, etc. This Energy Audit manual refers guidance to the Indian Railway staff for preparing themselves for conducting Energy Audits in their installations. It is both an interpretive guide and a benchmark of current best practice. This Energy Audit Manual also aims to provide technical references that are commonly needed during an energy audit. The manual is intended to provide most of the references information needed for a typical energy audit.

As on date, there are no guidelines or manual available in India, which exclusively speaks about the practical energy auditing methodology which can be adopted by Indian railways staff or external auditors. Thus, this manual depicted the approach and scientific calculations needed for conducting energy audit. This manual contains initial guidelines for doing energy audit in Indian Railways.

## Chapter 2. BACKGROUND

With the climate negotiations moving at a sluggish pace over the last three annual global summits, attention is shifting towards energy and climate schemes in the major economies. Under pressure after other emerging economies announced domestic schemes, India announced a target reduction of carbon intensity of Gross Domestic Production (GDP) by 20% to 25% of 2005 levels by 2020 in Copenhagen. This reduction is to be achieved through India's National Action Plan of Climate Change (NAPCC) consisting of eight missions launched in 2008. The main targets and strategies with regard to energy efficiency are set in the Five-Year Plans of the Government of India. The Ninth-Five-Year Plan (1999-2003) provided the basis for the issuance of the Energy Conservation (EC) Act in 2001 and the establishment of the Bureau of Energy Efficiency as central institution for the implementation of an energy conservation program. The Tenth-Five-Year Plan (2003-2007) focused on the need for an efficient use of energy sources to achieve sustainable development and provided the basis for the establishment of an appropriate institutional set-up for the provision of energy efficiency services, including the authorization of the Ministry of Power (MOP) to develop energy efficiency programs. The Eleventh Five-Year Plan (2007-2012) aims at enhancing rural energy access and target savings of 5% of energy consumption levels through the implementation of a set of energy efficiency interventions in all sectors, including the establishment of an appropriate set of incentives; the creation of an enabling institutional framework; the promotion of energy service companies (ESCOs) and the promotion of energy efficient technologies including use of energy efficient equipments, mandatory audits of facilities with loads above 1 MW.

Indian Railway (IR) is the one of the largest organization with the highest electricity consumption in India. It consumes about 2.4% of India's total electricity consumption. In the fiscal year (FY) 2007-08, Indian Railways consumed 14.1 billion kilowatt-hours (kWh), of which 11.7 billion (about 83%) for traction usages and 2.4 billion (17%) in non-traction usages (IR Year Book 2007-08).

It is estimated that electricity demand in Indian Railway will grow in the coming years. First, in compliance with the Integrated Energy Policy, India plans to progressively shift freight traffic to railways and development of Dedicated Freight Corridor. Passenger traffic is also expected to increase due to high population growth and increase in mobility of the people. Overall, it is estimated that the railway sector will have a growth in the total traffic (freight and passengers) of 8-9% in the next decade. Second, Indian Railways has initiated an ambitious Electrification Plan to increase the electrification of its routes converting diesel-fuelled traffic (which represented 36% and 53% of the freight and passenger traffic respectively in fiscal year 2007-

08) into electric traffic, because electric traction is more efficient than diesel traction and also diesel is being imported into the country.

According to this Plan, 80% of rail freight and 60% of passenger traffic will run on electric energy by 2031-32. It is estimated that the total demand of electricity in the railways sector will grow at a rate of more than 9% annually. The electricity consumption is projected to be about 100.5 billion kWh by 2031-32 with the electrification dominant scenario. Therefore, an enormous energy saving potential exists in the Indian Railways (IR) sector for implementing energy efficiency measures and energy conservation technologies. In addition, In FY 2007-08, energy cost represented about 24% of the ordinary working expenses of Indian Railways (electricity accounts for 14.6% of the total ordinary working expenses). Thus, the possibility of savings on electricity would have a positive effect on the operating margins of Indian Railways.

Usage of Energy in Indian Railways is basically under two heads namely Traction and Non-traction and measured separately. Traction Energy is consumed towards hauling of trains whereas Non-traction energy is towards offices, railway station, yards, residential, water supply, air conditioning, workshops, maintenance depots etc.

Energy audit, and energy audit programs, are one of the most widespread and used instrument to overcome barriers to energy efficiency and promoting energy efficiency in industry.



## **Chapter 3. SCOPE**

The purpose of the energy audit manual is to develop long term energy efficiency and adopt the newest energy efficient technologies to conserve maximum energy for the non-traction area over Indian Railways. To maximise the efficient usages of the present system it is required to collect, monitor, analyse the energy consumption pattern for various energy intensive areas such as production units, workshops and sheds, washing lines, railway stations, offices and residential colonies. This manual shall help in the development of a long-term vision, internal policies, directives, regulations, procedures on energy efficiency. It also helps for identifying specific energy efficiency technologies and measures, standards, performance criteria, material standards and specifications, etc., and promoting and monitoring the implementation of EE measures; preparation of annual plans for energy efficiency with specific targets and allocated budget; development and institutionalization of a monitoring and verification and audit system; the institutionalization of energy efficiency and conservation awareness programs within the organization.

The manual shall also provides technical references, sum “how-to” information (how to produce a good energy balance, for example) and a guide on the expertise that should be sought for different applications. It was not the intention for this manual for provide a comprehensive list of saving opportunities, but rather to identify those opportunities that commonly occur. The energy audit manual also provides references as to where detailed technical information can be found on these and on less common opportunities. The energy audit manual is not intended to break new ground, but rather to collect and summarize existing information sources and in particular the individual experiences. These experiences can be quite different from those of energy auditors.

## **Chapter 4. STAKEHOLDER FOR ENERGY AUDIT MANUAL**

The project stake-holders for this energy audit manual has been defined in line with UNDP project document titled “Improving Energy Efficiency in the Indian Railway System”. The detail has been provided in below mentioned sections:

### **4.1 Government Entities**

#### **4.1.1 Planning Commission, Government of India**

The Planning Commission has the responsibility of making assessment of all resources of the country, augmenting deficient resources, formulating plans for the most effective and balanced utilization of resources and determining priorities. Five Year Plans are formulated by Planning Commission.

Inclusion of appropriate outcome of the project in the policy formulation such as Five Year Plans, etc. may be best affected through the Planning Commission. Therefore Planning

Commission is one of the most important stakeholders for achieving the goal of energy efficiency in India Railway in terms of fund allocation in the plan of Indian Railway.

#### **4.1.2 Ministry of Environment, Forestry and Climate Change**

This ministry is the nodal agency in the administrative structure of the Central Govt. for the planning, promotion, co-ordination and overseeing the implementation of India's environmental and forestry policies and programs.

#### **4.1.3 Bureau of Energy Efficiency (BEE)**

BEE is the coordinator of umbrella programme on “Programmatic Framework Project for EE” under which the Improving EE in Indian Railways System is one of the projects. BEE is one of the project steering committee (PSC) member and play a key role in risk mitigation, particularly in mitigating the risks to project implementation due to lack of manufacturers’ interest in investing in EE products BEE will also play a key facilitation role among partners.

#### **4.1.4 Ministry of Power (MOP)**

MOP is responsible for perspective planning, policy formulation, processing of projects for investment decision, monitoring of the implementation of power projects, the administration and enactment of legislation in regard to thermal, hydro power generation, transmission and distribution, rural electrification and energy efficiency and conservation. MoP will ultimately serve as central authority and guide BEE in meeting program objectives and in implementation of programs listed in EC Act 2001.

#### **4.1.5 Ministry of Railways**

The Ministry of Railways in India is in charge of the Indian Railways, the state-owned company that enjoys a monopoly in Rail transport in India.

### **4.2 Indian Railway Entities**

#### **4.2.1 Indian Railways (IR)**

Indian Railways is the state-owned railway company of India, which owns and operates most of the country's rail transport. It is overseen by the Ministry of Railways of the Government of India. It is governed by the Railway Board, which is headed by Chairman Railway Board.

#### **4.2.2 IR Board and Directorates**

The Indian Railway Board is the apex body of the Indian Railways.. It has the following members currently; Chairman Railway Board: Member Electrical, Member Staff, Member Mechanical, Member Engineering, Member Traffic, and Finance Commissioner. Important Directorates as related to EE are: Long-Range Decision Support Systems (LRDSS), Electrical Engineering, Planning, Tracks, Mechanical Engineering (Production Units) and Workshops etc.

These directorates of Railway Board would provide logistical and technical support for the implementation of the energy efficiency projects over Indian Railways.

#### **4.2.3 Zonal Railways**

Indian Railways is divided into 16 zones, which are further sub-divided into 68 divisions. These 16 Zonal Railways manages Indian Railway operations within zone boundaries. Each Zone has zonal training centers (ZTCs) to impart training to the staff and a workshop where to repair and maintain their assets and rolling stock. Zonal field units will function as implementer as well as develop training and capacity building to the staff towards energy efficiency.

#### **4.2.4 Indian Railway Production Units**

Indian Railway production units take care of production of parts and are integral part of proper functioning of railway system in India. They are categorized (located in) as; locomotives (Chittaranjan, Patiala, Varanasi); coaching stock (Kapurtala and Chennai); axles and wheels (Bengaluru). These production units will prepare themselves for energy audit with the help of this manual.

#### **4.2.5 RDSO (Research, Designs and Standards Organisation)**

RDSO is the organization of Indian Railways (IR) responsible for research and design. It serves as the technical advisor to the Railway Board, Zonal Railways and Production Units. It is responsible for the development of new and improved designs, adoption, absorption of new technologies, development of standards and specifications for materials and equipment, technical investigation, statutory clearances, testing and providing consultancy services. IR procurement is based on the specifications that are released by RDSO. RDSO would assist in framing/updating the technical requirements and specifications of the equipment.

#### **4.2.6 RITES Ltd**

RITES, a Government of India Enterprise, provide comprehensive engineering, consultancy and project management services in the transport infrastructure sector. Export/leasing maintenance and rehabilitation of railway rolling stock, operation and maintenance of railway systems under concession agreements and BOT, BOOT and PPP projects that are specific to Railways.

#### **4.2.7 Central Organisation for Modernisation of Workshops (COFMOW)**

COFMOW was established under the Ministry of Railways by the Govt. of India for modernizing Indian Railway workshops in 1979. The modernization project was funded through World Bank credits. COFMOW provides professional advice and a single window service in planning and procurement of machine tools and allied equipment. COFMOW would assist in vendor development of EE technologies.

#### **4.2.8 Central Training Institutes, Indian Railways**

The Indian Railways employ approximately 1.4 million people (largest civilian employer in the world). The training of all the cadres is entrusted and shared between six Centralized Training Institutes namely (i) the Indian Railway Institute of Transportation Management (IRTM) in Lucknow for officers of the Traffic department, (ii) the Indian Railway Institute of Civil Engineering (RICEN) in Pune for civil engineers, (iii) the Indian Railway Institute of Signal and Telecommunications Engineering (IRISAT) in Secunderabad for engineers of S&T department, (iv) the Indian Railway Institute of Mechanical and Electrical Engineering & Jamalpur Gymkhana (IRIME) in Jamalpur for mechanical engineers; (v) the Indian Railway Institute of Electrical Engineering (IRIEEN) in Nasik for Electrical Engineers, (vi) the RPF Academy (IRT) in Lucknow for officers of the Railway Protection Force, and (vii) the Railway Staff College in Vadodara which functions as the apex training institute for the officers of all departments in general and Accounts, Personnel, Stores and Medical departments in particular.

These training institutions, primarily IRIEEN, will be involved in training their trainers and further train the trainees.

#### **4.2.9 Indian Railway Finance Corporation Limited (IRFC).**

IRFC is a dedicated financing arm of the Ministry of Railways. Its objective is to raise money from the market to part finance the plan outlay of Indian Railways. The money made available will be used for acquisition of rolling stock assets and for meeting other developmental needs of the Indian Railways.

IRFC will be informed of the project for possible future requirement in raising finance for EE measures.

### **4.3 Other organizations**

#### **4.3.1 Manufactures and their associations**

The companies like Siemens, ABB, Bombardier, SNCF, Balfour Beatty etc. are in the business of manufacturing and supply equipments including energy appliances to IR.

These companies are expected to produce and supply the energy efficient devices decided for intervention.

#### **4.3.2 International agencies: UIC, SNCF, etc.**

Leading Centres of Excellence in industrialized countries, international agencies like International Union of Railways (UIC) or at country level (e.g., SNCF/ France) provide assistance on energy efficiency.

Interaction with these agencies will help in obtaining the know-how on EE technologies for railway systems and identify suitable options for India.

## Chapter 5. BEE REGULATIONS ON ENERGY AUDIT

India, recognising the challenge of pursuing rapid economic growth in a sustainable manner, has developed an energy efficiency scheme to govern large energy consumers. There is a significant potential to improve efficiency in energy-intensive industries and the electricity sector, which together were responsible for about 60% of India's GHG emissions. The Perform, Achieve and Trade (PAT), is an energy efficiency trading scheme that uses market-based mechanisms. PAT is the flagship programme under the National Mission on Enhanced Energy Efficiency, one of the eight missions under the National Action Plan on Climate Change, 2008. It was conceived in 2008 to promote India's development objectives – to strengthen energy security, reduce energy deficit and enhanced the global competitiveness of Indian Industries – while yielding climate change mitigation co-benefits. The programme aims to scale up energy efficiency in targeted industries in a cost-effective manner through various incentives and penalties, while allowing for increased production and energy consumption to meet the needs of growing economy.

### 5.1 PAT Rules

The PAT scheme originated in the 2001 Energy Conservation Act, which empowers the Indian Government to identify energy-intensive industries as Designated Consumer (DCs) and set mandatory energy conservation standards for them. The Ministry of Power's Bureau of Energy Efficiency (BEE) identified 9 Designated Consumers and targeted them in PAT scheme: Aluminium, chlor-alkali, textile, pulp and paper, iron and steel, fertiliser, cement, thermal power plants and railways. The scheme covers 478 facilities.

Each facility under the PAT scheme has been assigned a specific energy consumption (SEC) reduction target compared to its baseline SEC, to be achieved by March 2015. SEC is energy consumed per unit of production, expressed in toe per tonne of product. DCs receive tradable, certified energy savings credits if they achieve efficiency gains beyond their target, if they fall short of the target, they can buy energy savings credits to make up the difference. Energy savings credits will be issued to eligible facilities annually after the first year of the compliance period (2012). BEE has not set a minimum price for trading of energy savings credits, the market will determine the price.

#### 5.1.1 PAT Framework

The PAT framework has been developed considering the legal requirement under EC Act, 2001, situation analysis of designated consumers, national goal to be achieved in terms of energy saving and sustainability of the entire scheme. The PAT scheme is involved in order to incentivize industry to achieve better energy efficiency improvements than their specified SEC

improvement target in a cost-effective manner. The additional certified energy savings can be traded with other designated consumers who could use these certificates to comply with their SEC reduction targets. The Energy Savings Certificates (ESCerts) will be traded on special trading platforms to be created in the two power exchanges (IEX and PXIL). The guiding principles for developing the PAT mechanism are Simplicity, Accountability, Transparency, Predictability, Consistency, and Adaptability. The PAT framework includes the following elements:

- Methodology for setting specific energy consumption (SEC) for each DC in the baseline year
- Methodology for setting target to reduce the Specific Energy Consumption (SEC) by the target year from the baseline year.
- The process to verify the SEC of each DC in the baseline year and in the target year by an accredited verification agency
- The process to issue energy savings certificates (ESCerts) to those DCs who achieve SEC lower than the specified value
- Trading of ESCerts
- Compliance and reconciliation of ESCerts
- Cross-sectoral use of ESCerts and their synergy with renewable energy certificates

The SEC of an industry is calculated based on Gate-to-Gate concept with the following formula:

Specific energy consumption (SEC) =

Net energy input into the designated consumers' boundary

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Total quantity of output exported from the designated consumers' boundary

### 5.1.2 Designated Consumers (DCs)

The Ministry of Power (MoP) has notified industrial units and other establishments consuming energy more than the threshold in 9 sectors namely Thermal Power Plants, Fertilizer, Cement, Pulp and Paper, Textiles, Chlor-Alkali, Iron & Steel, Aluminum and Railways in March, 2007 as DCs. .

Minimum annual energy consumption and estimated number of Designated Consumers (DCs)  
in PAT sectors

Sector	Minimum annual energy consumption for the DC*	No. of probable DCs
Aluminium	7,500	11
Cement	30,000	83
Chlor-alkali	12,000	20
Fertilizer	30,000	23

Iron and steel	30,000	101
Pulp and paper	30,000	51
Railways (diesel locosheds and workshops)		8
Textiles	3,000	128
Thermal power plants	30,000	146

\* Ton of oil equivalent (toe)/per unit of product (1 MTOE = 10<sup>7</sup> kcal)

#### Sector wise Energy consumption and Energy Saving Targets under PAT Cycle-1 (2012-2015)

Sr. No.	Sector	No of Identified DCs PAT Cycle-1	Energy Saving Targets under PAT Cycle-1 (million toe)
1	Aluminium	10	0.456
2	Cement	85	0.816
3	Chlor-alkali	22	0.054
4	Fertilizer	29	0.478
5	Iron and steel	67	1.486
6	Pulp and paper	31	0.119
7	Textiles	90	0.066
8	Thermal power plants	144	3.211
Total		478	6.686

The Act requires the DCs to:

- Furnish report of energy consumption to the Designated Authority of the State as well as to BEE (section 14(k)).
- Designate or appoint an Energy Manager who will be in-charge of submission of annual energy consumption returns of the Designated Agencies and BEE (section 14 (l)).
- Comply with the energy conservation norms and standards prescribed under section 14 (g) of the Act.
- Purchase Energy Saving Certificates (ESCerts) for compliance to section 14 (g) in the event of default. The Act has been amended with the addition of new subsection 14A to enable this and section 14A (2) allows such trading. ESCerts are defined by adding a new subsection 2(ma).
- Monitoring and Verification of compliance by Designated Energy Auditors (DENA) which will be prescribed the Government/ BEE under section 14A/13 (p) of the Act.
- Excess achievement of the target set would entail issuance of ESCerts under section 14A(1).
- Penalty for non-compliance being Rs. 10 lakhs and the value of noncompliance measured in terms of the market value of tones of oil equivalent by inserting a new section 26(1A).

- BEE to be the overall regulator and dispute resolution agency and Energy Efficiency Service Ltd. (EESL) to be the process manager.

The PAT scheme will be participated by 'Designated Consumers (DC)' of energy intensive sector. In the first cycle of PAT scheme i.e. during 2011-12 to 2013-14, 8 energy intensive sectors such as Thermal Power plants, Iron & Steel, Cement, Fertilizer, Aluminium, Textile, Pulp & Paper, Chlor-alkali have been included. As per annual energy consumption reported by industries of these sectors through a mandatory reporting (section 14(k) EC Act, 2001) or otherwise, there are about 563 number of DCs in these 8 sectors . All these DCs except Railways will automatically be required to participate in the 1st cycle of PAT scheme.

Railways are having 8 DCs as per the notification of MoP. As the sectoral energy scenario and energy usage pattern is under study by BEE, these DCs have been excluded from the 1st cycle of PAT scheme.

In the next cycle(s) of PAT scheme (post 2013-14), the number of DCs may get revised as more number of sectors will be added up and more/less number of plants may be there in the present 8 sectors.

Recently, Ministry of Power (MoP) in its notification dated 27/05/2014 directed that every Designated Consumer shall

- (a) get energy audit conducted by an accredited energy auditor, in accordance with the Bureau of Energy Efficiency (Manner and Intervals of Time for Conduct of Energy Audit) Regulations, 2010;
- (b) furnish to the concerned designated agency, details of information on energy consumed and details of the action taken on the recommendations of accredited energy auditor, in accordance with the Energy Conservation (Form and Manner and Time for Furnishing Information With Regard to Energy Consumed and Action Taken on Recommendations of Accredited Energy Auditor) Rules, 2008

### **5.1.3 Phases of PAT scheme**

The 1<sup>st</sup> cycle of PAT scheme would be operational during April 2011 to March 2014. The following basic phases would be involved during this cycle

- Target Setting Phase: By March 2011
- Target Achieve Phase: April 2011 to March 2014
- M&V Phase: April 2012 and beyond
- Trading Phase : After M&V Phase



## 5.2 BEE-Gazette Notification for Indian Railways

As per Ministry of Power (referred hereafter as MOP) Notification S.O. 394 (E), dated 12/03/2007, the Central Government in consultation with Bureau of Energy Efficiency (BEE) has identified Indian Railways as a Designated Consumer (DC). Indeed, IR is the single largest organization with the highest electricity consumption in India. Indian Railways consumes approx. 2.4% of India's total electricity consumption. As per the said MOP notification, the following IR entities have been identified as DC: 13 Traction Sub Stations (TSSs), 16 Diesel Loco Sheds, 6 production units i.e. Integral Coach Factory (ICF), Rail Coach Factory (RCF), Chittaranjan Locomotive Works (CLW), Diesel Locomotive Works (DLW), Diesel Component Works (DCW), and Rail Wheel Factory (RWF) and Workshops having annual energy consumption of 30,000 MTOE or more. Further, each identified DC has to furnish its Specific Energy Consumption to BEE and conduct an energy audit of its installations as per the Notification S.O. 02/11(6)/05-BEE dated 28/04/2010 at defined interval of time. Thus, the guidelines mentioned in this document will help each of the aforesaid units of IR to prepare for an energy audit. The detail notification has been provided in appendix 1 of this manual.

### 5.1.4 Need of Energy Audit

Energy Audit is an effective energy management tool. By identifying and implementing the means to achieve energy efficiency and conservation, not only can energy savings be achieved, but also equipment/system services life can be extended. All these mean savings in money. Based on the principle of "The less energy is consumed, the less fossil fuels will be burnt", the power supply companies will generate relatively less pollutants and by-products. Therefore, all stakeholders contribute to conserve the environment and to enhance sustainable development.

In Indian Railway, there are three top operating expenses which include energy, labour and machinery. In one were to relate to the manageability of the cost or potential cost saving in each of the above components, energy would invariably emerge as a top ranker. As discussed in earlier section, energy cost in Indian Railway represents about 24% of the ordinary working expenses of Indian Railways. Thus, the possibility of savings on electricity would have a positive effect on the operating margins of Indian Railways. Energy audit will help in ensure that energy is being used efficiently in different types of equipment/system.

The energy audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programme which will be vital for operation for India Railway. Such an audit programme will help to keep focus on variations which occur in the energy cost, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc.

In general Energy Audit is the translation of conservation ideas into realities, by lending technologically feasible solution within a specific time frame. The primary objective of the energy audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. The energy audit provides a benchmark, or reference point, for managing and assessing energy use across the organization and provides the basis for ensuring more effective use of energy.

### 5.3 Broad Areas of Energy Conservation in Non traction

Broad areas of Energy Conservation in non traction area are summarized as follows:

#### 5.4.1 Illumination:

- **Energy Efficient Luminaries:**

Illumination is an ever increasing need of human being. Energy conservation in the field of illumination is by use of energy efficient lamp such as T5, CFL and LED luminaire. In general, usage of different type of lamps standardized is as follows:

- Incandescent Lamp should be prohibited unless required for decorative purpose or specific application.
- Fluorescent Tube Light T15 & CFL
- High Pressure Sodium Vapor Lamp: Application restricted for high mast tower not falling in the vision of train movement.
- Metal Halide: High mast tower in yards, circulating area etc.
- LED lamp

Table 1: Comparative Table of different lamps

S. No.	Type of Lamp	Lumen/Watt	CRI	Avg. Life (hrs)	Avg Cost	Application
1.	Incandescent lamp	14	100	1000-2000	Low	Prohibited
2.	FL tube T-8 , T-12	83-90	85	5000	Low	Phased out
3.	FL tube T-5	104	85	18000	Medium	Regular
4.	CFL 18 W - 55 W	62-87	82	8000 - 20000	Medium	Regular
5.	MH, 70 W - 400 W	72-92	65 - 90	9000 - 2000	Medium	High Mast
6.	HPSV, 70 W- 400 W	90-140	20-25	28000 - 32000	Medium	High Mast
7.	HPMV, 70- 250 W	50	70-80	8000-1000	Medium	Restricted
8.	LED	105	85	50,000	High	Trial

### **Timer & Sensor:**

Illumination is not required at uniform level throughout the night time at different locations. Timer and Sensors has been provided. Sensor helps in switching on and off the lamp depending on natural light. Timer is required to switch off part of the mast tower lights after 22 hrs or as per actual survey of train/passenger movement.

### **Automatic Platform Lighting:**

100% light works at Railway Station when train comes to the station and only 30% during rest of the time. This is achieved automatically by taking a feed from signalling system by which 100% lights switches on when the signal is lowered for the train. Railway may adopt other methodology for automatic switches of PF lighting.

### **5.4.2 Pumping**

Pumping installation consumes considerable amount of electric energy. With increase in passenger services, demand is continuously increasing. Actions taken to contain energy consumption are as follows:

- Selection of pump depending on the head and yield test. Over capacity pump is energy inefficient and shall be avoided.
- Use of energy efficient motors and pump
- Provision of capacitor bank at load centre to improved power factor
- Provision of timer to control the pumping hours
- Provision of electrical controlled water level sensor
- To make best use of overhead tank capacity to work the pump with electric power instead diesel. The situation arises due to load shedding by Electricity Board.
- To stop water leakage through pipe line and water tap

### **5.4.3 Air Conditioning**

Air Conditioning load is having a rising trend. This is mainly for the fact that air conditioning is now being considered as an efficiency multiplier instead a luxury. Hospitals, Office Buildings, Upper Class waiting Hall, Reservation Office, Control office, etc. are being provided with air conditioned comfort. Actions taken to contain energy consumption in these areas are:

- Use of energy efficient BEE standard star rated air conditioning machine
- Air sealing
- Temperature setting at a comfort level of 23-25°C and its remote control. 3% increase in energy consumption for every 1 degree reduction in temperature.
- Directing cool air flow towards the occupant when there are only few user

- Use of occupancy sensor
- Training of office peons to switch off the air conditioners when Boss is away.
- Switching off supply for air conditioner load of the office building just after 15 minutes of schedule office hours.

#### 5.4.4 Air Compressor

Air compressor is used in carriage and wagon repair center for testing of the rake at 5kg/cm<sup>2</sup> pressure. Energy conservation scope exists in the following area:

- To control air leakage and to increase time taken for cut in of the compressor.
- To reduce the setting for cut out. Optimum setting is 7kg/cm<sup>2</sup>
- To install energy saver to reduce energy consumption while working during unloading period.

#### 5.4.5 Fan

- Extensive service duty with working for almost 24 hours during summer in 24×7 buildings.
- Selection of fan size shall be decided based on plinth area
- Blade pitch or the angle with the horizontal shall be between 120-150
- BEE has defined service value of more than 4 for best result. 1200mm sweep fan delivers 210cum/min air.
- Mounting of fan shall be such to maintain a gap of 24" between ceiling and fan blade. Using ceiling fans at slow speed along with air-conditioner will help in increasing the thermostat setting to a comfortable value of 26<sup>0</sup>C.
- Electronic regulator is commonly used now-a-days. Energy consumption at step 1 is almost half as compared to full step.
- Ceiling fans are suitable for the enclosed area. Heavy duty air circulators are more suitable for covered platform. Heavy wind damages the blade angle and deforms the mounting, sometime even making it unsafe.
- Fans are provided with fixed and running capacitor. The speed drops if the value deteriorates with time. Timely replacement of capacitor is necessary. This should be done as a must change item along with some cleaning/painting schedule as this is a low value item. One can find many fans rotating at slow speed during a visit to a Railway Station.

#### 5.4.6 Workshop and Yards

- Electric energy is consumed in the operation of machines, blower, compressor, cranes etc. The efficiency of these machines at part load is poor. Use power controller for variable voltage or vvvf control. The horsepower is directly

proportional to cube of angular velocity of the blower motor. Frequency control shall be preferred as compared to damper control for controlling the air flow.

- Compressors are used in yards, maintenance sheds and workshop for supplying compressed air which is used for air testing of the wagon and coaching stock and working on tools operated on air and plays a vital role towards energy conservation.
- Leakage in compressed air system shall be checked at regular intervals and attended.
- Compressor works by loading and unloading cycle. During unloading cycle, energy consumption can be reduced by lowering the voltage. Energy savers are available to achieve this function.

#### **5.4.7 Promotion of Renewable Sources of Energy**

Indian Railway has gone for use of solar power energy at manned level crossing gates, way side stations etc. It is difficult to extend power supply at these locations; therefore, solar power at these remote locations is an attractive proposition. This application being in remote area therefore, anti-theft measures have been built in the design of the solar panel at way side stations

LED lamp is preferred with solar panel for reasons that LEDs are available in lower power ratings and battery supply can directly feed to LED lamp thus saving on inverter. LED lamp is normally justified on life costing therefore decided to design with antitheft measures and IP65 protection.

### **5.4 Type of Energy Audit**

The type of Energy Audit to be performed depends on:

- Function and type of utility
- Depth to which final audit is needed and
- Potential and magnitude of cost reduction desired

Thus Energy Audit can be classified into the following two types:

- Preliminary Audit
- Detailed Audit

#### **5.4.1 Preliminary Audit**

The preliminary energy audit uses existing or easily obtained data through walk survey, study of available historical data, consultation etc. Preliminary energy audit is a relatively quick exercise to:

- Establish energy consumption
- Identify and estimate the scope of saving
- Identify immediate (especially no/low cost) improvement/saving

- Set reference point
- Identify areas for more detailed study/measurement

### 5.4.2 Detailed Energy Audit Methodology

A detailed energy audit provides a comprehensive energy project implementation plan for a facility, since it evaluates all major energy-using systems.

This type of audit offers the most accurate estimate of energy savings and cost. It considers the interactive effects of all projects, accounts for the energy use of all major equipment, and includes detailed energy cost saving calculations and project cost.

In a detailed audit, one of the key elements is the energy balance. This is based on an inventory of energy-using systems, assumptions of current operating conditions, and calculations of energy use. This estimated use is then compared to utility bill charges.

Detailed energy auditing is carried out in three phases:

- Phase I – Pre-Audit
- Phase II – Audit
- Phase III – Post-Audit

The various steps of conducting detailed energy audit at the unit/field level are listed below. These steps can be modified based upon the requirement of field condition and time.

Table 2: Steps of Detail Energy Audit

Step	Action	Purpose
<b>Phase I – Pre-Audit Phase</b>		
1	Plan and organize Walk-through audit Informal interviews with energy manager, production/plant manager	<ul style="list-style-type: none"> <li>• Resource planning; establish/organize energy audit team</li> <li>• Organize instrumentation &amp; time frame</li> <li>• Macro data collection (suitable to type of industry)</li> <li>• Familiarization of process/plant activities</li> <li>• First-hand observation &amp; assessment of current level operation and practices</li> </ul>
2	Conduct briefing/ awareness session with all divisional heads and persons concerned (2–3 hrs)	<ul style="list-style-type: none"> <li>• Building up cooperation</li> <li>• Issue forms/questionnaire for each department</li> <li>• Orientation, awareness creation</li> </ul>
<b>Phase I – Audit Phase</b>		

3	Primary data gathering, process flow diagram, & energy utility diagram	<ul style="list-style-type: none"> <li>• Historic data analysis; baseline data collection</li> <li>• Prepare process flow chart(s)</li> <li>• All service utilities system diagram (Example: Single line power distribution diagram, water, compressed air)</li> <li>• Design, operating data and schedule of operation</li> <li>• Annual energy bill and energy consumption pattern (refer to manuals, log sheets, equipment spec sheets, interviews)</li> </ul>
	Conduct survey and monitoring	<ul style="list-style-type: none"> <li>• Measurements:</li> <li>• Motor survey, insulation, and lighting survey with portable instruments to collect more and accurate data. Confirm and compare actual operating data with design data.</li> </ul>
5	Conduct detailed trials/experiments for biggest energy users / equipment	<ul style="list-style-type: none"> <li>• Trials/experiments:</li> <li>• 24-hr power monitoring (MD, PF, kWh, etc.).</li> <li>• Load variation trends in pumps, fans, compressors, heaters, etc.</li> <li>• Equipment performance experiments, etc.</li> </ul>
6	Analysis of energy use	<ul style="list-style-type: none"> <li>• Energy and material balance &amp; energy loss/waste analysis</li> </ul>
7	Identification and development of energy conservation (ENCON) opportunities	<ul style="list-style-type: none"> <li>• Identification &amp; consolidation of ENCON measures</li> <li>• Conceive, develop, and refine ideas</li> <li>• Review ideas suggested by unit personnel</li> <li>• Review the previous ideas suggested by preliminary energy audit</li> <li>• Use brainstorming and value analysis techniques</li> <li>• Contact vendors for new/efficient technology</li> </ul>

8	Cost-benefit analysis	<ul style="list-style-type: none"> <li>• Assess technical feasibility, economic viability, and prioritization of ENCON options for implementation</li> <li>• Select the most promising projects</li> <li>• Prioritize by low, medium, long-term measures</li> <li>• Documentation, report presentation to top management</li> </ul>
9	Reporting & presenting to top management	<ul style="list-style-type: none"> <li>• Documentation, report presentation to top management</li> </ul>
<b>Phase I – Post-Audit Phase</b>		
10	Implementation and follow-up	<ul style="list-style-type: none"> <li>• Assist and implement ENCON measures and monitor performance</li> <li>• Action plan, schedule for implementation</li> <li>• Follow-up and periodic review</li> </ul>

## 5.5 Guidelines for energy audits of non-traction facilities of IR

The first exercise towards energy audit railway station, offices, hospital, workshops, production units and residential colony is to formulate the energy audit team. The energy audit team will include the representatives from each department where energy audit will be performed. The energy audit team will collect, analyse and document data for energy consumption of each utility, equipment and appliances etc.

Responsibility of energy efficiency team:

- Obtain copies of monthly utility bills and invoices for delivered fuel
- Classify utility bills either by meter or by building and put them together into 12-month blocks using the meter-read dates
- Pinpoint location of all meters and sub-meters
- Identify which facility, building or space is served by which meter

The energy team will develop simple recording forms each department, production unit etc.

The following should be recorded:

- Energy usage in appropriate units (kWh, Litre, etc.);
- Electric demand (kW); and
- Cost/ rate schedule.

Conduct a brief meeting/awareness programme with all divisional heads and persons concerned to building up cooperation between each department. The forms developed by energy audit team will be circulated to head of each department. Discussion will be held on



establishing a methodology on accurately calculate the specific energy consumption of various products/services or activity etc.

An improved data recording, collection and analysis system to keep track of energy consumption is to be developed.

- Identify key locations for Installation of energy meters at all feeders to monitor electricity consumption
- Separate monitoring and recording of electricity consumed by ATM, canteen, and other establishments at railway station. Prepaid meters can be installed.
- Maintaining and cleaning of all lighting fixtures on a regular basis. Maintain record of cleaning of all lighting fixtures against each location.
- Regular services are to be done for air conditions, fans, motors etc.
- Monitoring of load variations trends in pump, fans and compressors etc.
- Regular monitoring of transformer core loss reduction in distribution system
- Regular checking of leakage and pressure reduction in compressor system
- Seasonal reset of timers for street light and platform light where automation has been done
- Promotion of using natural light wherever feasible. This will allow putting off all the lamps during sunny days.
- Replace 40 watt conventional TFL and Incandescent lamp with 28 watt energy efficient TFL (T5)
- Promote efficient lamps for lighting purpose
- Promote variable frequency drives for traversors and cranes
- Promotion of Renewable Energy for non-traction railway sites
- Ensure proper functioning, operation & maintenance and calibration of meters to avoid any in-consistency in monitoring of energy consumption
- Monitoring and recording of electricity generated from diesel generators and monitoring of diesel consumption of generators
- Regular energy awareness training programmes are to be conducted within the each department
- Identification of energy conservation opportunities in fuel substitution, energy generation, energy distribution and energy usage by process.
- Recording of maximum demand (MD) over the period of time and compare it with contract demand. If the MD is less than the contract demand for a long time then reduce the contract demand.
- Identify motors with less than 50% loading, 50-75% loading, 75-100% loading and over 100% loading. Motor loading above than 70% can be avoided by properly sizing the motor and by optimising the load on the motor.

- To find out possibilities of replacement of old motors and pump with energy efficient motors and pump for pumping system
- Regular overhauling and maintenance of DG sets with special consideration to fuel injection and discharge system; removal of hot spots; and reduction of blow – by.
- The log book should be properly maintained so that the performance of the DG sets can be assessed in – house by monitoring the parameters such as specific power generation as lube oil consumption with respect to fuel oil consumption.

## **5.6 Post Audit Activities-Implementing Energy Efficiency**

The process of key importance – an energy audit – has been concluded. As soon as possible after audit, the management team in consultation with the implementing agency should review the result and decide on the course of action to be taken. At this point in the process, the facility is ready to act on ESOs and develop new operating scenarios.

## **Chapter 6. ENERGY AUDIT PROCEDURES**

### **6.1 Energy Audit Procedure for Electrical supply (Transformer) and Distribution System**

- Record all source of energy for each utility, collect and record contract demand for each utility and prepare single line diagram of the electrical supply and distribution.
- Prepare transformer design detail in the format given in energy audit manual.
- Prepare and Maintain record on periodic testing and schedule maintenance of transformer
- Collect last two year energy bills and record data in specified format for benchmarking purpose.
- Record and measure peak load on daily basis for last 2 years, Maximum Demand , KW, PF, KVAR, etc.
- Prepare inventories of all connected loads including load distribution, peak load, Energy use and power factor pattern for monthly basis.
- Prepare energy consumption breakup of different utilities in Railway Stations, Hospitals, Offices, Workshops, Production Units and Residential Colonies etc.
- Prepare inventory of all energy-using equipment, including the capacity, year of installation and rated consumption data for each.
- Optimize transformer loading by load shifting, proper sizing of transformer and better maintenance practices.
- All the meters installed at each utility should be calibrated at defined interval by manufacturer.

### **6.2 Energy Audit Procedure for Motors**

- Prepare inventory of motors/drives rating, operating hours. Voltage, frequency, line current, power factor, power drawn and the shaft RPM at the operating conditions for the motors rating 20 HP or more.
- Ensure rewinding of motors shall be allow only if the rewinding cost is less than 50% of the motors cost otherwise purchased new energy efficient motors.
- Ensure periodical motor load survey or identify the following
  - Motors with less than 50 % loading, 50 – 75 % loading, 75 – 100 % loading, over 100 % loading.

- Motors with low voltage / power factor / voltage imbalance for needed improvement measures.
- Motors with machine side losses / inefficiencies like idle operations, throttling / damper operations for avenues like automatic controls / interlocks, variable speed drives, etc
- Ensure use of Energy-efficient motors in all installations. The energy- efficient motors have lower operating temperatures and noise levels, greater ability to accelerate higher-inertia loads, and are less affected by supply voltage fluctuations.

Motor load survey is aimed not only as a measure to identify motor efficiency areas but equally importantly, as a means to check combined efficiency of the motor, driven machine and controller if any. The margins in motor efficiency may be less than 10 % of consumption often, but the load survey would help to bring out savings in driven machines / systems, which can give 30 – 40 % energy savings.

### **6.3 Energy Audit Procedure compressed Air System**

- Ensure air intake to compressor is not warm and humid by locating compressors in well-ventilated area or by drawing cold air from outside. Every 4°C rise in air inlet temperature will increase power consumption by 1 percent.
- Ensure cleaning of air-inlet filters regularly. Compressor efficiency will be reduced by 2 percent for every 250 mm WC pressure drop across the filter.
- Ensure compressor valves in good condition by removing and inspecting once every six months. Worn-out valves can reduce compressor efficiency by as much as 50 percent.
- Ensure Installation of manometers across the filter and monitor the pressure drop as a guide to replacement of element.
- Ensure minimize low-load compressor operation; if air demand is less than 50 percent of compressor capacity, consider change over to a smaller compressor or reduce compressor speed appropriately (by reducing motor pulley size) in case of belt driven compressors.
- Consider the use of regenerative air dryers, which uses the heat of compressed air to remove moisture.
- Fouled inter-coolers reduce compressor efficiency and cause more water condensation in air receivers and distribution lines resulting in increased corrosion. Periodic cleaning of intercoolers must be ensured.
- Compressor free air delivery test (FAD) must be done periodically to check the present operating capacity against its design capacity and corrective steps must be taken if required.

- If more than one compressor is feeding to a common header, compressors must be operated in such a way that only one small compressor should handle the load variations whereas other compressors will operate at full load.
- The possibility of heat recovery from hot compressed air to generate hot air or water for process application must be economically analyzed in case of large compressors.
- Consideration should be given to two-stage or multistage compressor as it consumes less power for the same air output than a single stage compressor.
- If pressure requirements for processes are widely different (e.g. 3 bar to 7 bar), it is advisable to have two separate compressed air systems.
- Reduce compressor delivery pressure, wherever possible, to save energy.
- Provide extra air receivers at points of high cyclic-air demand which permits operation without extra compressor capacity.
- Retrofit with variable speed drives in big compressors, say over 100 kW, to eliminate the 'unloaded' running condition altogether.
- Keep the minimum possible range between load and unload pressure settings.
- Automatic timer controlled drain traps wastes compressed air every time the valve opens. So frequency of drainage should be optimized.
- Check air compressor logs regularly for abnormal readings, especially motor current cooling water flow and temperature, inter-stage and discharge pressures and temperatures and compressor load-cycle.
- Ensure periodic leak tests to estimate the quantity of leakage.
- Install equipment interlocked solenoid cut-off valves in the air system so that air supply to a machine can be switched off when not in use.
- Ensure correct pipe size to minimize falling pressure. Excessively small pipes result in resistance to the air flow, which increases energy consumption and pressure fluctuation.
- Compressed air piping layout should be made preferably as a ring main to provide desired pressures for all users.
- A smaller dedicated compressor can be installed at load point, located far off from the central compressor house, instead of supplying air through lengthy pipelines.
- All pneumatic equipment should be replaced with electric driven equipment.

- On account of high pressure drop, ball or plug or gate valves are preferable over globe valves in compressed air lines.
- Use air amplifier nozzles for all cleaning application.

#### **6.4 Energy Audit Procedure for Air Conditioning System (Window, Spilt and Centralized AC)**

- Prepare Inventory of all air conditioners (capacity, make, type, number, hours of operation and age).
- Use solar rejecting films in the room where AC are installed and windows are facing sun.
- Optimise air conditioning volumes by measures such as use of false ceiling and segregation of critical areas for air conditioning by air curtains.
- Minimise the air conditioning loads by measures such as roof cooling, roof painting, efficient lighting, pre-cooling of fresh air by air- to-air heat exchangers, variable volume air system, optimal thermo-static setting of temperature of air conditioned spaces, sun film applications, etc.
- Ensure regular maintenance of all A/C plant components as per manufacturer guidelines.
- Ensure adequate quantity of chilled water and cooling water flows, avoid bypass flows by closing valves of idle equipment.
- Minimize part load operations by matching loads and plant capacity on line; adopt variable speed drives for varying process load.
- Make efforts to continuously optimize condenser and evaporator parameters for minimizing specific energy consumption and maximizing capacity.
- Adopt VAR system where economics permit as a non-CFC solution.
- Make sure that the temperature of air conditioner should be in range of 23-25°C.
- Replace old starting and running capacitor during periodic overhauling in a year to reduce electricity consumption.

#### **6.5 Energy Audit Procedure for Chillers**

- Increase the chilled water temperature set point if possible.
- Use the lowest temperature condenser water available that the chiller can handle. (Reducing condensing temperature by 5.5°C, results in a 20 - 25% decrease in compressor power consumption)
- Increase the evaporator temperature
- Clean heat exchangers when fouled.
- Optimize condenser water flow rate and refrigerated water flow rate.

- Replace old chillers or compressors with new higher-efficiency models.
- Use water-cooled rather than air-cooled chiller condensers.
- Use energy-efficient motors for continuous or near-continuous operation.
- Specify appropriate fouling factors for condensers.
- Do not overcharge oil.
- Install a control system to coordinate multiple chillers.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple chillers.
- Run the chillers with the lowest energy consumption. It saves energy cost, fuels a base load.
- Avoid oversizing -- match the connected load.
- Isolate off-line chillers and cooling towers.
- Periodic maintenance need to be carry out to access the degree of scaling both on the evaporator and condenser side and further de-scaling of condensers and evaporators should be done every quarter/ six monthly basis.
- Periodic inspection of capacitor for motor and compressor shall be carried out on annual basis.

## **6.6 Energy Audit Procedure for Cooling Towers**

- Prepare inventory of cooling towers make, model, type, rating and operating hours of individual tower. Water & Air flowrate, Hot & Cold water temperature (Inlet/outlet water temp), Ambient dry and wet bulb temperature
- Follow manufacturer's recommended clearances around cooling towers and relocate or modify structures that interfere with the air intake or exhaust.
- Optimise cooling tower fan blade angle on a seasonal and/or load basis.
- Correct excessive and/or uneven fan blade tip clearance and poor fan balance.
- On old counter-flow cooling towers, replace old spray type nozzles with new square spray ABS practically non-clogging nozzles.
- Replace splash bars with self-extinguishing PVC cellular film fill.
- Install new nozzles to obtain a more uniform water pattern
- Periodically clean plugged cooling tower distribution nozzles.
- Balance flow to cooling tower hot water basins.
- Cover hot water basins to minimise algae growth that contributes to fouling.
- Optimise blow down flow rate, as per COC limit.

- Replace slat type drift eliminators with low pressure drop, self extinguishing, PVC cellular units.
- Restrict flows through large loads to design values.
- Segregate high heat loads like furnaces, air compressors, DG sets, and isolate cooling towers for sensitive applications like A/C plants, condensers of captive power plant etc. A 1°C cooling water temperature increase may increase A/C compressor kW by 2.7%. A 1°C drop in cooling water temperature can give a heat rate saving of 5 kCal/kWh in a thermal power plant.
- Monitor L/G ratio, CW flow rates w.r.t. design as well as seasonal variations. It would help to increase water load during summer and times when approach is high and increase air flow during monsoon times and when approach is narrow.
- Monitor approach, effectiveness and cooling capacity for continuous optimization efforts, as per seasonal variations as well as load side variations.
- Consider COC improvement measures for water savings.
- Consider energy efficient FRP blade adoption for fan energy savings.
- Consider possible improvements on CW pumps w.r.t. efficiency improvement.
- Control cooling tower fans based on leaving water temperatures especially in case of small units.
- Optimise process CW flow requirements, to save on pumping energy, cooling load, evaporation losses (directly proportional to circulation rate) and blow down losses.

## **6.7 Energy Audit Procedure for Pump and Pumping Stations**

- Prepare inventory of pumps to record type, rating, and operating hours of individual pumps. Pump discharge flow, Suction head, Discharge head, water distribution pipeline network for calculating the pressure drop across the pipeline.
- Ensure operation of pumps near best efficiency point.
- Modify pumping system and pumps losses to minimize throttling.
- Stop running multiple pumps - add an auto-start for an on-line spare or add a booster pump in the problem area.
- Use booster pumps for small loads requiring higher pressures.
- Repair seals and packing to minimize water loss by dripping.
- Balance the system to minimize flows and reduce pump power requirements.



- Avoid pumping head with a free-fall return (gravity); Use siphon effect to advantage:
- Conduct water balance to minimize water consumption
- Replace old pumps by energy efficient pumps
- In the case of over designed pump, provide variable speed drive, or downsize / replace impeller or replace with correct sized pump for efficient operation.
- Optimise number of stages in multi-stage pump in case of head margins
- Reduce system resistance by pressure drop assessment and pipe size optimisation

## **6.8 Energy Audit Procedure for Lighting**

- Prepare inventory of lighting fixtures floor wise– number and type of fixtures.
- Prepare and maintain power consumption of light in kW/fixture (for each type of fitting), Hours of operation etc.
- Ensure cleaning of all lighting fixtures on a regular basis. Maintain record of cleaning of all lighting fixtures against each location.
- Seasonal reset of timers for street light and platform light where automation has been done.
- Lights can be shut off during non-working hours by automatic controls, such as occupancy sensors which turn off lights when a space becomes unoccupied.
- Use natural light wherever feasible. This will allow putting off all the lamps during sunny days.
- Replace obsolete incandescent lighting with CFL and LED
- Change exit signs from incandescent to LED.
- Installation of energy efficient fluorescent lamps in place of "Conventional" fluorescent lamps
- Installation of metal halide lamps in place of mercury / sodium vapour lamps (Metal halide lamps provide high color rendering index when compared with mercury & sodium vapour lamps. These lamps offer efficient white light. Hence, metal halide is the choice for colour critical applications where, higher illumination levels are required)
- Installation of High Pressure Sodium Vapour (HPSV) lamps for applications where colour rendering is not critical (High pressure sodium vapour (HPSV) lamps offer more efficacy. But the colour rendering property of HPSV is very low. Hence, it is recommended to install HPSV lamps for applications such street lighting, yard lighting, etc.)

- Installation of LED panel indicator lamps in place of filament lamps (Panel indicator lamps are used widely in industries for monitoring, fault indication, signalling, etc.)
- Installation of "exclusive" transformer for lighting (Generally, lighting load varies between 2 to 10%. Most of the problems faced by the lighting equipment and the "gears" is due to the "voltage" fluctuations. Hence, the lighting equipment has to be isolated from the power feeders. This provides a better voltage regulation for the lighting)
- Installation of servo stabilizer for lighting feeder
- Installation of high frequency (HF) electronic ballasts in place of conventional ballasts

## **6.9 Energy Audit Procedure for DG Sets**

- Prepare inventory of DG sets including technical specification, rating and operating hours, fuel consumed of individual DG set.
- Specific Fuel Consumption of DGs should be prepared by maintaining fuel consumption log book. The specific fuel consumption will be calculated by dividing unit generation with fuel consumption.
- Ensure steady load conditions on the DG set, and provide cold, dust free air at intake (use of air washers for large sets, in case of dry, hot weather, can be considered).
- Clean air filters regularly
- Improve air filtration.
- Insulate exhaust pipes to reduce DG set room temperatures
- Calibrate fuel injection pumps frequently.
- Ensure compliance with maintenance checklist.
- Ensure steady load conditions, avoiding fluctuations, imbalance in phases, harmonic loads.
- Carryout regular field trials to monitor DG set performance, and maintenance planning as per requirements.
- Maintained periodic overhauling/maintenance records of DGs
- Ensure fuel oil storage, handling and preparation as per manufacturers' guidelines/oil company data.
- Consider fuel oil additives in case they benefit fuel oil properties for DG set usage.
- Consider parallel operation among the DG sets for improved loading and fuel economy thereof.

## Chapter 7. ENERGY AUDIT TOOLS & INSTRUMENT

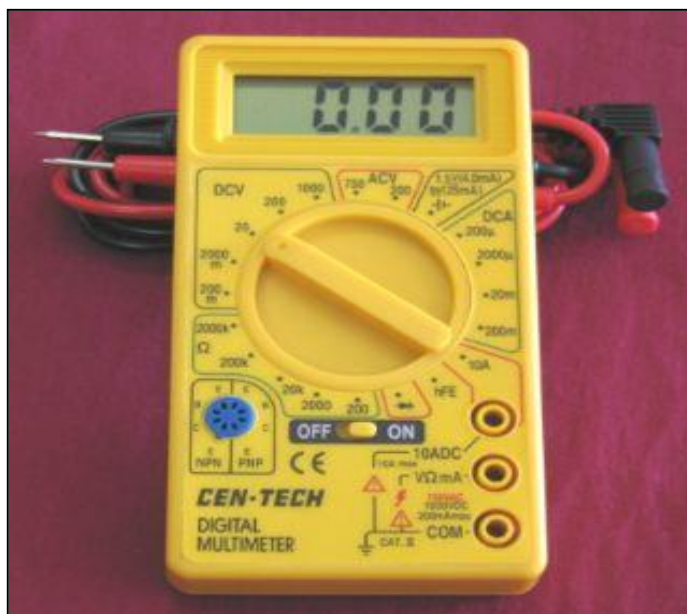
For carrying out energy audit activity, team will require some portable measuring devices which can able to observe the actual measurements and monitor parameters (e.g. luminous intensity, Pressure, flow, voltage, current) of the equipment. These instruments must be portable, durable, easy to operate and relatively inexpensive. Basic monitored parameters during the energy audit includes following:

Basic Electrical Paramters in AC & DC system – Voltage (V),Current (I), Power Factor, Active Power (kW), Apparent Power (Demand) (kVA), Reactive Power (kVAR), Energy Consumption (kWh), Frequency (Hz), Harmonics etc.

Paramters of importance other than electrical parameters such as temperature & heat flow, radiation, air and gas flow, liquid flow, RPM, noise & vibration, dust concentration, TDS, pH, moisture content, RH, Flue gas analysis – CO<sub>2</sub>, O<sub>2</sub>, CO, SO<sub>x</sub>, NO<sub>x</sub>, Combustion efficiency.

### Voltmeter:

A voltmeter is useful for determining operating voltages on electrical equipment and especially useful when the nameplate of the equipment has worn off of a piece of equipment or is otherwise unreadable or missing. The most versatile instrument is a combined volt- ohm-ammeter with a clamp on feature for measuring currents in conductors that are easily accessible. This type of multi-meter is convenient and relatively inexpensive.



### Factor Meter:

A portable hand power factor

meter are very handy for determining the power consumption and power factor of the individual electrical equipment and other inductive devices, and the load factors of motors. This motor typically has

### Wattmeter/Power

held wattmeter and

a clamp-on feature which allows easy and safe connection to the current-carrying conductor, and has probes for voltage connections.



## Flue Gas Analyser/Combustion Analyzer

This instrument has in-built chemical cells which measure various gases such as O<sub>2</sub>, CO, NO<sub>x</sub> and SO<sub>x</sub> as well as combustion efficiency of the engine by measuring CO<sub>2</sub> & CO ration. It also monitors the temperature of the flue gas.

## Infrared Thermometer

This is a non-contact type measurement which when directed at a heat source directly gives the temperature read out. This instrument is useful for measuring hot spots in furnace, surface temperature etc.



## Pitot tube and Manometer

Air velocity in ducts can be measured using a pitot tube and inclined manometer for further calculation of flow.

## Flow meter:

A portable flow meter which measures the flow rates in liters per second or cubic meters per hour and water velocities is one of the most important energy audit equipment in water utilities.



## Tape measures:

The most basic measuring device is the tape measure. A 25-foot and 100-foot tape measures are used to verify the dimensions of the walls, ceilings, doors and distances between pieces of equipment, for example, to determine the length of a pipe.



## Power Analyser:

Used for measurement and analysis of electrical Power.



## Demand Analyser:

Used for measurement and analysis of electrical Power.



## Non-Contact Tachometer:

Used for measurement of speed of rotation equipment.



## Lux Meter:

Used for measurement of illumination level



## Harmonic Analyser:

Used for analysis of harmonics in power System.



## Frequency Meter:

Used for measurement of power supply frequency.



## Chapter 8. ENERGY CONSERVATION OPPORTUNITIES

### 8.1 Tariff Analysis

It is a key process in carrying out an energy audit. Energy cost saving are achieved by reducing one or both, of two main component:



- The rate pay for energy (Rs/kWh and /or Rs/kVA) and
- The amount of energy used (kWh and/or kVA).

## **8.2 Overview**

Tariff analysis needs to be applied to all energy sources: electricity, oil, gas, diesel, coal, wood and other fuel used. An understanding of the fee structure for each energy source is essential for identifying where an energy audit should focus. It is important for determining what rates should be used in cost saving calculation for example, the difference between gross and marginal costs of the electricity need to be analysed. In addition, tariff analysis of all fuels helps in identifying fuel switching opportunities. Tariff varies from source to source, supplier to supplier and location to location.

## **8.3 Electricity Tariffs**

Electricity Tariffs are the summation of network tariffs and supplier energy usage tariffs, and both can include fixed and variable charge components. Electricity tariffs vary by Distribution Company, site management and type of electricity meter. At the industrial/commercial level, meter are often Time-of-day (TOD – Tariff varies according to time of the day) meters, but sometime non-TOD meters are used. This usually occurs where the metered load are smaller.

## **8.4 Applying Tariff Analysis to Energy Audit**

Tariff Analysis is used in an energy audit to help calculate energy costs and saving accurately and to determine where emphasis should be focused in saving opportunities. For example, th e energy auditor would usually focus on energy saving opportunities where a tariff structure is based mostly on Rs/kWh, whereas an energy auditor would put an equal amount of emphasis on reducing peak loads where the tariff had a significant peak load tariff. Some exceptions to this occur; for example, in places where occasional occupancy such as party hall, stadium is only for a short period resulting in the fixed tariff dominate the overall cost.

In such cases, consideration should be focus on reducing consumption with same cost saving opportunities also possible from reducing peak load kVA.

## **8.5 Saving Opportunity**

Saving opportunities can be achieved by adopting following measures:

### **Tariff**

Analysis of tariffs also needs to be undertaken to identify tariff cost saving opportunities. Energy use pattern need to be analysed and matched with all tariff options (including oil, gas and other fuel) available to determine what tariff will be most cost effective. This also needs to

be done in combination with any likely changes in energy use as a result of load growth or energy saving measures. Analysis includes reviewing all factors that affect the tariff.

Factors to analyse in identifying tariff saving opportunity are:

- Energy use load patterns by day and year
- Ability to load shift
- Power factor at different load
- Fuel switching options
- Diesel, gas, wood fuel, oil

Power factor affects how much you pay for electricity if you use ToD meter and pay for kVA peaks or kVAR penalties. Often when power factor is less than 90% particularly at peak load time, then correcting the power factor to above 90% usually provides an acceptable payback.

### **Electricity Distribution System**

- Optimise the tariff structure with utility supplier
- Schedule your operations to maintain a high load factor
- Shift loads to off-peak times if possible.
- Minimise maximum demand by tripping loads through a demand controller
- Stagger start-up times for equipment with large starting currents to minimize load peaking.
- Use standby electric generation equipment for on-peak high load periods.
- Correct power factor to at least 0.90 under rated load conditions.
- Relocate transformers close to main loads.
- Set transformer taps to optimum settings.
- Disconnect primary power to transformers that do not serve any active loads
- Consider on-site electric generation or cogeneration.
- Export power to grid if you have any surplus in your captive generation
- Check utility electric meter with your own meter.
- Shut off unnecessary computers, printers, and copiers at night.

### **Motors**

- Properly size to the load for optimum efficiency. (High efficiency motors offer of 4 - 5% higher efficiency than standard motors)
- Use energy-efficient motors where economical.
- Use synchronous motors to improve power factor.
- Check alignment.

- Provide proper ventilation
- For every 10<sup>0</sup>C increase in motor operating temperature over recommended peak, the motor life is estimated to be halved
- Check for under-voltage and over-voltage conditions.
- Balance the three-phase power supply.
- An imbalanced voltage can reduce 3 - 5% in motor input power
- Demand efficiency restoration after motor rewinding.
- If rewinding is not done properly, the efficiency can be reduced by 5 - 8%

## **Drives**

- Use variable-speed drives for large variable loads.
- Use high-efficiency gear sets.
- Use precision alignment.
- Check belt tension regularly.
- Eliminate variable-pitch pulleys.
- Use flat belts as alternatives to v-belts.
- Use synthetic lubricants for large gearboxes.
- Eliminate eddy current couplings.
- Shut them off when not needed.

## **Fans**

- Use smooth, well-rounded air inlet cones for fan air intakes.
- Avoid poor flow distribution at the fan inlet.
- Minimize fan inlet and outlet obstructions.
- Clean screens, filters, and fan blades regularly.
- Use aerofoil-shaped fan blades.
- Minimize fan speed.
- Use low-slip or flat belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable fan loads.
- Use energy-efficient motors for continuous or near-continuous operation
- Eliminate leaks in ductwork.
- Minimise bends in ductwork

- Turn fans off when not needed.

## **Blowers**

- Use smooth, well-rounded air inlet ducts or cones for air intakes.
- Minimize blower inlet and outlet obstructions.
- Clean screens and filters regularly.
- Minimize blower speed.
- Use low-slip or no-slip belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable blower loads.
- Use energy-efficient motors for continuous or near-continuous operation.
- Eliminate ductwork leaks.
- Turn blowers off when they are not needed.

## **Pumps**

- Operate pumping near best efficiency point.
- Modify pumping to minimize throttling.
- Adapt to wide load variation with variable speed drives or sequenced control of smaller units.
- Stop running both pumps -- add an auto-start for an on-line spare or add a booster pump in the problem area.
- Use booster pumps for small loads requiring higher pressures.
- Increase fluid temperature differentials to reduce pumping rates.
- Repair seals and packing to minimize water waste.
- Balance the system to minimize flows and reduce pump power requirements.
- Use siphon effect to advantage: don't waste pumping head with a free-fall (gravity) return.

## **Compressors**

- Consider variable speed drive for variable load on positive displacement compressors.
- Use a synthetic lubricant if the compressor manufacturer permits it.
- Be sure lubricating oil temperature is not too high (oil degradation and lowered viscosity) and not too low (condensation contamination).
- Change the oil filter regularly.

- Periodically inspect compressor intercoolers for proper functioning.
- Use waste heat from a very large compressor to power an absorption chiller or preheat process or utility feeds.
- Establish a compressor efficiency-maintenance program. Start with an energy audit and follow-up, then make a compressor efficiency-maintenance program a part of your continuous energy management program.

## Compressed air

- Install a control system to coordinate multiple air compressors.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple air compressors.
- Avoid over sizing -- match the connected load.
- Load up modulation-controlled air compressors. (They use almost as much power at partial load as at full load.)
- Turn off the back-up air compressor until it is needed.
- Reduce air compressor discharge pressure to the lowest acceptable setting.
- Reduction of 1 kg/cm<sup>2</sup> air pressure (8 kg/cm<sup>2</sup> to 7 kg/cm<sup>2</sup>) would result in 9% input power savings. This will also reduce compressed air leakage rates by 10%
- Use the highest reasonable dryer dew point settings.
- Turn off refrigerated and heated air dryers when the air compressors are off.
- Use a control system to minimize heatless desiccant dryer purging.
- Minimize purges, leaks, excessive pressure drops, and condensation accumulation.
- Compressed air leak from 1 mm hole size at 7 kg/cm<sup>2</sup> pressure would mean power loss equivalent to 0.5 kW)
- Use drain controls instead of continuous air bleeds through the drains.
- Consider engine-driven or steam-driven air compression to reduce electrical demand charges.
- Replace standard v-belts with high-efficiency flat belts as the old v-belts wear out.
- Use a small air compressor when major production load is off.
- Take air compressor intake air from the coolest (but not air conditioned) location.
- Every 5<sup>0</sup>C reduction in intake air temperature would result in 1% reduction in compressor power consumption
- Use an air-cooled after cooler to heat building makeup air in winter.
- Be sure that heat exchangers are not fouled (e.g. -- with oil).
- Be sure that air/oil separators are not fouled.

- Monitor pressure drops across suction and discharge filters and clean or replace filters promptly upon alarm.
- Use a properly sized compressed air storage receiver. Minimize disposal costs by using lubricant that is fully demulsible and an effective oil-water separator.
- Consider alternatives to compressed air such as blowers for cooling, hydraulic rather than air cylinders, electric rather than air actuators, and electronic rather than pneumatic controls.
- Use nozzles or venturi-type devices rather than blowing with open compressed air lines.
- Check for leaking drain valves on compressed air filter/regulator sets. Certain rubber-type valves may leak continuously after they age and crack.
- In dusty environments, control packaging lines with high-intensity photocell units instead of standard units with continuous air purging of lenses and reflectors.
- Establish a compressed air efficiency-maintenance program. Start with an energy audit and follow-up, then make a compressed air efficiency-maintenance program a part of your continuous energy management program.

## Chillers

- Increase the chilled water temperature set point if possible.
- Use the lowest temperature condenser water available that the chiller can handle.
- Reducing condensing temperature by 5.5<sup>0</sup>C, results in a 20 - 25% decrease in compressor power consumption
- Increase the evaporator temperature
- 5.5<sup>0</sup>C increase in evaporator temperature reduces compressor power consumption by 20 - 25%
- Clean heat exchangers when fouled.
- 1 mm scale build-up on condenser tubes can increase energy consumption by 40%
- Optimize condenser water flow rate and refrigerated water flow rate.
- Replace old chillers or compressors with new higher-efficiency models.
- Use water-cooled rather than air-cooled chiller condensers.
- Use energy-efficient motors for continuous or near-continuous operation.
- Specify appropriate fouling factors for condensers.
- Do not overcharge oil.
- Install a control system to coordinate multiple chillers.

- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple chillers.
- Run the chillers with the lowest energy consumption. It saves energy cost, fuels a base load.
- Avoid oversizing -- match the connected load.
- Isolate off-line chillers and cooling towers.
- Establish a chiller efficiency-maintenance program. Start with an energy audit and follow-up, then make a chiller efficiency-maintenance program a part of your continuous energy management program.

### **HVAC (Heating / Ventilation / Air Conditioning)**

- Tune up the HVAC control system.
- Consider installing a building automation system (BAS) or energy management system (EMS) or restoring an out-of-service one.
- Balance the system to minimize flows and reduce blower/fan/pump power requirements.
- Eliminate or reduce reheat whenever possible.
- Use appropriate HVAC thermostat setback.
- Use morning pre-cooling in summer and pre-heating in winter (i.e. -- before electrical peak hours).
- Use building thermal lag to minimize HVAC equipment operating time.
- In winter during unoccupied periods, allow temperatures to fall as low as possible without freezing water lines or damaging stored materials.
- In summer during unoccupied periods, allow temperatures to rise as high as possible without damaging stored materials.
- Improve control and utilization of outside air.
- Use air-to-air heat exchangers to reduce energy requirements for heating and cooling of outside air.
- Reduce HVAC system operating hours (e.g. -- night, weekend).
- Optimize ventilation.
- Ventilate only when necessary. To allow some areas to be shut down when unoccupied, install dedicated HVAC systems on continuous loads (e.g. -- computer rooms).
- Provide dedicated outside air supply to kitchens, cleaning rooms, combustion equipment, etc. to avoid excessive exhausting of conditioned air.
- Use evaporative cooling in dry climates.

- Reduce humidification or dehumidification during unoccupied periods.
- Use atomization rather than steam for humidification where possible.
- Clean HVAC unit coils periodically and comb mashed fins.
- Upgrade filter banks to reduce pressure drop and thus lower fan power requirements.
- Check HVAC filters on a schedule (at least monthly) and clean/change if appropriate.
- Check pneumatic controls air compressors for proper operation, cycling, and maintenance.
- Isolate air conditioned loading dock areas and cool storage areas using high-speed doors or clear PVC strip curtains.
- Install ceiling fans to minimize thermal stratification in high-bay areas.
- Relocate air diffusers to optimum heights in areas with high ceilings.
- Consider reducing ceiling heights.
- Eliminate obstructions in front of radiators, baseboard heaters, etc.
- Check reflectors on infrared heaters for cleanliness and proper beam direction.
- Use professionally-designed industrial ventilation hoods for dust and vapor control.
- Use local infrared heat for personnel rather than heating the entire area.
- Use spot cooling and heating (e.g. -- use ceiling fans for personnel rather than cooling the entire area).
- Purchase only high-efficiency models for HVAC window units.
- Put HVAC window units on timer control.
- Don't oversize cooling units. (Oversized units will "short cycle" which results in poor humidity control.)
- Install multi-fueling capability and run with the cheapest fuel available at the time.
- Consider dedicated make-up air for exhaust hoods. (Why exhaust the air conditioning or heat if you don't need to?)
- Minimize HVAC fan speeds.
- Consider desiccant drying of outside air to reduce cooling requirements in humid climates.
- Consider ground source heat pumps.
- Seal leaky HVAC ductwork.
- Seal all leaks around coils.
- Repair loose or damaged flexible connections (including those under air handling units).
- Eliminate simultaneous heating and cooling during seasonal transition periods.



- Zone HVAC air and water systems to minimize energy use.
- Inspect, clean, lubricate, and adjust damper blades and linkages.
- Establish an HVAC efficiency-maintenance program. Start with an energy audit and follow-up, then make an HVAC efficiency-maintenance program a part of your continuous energy management program.

## **Cooling towers**

- Control cooling tower fans based on leaving water temperatures.
- Control to the optimum water temperature as determined from cooling tower and chiller performance data.
- Use two-speed or variable-speed drives for cooling tower fan control if the fans are few. Stage the cooling tower fans with on-off control if there are many.
- Turn off unnecessary cooling tower fans when loads are reduced.
- Cover hot water basins (to minimize algae growth that contributes to fouling).
- Balance flow to cooling tower hot water basins.
- Periodically clean plugged cooling tower water distribution nozzles.
- Install new nozzles to obtain a more-uniform water pattern.
- Replace splash bars with self-extinguishing PVC cellular-film fill.
- On old counterflow cooling towers, replace old spray-type nozzles with new square-spray ABS practically-non-clogging nozzles.
- Replace slat-type drift eliminators with high-efficiency, low-pressure-drop, self-extinguishing, PVC cellular units.
- If possible, follow manufacturer's recommended clearances around cooling towers and relocate or modify structures, signs, fences, dumpsters, etc. that interfere with air intake or exhaust.
- Optimize cooling tower fan blade angle on a seasonal and/or load basis.
- Correct excessive and/or uneven fan blade tip clearance and poor fan balance.
- Use a velocity pressure recovery fan ring.
- Divert clean air-conditioned building exhaust to the cooling tower during hot weather.
- Re-line leaking cooling tower cold water basins.
- Check water overflow pipes for proper operating level.
- Optimize chemical use.
- Consider side stream water treatment.
- Restrict flows through large loads to design values.

- Shut off loads that are not in service.
- Take blowdown water from the return water header.
- Optimize blowdown flow rate.
- Automate blowdown to minimize it.
- Send blowdown to other uses (Remember, the blowdown does not have to be removed at the cooling tower. It can be removed anywhere in the piping system.)
- Implement a cooling tower winterization plan to minimize ice build-up.
- Install interlocks to prevent fan operation when there is no water flow.
- Establish a cooling tower efficiency-maintenance program. Start with an energy audit and follow-up, then make a cooling tower efficiency-maintenance program a part of your continuous energy management program.

## **Lighting**

- Reduce excessive illumination levels to standard levels using switching, delamping, etc. (Know the electrical effects before doing delamping.)
- Aggressively control lighting with clock timers, delay timers, photocells, and/or occupancy sensors.
- Install efficient alternatives to incandescent lighting, mercury vapor lighting, etc. Efficacy (lumens/watt) of various technologies range from best to worst approximately as follows: low pressure sodium, high pressure sodium, metal halide, fluorescent, mercury vapor, incandescent.
- Select ballasts and lamps carefully with high power factor and long-term efficiency in mind.
- Upgrade obsolete fluorescent systems to Compact fluorescents and electronic ballasts
- Consider daylighting, skylights, etc.
- Consider painting the walls a lighter color and using less lighting fixtures or lower wattages.
- Use task lighting and reduce background illumination.
- Re-evaluate exterior lighting strategy, type, and control. Control it aggressively.
- Change exit signs from incandescent to LED.

## **DG sets**

- Optimise loading
- Use waste heat to generate steam/hot water /power an absorption chiller or preheat process or utility feeds.

- Use jacket and head cooling water for process needs
- Clean air filters regularly
- Insulate exhaust pipes to reduce DG set room temperatures
- Use cheaper heavy fuel oil for capacities more than 1MW

## **Building**

- Seal exterior cracks/openings/gaps with caulk, gasketing, weatherstripping, etc.
- Consider new thermal doors, thermal windows, roofing insulation, etc.
- Install windbreaks near exterior doors.
- Replace single-pane glass with insulating glass.
- Consider covering some window and skylight areas with insulated wall panels inside the building.
- If visibility is not required but light is required, consider replacing exterior windows with insulated glass block.
- Consider tinted glass, reflective glass, coatings, awnings, overhangs, draperies, blinds, and shades for sunlit exterior windows.
- Use landscaping to advantage.
- Add vestibules or revolving doors to primary exterior personnel doors.
- Consider automatic doors, air curtains, strip doors, etc. at high-traffic passages between conditioned and non-conditioned spaces. Use self-closing doors if possible.
- Use intermediate doors in stairways and vertical passages to minimize building stack effect.
- Use dock seals at shipping and receiving doors.
- Bring cleaning personnel in during the working day or as soon after as possible to minimize lighting and HVAC costs.

## **Miscellaneous**

- Meter any unmetered utilities. Know what is normal efficient use. Track down causes of deviations.
- Shut down spare, idling, or unneeded equipment.
- Make sure that all of the utilities to redundant areas are turned off -- including utilities like compressed air and cooling water.
- Install automatic control to efficiently coordinate multiple air compressors, chillers, cooling tower cells, boilers, etc.

- Renegotiate utilities contracts to reflect current loads and variations.
- Consider buying utilities from neighbors, particularly to handle peaks.
- Leased space often has low-bid inefficient equipment. Consider upgrades if your lease will continue for several more years.
- Adjust fluid temperatures within acceptable limits to minimize undesirable heat transfer in long pipelines.
- Minimize use of flow bypasses and minimize bypass flow rates.
- Provide restriction orifices in purges (nitrogen, steam, etc.).
- Eliminate unnecessary flow measurement orifices.
- Consider alternatives to high pressure drops across valves.
- Turn off winter heat tracing that is on in summer.

### **Application of non-conventional & renewable energy sources**

The electricity generation by installing renewable projects such as roof-top solar project or stand alone solar project can reduce Indian Railways dependency on grid as well as reduce GHG emission. The roof-top solar project can be installed on zonal head quarters, divisional offices, railway stations, hospitals and used generated electricity for captive consumption in same building and installation. The excess generation will be feed to the grid. The energy saving can also be achieve by installing solar panels on signals.

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