
MORMUGAO PORT TRUST –GOA

ENERGY EFFICIENCY AVENUES

DATE : 17TH MAY 2010



Objectives of Walkthrough Survey

- ✓ To study the present pattern of energy consumption
- ✓ Examination and evaluation of energy efficiency of major energy consuming systems, processes and equipments
- ✓ Identify the potential areas for energy optimization and GHG emission reduction.
- ✓ Establish performance indices for monitoring (such as specific energy consumption)
- ✓ To identify possible energy conservation measures for optimization.



Facility & Utility System Details

Facility :

MOHP (MECHANICAL ORE HANDLING PLANT) : A MAJOR CONSUMER OF POWER WITH OVER 80% OF TOTAL ENERGY CONSUMPTION

Non MOHP (Admin. Bldg., Guest House , Hospital, Auditorium, Work Shop etc.) : Less than 20% of overall consumption)

Average units consumed per month :

MOHP	: 13,29,000 units/ month	= Rs.160 Lakh p.a.
Non MOHP	: 2,85,000 units / month	= Rs. 34 Lakh p.a.
Average Unit Rate from RIL		= Rs. 11 / unit

Major Loads for MOHP : Stackers , Reclaimers , Ship loaders , Unloaders, Conveyors , CBU, High Mast Lighting .

Major Loads for Non MOHP : Lighting , Water Pumps , Airconditioning



Facility & Utility System Details

ELECTRICAL INSTALLATIONS

MOHP

- : 3 Nos. x 5000 KVA Transformers (RIL Supply) 33 KV → 3.3 KV
- : 2 Nos. x 4000 KVA Transformers (RIL Supply) 33 KV → 3.3 KV
- : 32 Nos. x 120 Kvar Capacitor banks
- : Average Unit Rate from RIL = Rs. 11 / unit

Contract Demand with RIL	= 7000 Kw
Minimum Billable Demand	= 5250 Kw
Max.Demand variation	= 1143 Kw to 5724 Kw
Average Max.Demand for 12 monts	= 4670 Kw
Average P.F. Variation	= 0.89 to 0.96
Average P.F. for 12 months	= 0.91



Facility & Utility System Details

MOHP Connected Load

Connected Load :

Stackers 3 Nos.	= HT 450 KW	LT 270 KW
Reclaimers 2 Nos.	= HT 1200 KW	LT 200 KW
Ship Loaders 2 Nos.	= HT 600 KW	LT 540 KW
Barge Unloaders & CBU	=	LT 4850 KW
HT Conveyor Drives 15 Nos.	= HT 5550 KW	
LT Conveyor Drives 9 Nos.	=	LT 680 KW
Shuttle Drives & Head Pullies	=	LT 35 KW
High Mast Lighting	=	LT 170 KW
A/C Units	=	LT 120 KW



Facility & Utility System Details

ELECTRICAL INSTALLATIONS

NON MOHP

- : 3 Nos. x 500 KVA Transformers (Govt.of Goa Supply) 11 KV → 433 V
- : Total 490 Kvar Capacitor banks (Hospital 390 Kvar / H/L 100 Kvar)
- : Average Unit Rate Govt.Supply = Rs. 3.5 / - unit
- : Average Total Units consumed Govt.Supply = 6,60,000 Units p.a.

Contract Demand with Govt.supply = HTC (184) 500 KVA / HTC 37 (100 KVA)
Average Max.Demand = 167 Kva (HTC 184) / 51 Kva (HTC 37)
Average P.F. Variation = 0.89 to 0.96
Average P.F. for 12 months = 0.91

Connected Load

Water Pumps : = 280 KW
Air Conditioning = 130 KW (Mainly Hospital)
High Mast Lighting = 300 KW
Hospital heating / Lighting etc. = 120 KW



MAJOR OBSERVATIONS

MAJOR OBSERVATIONS

RIL POWER TARIFFS ARE CONSIDERABLY HIGH COMPARED TO GOVT.SUPPLY IT IS RECOMMENDED TO HAVE OWN COAL BASED POWER PLANT OF CAPACITY ABOUT 7 MW (OR 10 MW)

MAXIMUM DEMAND VERY REARLY EXCEEDS BILLABLE DEMAND...ANY CONSERVATION MEASURES WITH PRESENT ARRANGEMENTS WILL NOT RESULT IN TO FINANCIAL BENEFITS WITH THE PRESENT TARRIF STRUCTURE CONTRACT DEMAND TO BE RENEGOTIATED

THERE ARE POTENTIAL AVENUES TO OPTIMIZE THE PRESENT ENERGY CONSUMPTION WHICH SHOULD BE EXPLORED AND IMPLEMENTED ASAP A DETAILED AUDIT OF THE FACILITY WOULD HELP IDENTIFYING ENERGY EFFICIENCY PROJECTS WITH ALL TECHNO COMMERCIAL DETAILS



POTENTIAL AREAS FOR ENERGY OPTIMIZATION

MOHP

- Replace underloaded motors with correct sized motors for improved efficiency
- Replace rewind motors with new high efficiency motors
- Provide full automation (or semi automation) for optimum loading of conveyors with variable speed drives for conveyor motors
- Improve power factor to near unity by providing appropriate capacitor banks and ensuring automatic P.F. control
- Provide capacitors at user ends wherever possible.
- Optimize loading on the transformers (by cyclic deenergizing of one of the transformers for optimum loading on the others)
- Monitor specific consumption (Such as units / ton of ore dispatched , and fuel Lit / ton of ore dispatch on a daily , monthly basis.
- Provide adequate energy metering for all major feeders to enable monitor specific energy consumption
- Analyse major motors for their daily pattern of loading & variation pattern in voltage , current , p.f . Also, monitor the harmonics during logging for above analysis.
- Optimize Capacitors to reduce capacitor losses
- Optimize High Mast Lighting / Consider LED
- Separate feeder for Lighting with voltage regulation

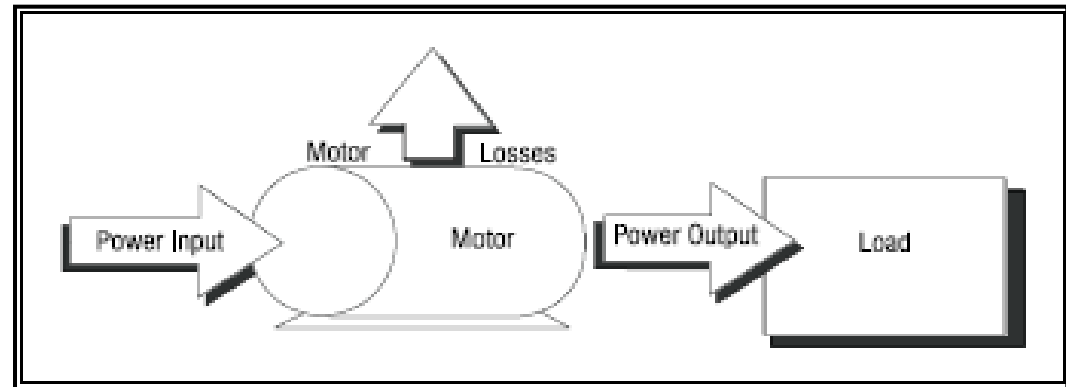


Assessment of Electric Motors

Efficiency of Electric Motors

Motors lose energy when serving a load

- Fixed loss
- Rotor loss
- Stator loss
- Friction and rewinding
- Stray load loss



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Assessment of Electric Motors

Efficiency of Electric Motors

Factors that influence efficiency

- Age
- Capacity
- Speed
- Type
- Temperature
- Rewinding
- Load

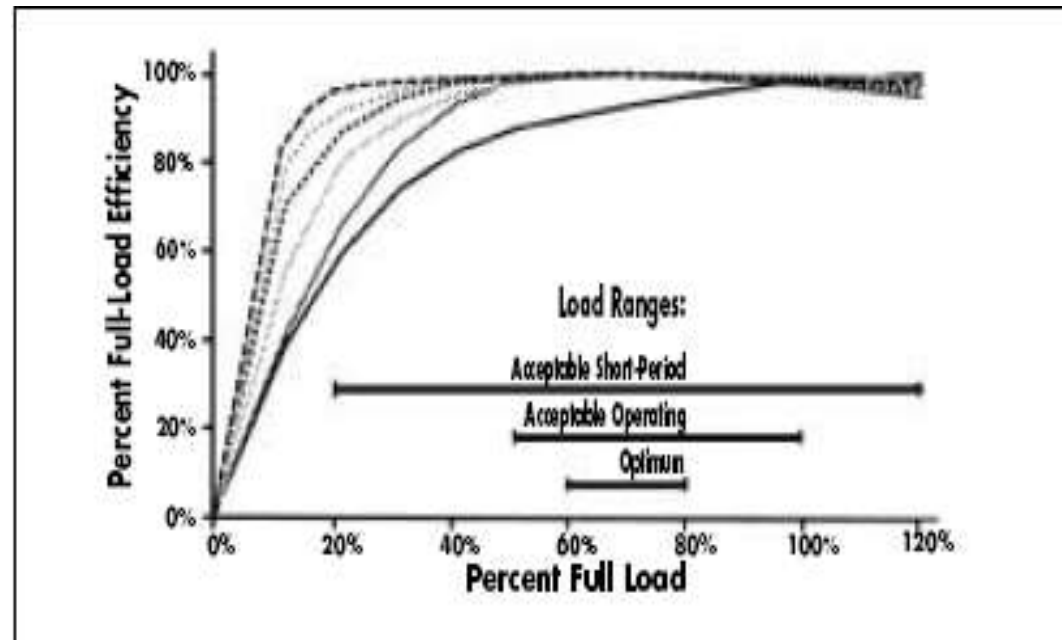


Assessment of Electric Motors

Efficiency of Electric Motors

Motor part load efficiency

- Designed for 50-100% load
- Most efficient at 75% load
- Rapid drop below 50% load



Assessment of Electric Motors

Motor Load

- Motor load is indicator of efficiency
- Equation to determine load:

$$\text{Load} = \frac{P_i \times \eta}{\text{HP}} \times 0.7457$$

η = Motor operating efficiency in %
HP = Nameplate rated horse power
Load = Output power as a % of rated power
 P_i = Three phase power in kW



Assessment of Electric Motors

Motor Load

Three methods for individual motors

- **Input power measurement**
 - Ratio input power and rate power at 100% loading
- **Line current measurement**
 - Compare measured amperage with rated amperage
- **Slip method**
 - Compare slip at operation with slip at full load



Assessment of Electric Motors

Motor Load

Input power measurement

- Three steps for three-phase motors

Step 1. Determine the input power:

$$P_i = \frac{V \times I \times PF \times \sqrt{3}}{1000}$$

P_i = Three Phase power in kW
V = RMS Voltage, mean line to line of 3 Phases
I = RMS Current, mean of 3 phases
PF = Power factor as Decimal



Assessment of Electric Motors

Motor Load

Input power measurement

Step 2. Determine the rated power:

$$P_r = hp \times \frac{0.7457}{\eta_r}$$

P_r = Input Power at Full Rated load in kW
 hp = Name plate Rated Horse Power
 η_r = Efficiency at Full Rated Load

Step 3. Determine the percentage load:

$$Load = \frac{P_i}{P_r} \times 100\%$$

Load = Output Power as a % of Rated Power
 P_i = Measured Three Phase power in kW
 P_r = Input Power at Full Rated load in kW



Assessment of Electric Motors

Motor Load

Result

Action

1. **Significantly oversized and underloaded** → **Replace with more efficient, properly sized models**
2. **Moderately oversized and underloaded** → **Replace with more efficient, properly sized models when they fail**
3. **Properly sized but standard efficiency** → **Replace most of these with energy-efficient models when they fail**



Energy Efficiency Opportunities

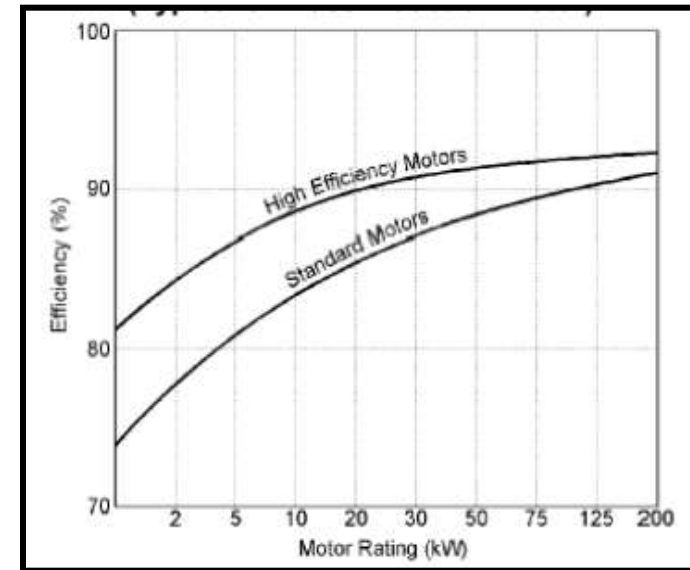
- 1. Use energy efficient motors**
- 2. Reduce under-loading (and avoid over-sized motors)**
- 3. Size to variable load**
- 4. Improve power quality**
- 5. Rewinding**
- 6. Power factor correction by capacitors**
- 7. Improve maintenance**
- 8. Speed control of induction motor**



Energy Efficiency Opportunities

Use Energy Efficient Motors

- Reduce intrinsic motor losses
- Efficiency 3-7% higher
- Wide range of ratings
- More expensive but rapid payback
- Best to replace when existing motors fail



(Bureau of Indian Standards)



Energy Efficiency Opportunities

Use Energy Efficient Motors

<i>Power Loss Area</i>	<i>Efficiency Improvement</i>
1. Fixed loss (iron)	Use of thinner gauge, lower loss core steel reduces eddy current losses. Longer core adds more steel to the design, which reduces losses due to lower operating flux densities.
2. Stator I ² R	Use of more copper & larger conductors increases cross sectional area of stator windings. This lower resistance (R) of the windings & reduces losses due to current flow (I)
3 Rotor I ² R	Use of larger rotor conductor bars increases size of cross section, lowering conductor resistance (R) & losses due to current flow (I)
4 Friction & Winding	Use of low loss fan design reduces losses due to air movement
5. Stray Load Loss	Use of optimized design & strict quality control procedures minimizes stray load losses



Energy Efficiency Opportunities

2. Reduce Under-loading

- **Reasons for under-loading**
 - Large safety factor when selecting motor
 - Under-utilization of equipment
 - Maintain outputs at desired level even at low input voltages
 - High starting torque is required
- **Consequences of under-loading**
 - Increased motor losses
 - Reduced motor efficiency
 - Reduced power factor



Energy Efficiency Opportunities

2. Reduce Under-loading

- **Replace with smaller motor**
 - If motor operates at <50%
 - Not if motor operates at 60-70%
- **Operate in star mode**
 - If motors consistently operate at <40%
 - Inexpensive and effective
 - Motor electrically downsized by wire reconfiguration
 - Motor speed and voltage reduction but unchanged performance



Energy Efficiency Opportunities

3. Sizing to Variable Load

- **Motor selection based on**
 - Highest anticipated load: expensive and risk of under-loading
 - Slightly lower than highest load: occasional overloading for short periods
- **But avoid risk of overheating due to**
 - Extreme load changes
 - Frequent / long periods of overloading
 - Inability of motor to cool down

Motors have 'service factor' of 15% above rated load

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Energy Efficiency Opportunities

4. Improve Power Quality

Motor performance affected by

- **Poor power quality: too high fluctuations in voltage and frequency**
- **Voltage unbalance: unequal voltages to three phases of motor**

	Example 1	Example 2	Example 3
Voltage unbalance (%)	0.30	2.30	5.40
Unbalance in current (%)	0.4	17.7	40.0
Temperature increase (oC)	0	30	40



Energy Efficiency Opportunities

4. Improve Power Quality

Keep voltage unbalance within 1%

- Balance single phase loads equally among three phases
- Segregate single phase loads and feed them into separate line/transformer



Energy Efficiency Opportunities

5. Rewinding

- **Rewinding: sometimes 50% of motors**
- **Can reduce motor efficiency**
- **Maintain efficiency after rewinding by**
 - **Using qualified/certified firm**
 - **Maintain original motor design**
 - **Replace 40HP, >15 year old motors instead of rewinding**
 - **Buy new motor if costs are less than 50-65% of rewinding costs**



Energy Efficiency Opportunities

6. Improve Power Factor (PF)

- **Use capacitors for induction motors**
- **Benefits of improved PF**
 - **Reduced kVA**
 - **Reduced losses**
 - **Improved voltage regulation**
 - **Increased efficiency of plant electrical system**
- **Capacitor size not >90% of no-load kVAR of motor**



Energy Efficiency Opportunities

7. Maintenance

Checklist to maintain motor efficiency

- **Inspect motors regularly for wear, dirt/dust**
- **Checking motor loads for over/under loading**
- **Lubricate appropriately**
- **Check alignment of motor and equipment**
- **Ensure supply wiring and terminal box and properly sized and installed**
- **Provide adequate ventilation**



Energy Efficiency Opportunities

8. Speed Control of Induction Motor

- **Multi-speed motors**
 - Limited speed control: 2 – 4 fixed speeds
- **Wound rotor motor drives**
 - Specifically constructed motor
 - Variable resistors to control torque performance
 - >300 HP most common



Energy Efficiency Opportunities

8. Speed Control of Induction Motor

- **Variable speed drives (VSDs)**
 - Also called inverters
 - Several kW to 750 kW
 - Change speed of induction motors
 - Can be installed in existing system
 - Reduce electricity by >50% in fans and pumps
 - Convert 50Hz incoming power to variable frequency and voltage: change speed



POTENTIAL AREAS FOR ENERGY OPTIMIZATION

Non MOHP

- Optimize Pump performance for higher rating pumps (Above 10 KW)
- Replace rewind motors with new high efficiency motors
- Improve power factor to near unity by providing appropriate capacitor banks and ensuring automatic P.F. control
- Provide capacitors at user ends wherever possible.
- Optimize loading on the transformers.
- Provide adequate energy metering for all major feeders to enable monitor specific energy consumption
- Optimize Capacitors to reduce capacitor losses
- Optimize High Mast Lighting / Consider LED
- Optimize Air conditioning system for Hospital
- Bio gas generation from food waste can be considered for Hospital
- Use solar heating system wherever possible.
- Separate feeder for lighting with voltage regulation.



COST ECONOMICS OF DIFFERENT LIGHTING SOURCES

DETAILS	INCANDESCENT LAMP	FLUROCENT LAMP	CFL	LED
Life Expectancy Hrs.	1500	25000	10000	60000
Watts	60	40	14	6
Cost Rs.	30	50	150	2400
Efficacy Lumens per Watt	10 to 18	50 to 100	35 to 60	60 to 150
No.of fittings used for 60000 Hrs. operation	40	3	6	1
Cost of fittings Rs.	1200	150	900	2400
Used units(KWH) per fitting (for 60,000 Hrs.)	3600	2400	840	360



OVERALL SAVINGS POTENTIAL

MOHP AVERAGE UNITS CONSUMPED PER ANNUM = 160 Lakh
POSSIBLE UNITS SAVED WITH SHORT TERM & MEDIUM TERM MEASURES @ 10 % = 16 Lakh
POSSIBLE SAVINGS (WITH APPROPRIATE SYSTEM OF BILLING) AT Rs.11/- PER UNIT = Rs.176 Lakh

NON MOHP AVERAGE UNITS CONSUMPED PER ANNUM = 34 Lakh
POSSIBLE UNITS SAVED WITH SHORT TERM & MEDIUM TERM MEASURES @ 10 % = 3.4 Lakh
POSSIBLE SAVINGS @ Rs. 4.1 per unit (Including MD charges) = Rs.14 Lakh

POSSIBLE SAVINGS WITH COAL BASED PLANT (REFER DETAILS FURTHER) = Rs. 20 Cr. P.a.



COAL BASED POWER PLANT OF 10 MW CAPACITY

Coal based captive power plant to meet MPT requirement & additional power generation for selling if required

Proposed Power plant Capacity	: 7 MW
Approximate Area requirement (Including coal storage / handling and Ash handling)	: 50,000 M2
Approximate Investment	: Rs.42 Crores
Approximate cost of coal	: Rs. 3.5 / kg
Coal GCV	:4500 kcal / kg
Considering 30 % efficiency of power plant with condensing turbine	
Net Power Generation per kg of coal	= 4500 x 0.30 / 860.4 = 1.56 KW
Fuel cost of power	= 3.5 / 1.56 = Rs.2.3 per KW
Adding 50% for other costs such as O& M ,spares etc.	
Estimated cost of power with coal based Power Plant = Rs.3.5 /- per KW	
Possible savings per annum with present energy consumption	= 19400000 x (11 – 3.5) = Rs. 14.6 Cr. P.a.
Additional revenue through selling of 3 MW to other users at say Rs.6 / unit	= 3000 x 8000 x (6 -3.5) = Rs. 6 Cr. P.a.
Simple pay back period of PP	= 42 / 20.6 = 2 Years.



COAL BASED POWER PLANT OF 10 MW CAPACITY

Possible Hurdles : Environmental concerns....These can be taken care by the latest technologies to meet the emission norms (such as ESP etc.)

ADVANTAGES TO MPT

- **Nearness to sea with optimized cooling water requirements**
- **Availability of required space for PP**
- **Availability of coal at an economical rates**
- **Reduced coal and ash handling costs**
- **Assured power quality and control on availability**
- **Reduced dependence on energy**
- **Entire Design / Installation / O & M can be out sourced.**



