TATA TOYO PROFILE

- **<u>Joint Venture between Partners</u>**
  TACO : 51%, Toyo : 40.25% & Mitsubishi Non Ferrous : 8.75%
- **<u>Equity Base</u>**
  Rs.320 million
- **<u>Initial Project Cost</u>**
  Rs.520 million
- **Integrated Plant Facility**
- **<u>Equivalent Capacity</u>**
  625,000 Heat Exchangers
- **<u>No. of Employees: 221</u>**
- **<u>Land :</u> 7 Acres**
- **<u>Plant :</u> 100,000 sq.ft.**

Tata Toyo today is the largest manufacturer of Heat Exchangers in India.

PRODUCT & FACILITIES

- <u>Products</u>

  Aluminum Brazed Radiator, Intercooler,

  Heater Core, Condenser

  •<u>Product Range Covers</u>

  Cars, MUV'S,CV'S,DG Sets & Agri Machinery

  Heat Exchangers up to Core size of 1.0 sq.mtrs

  Heat Exchangers up to 200 KW Heat Dissipation

- <u>Integrated Plant Facility</u>

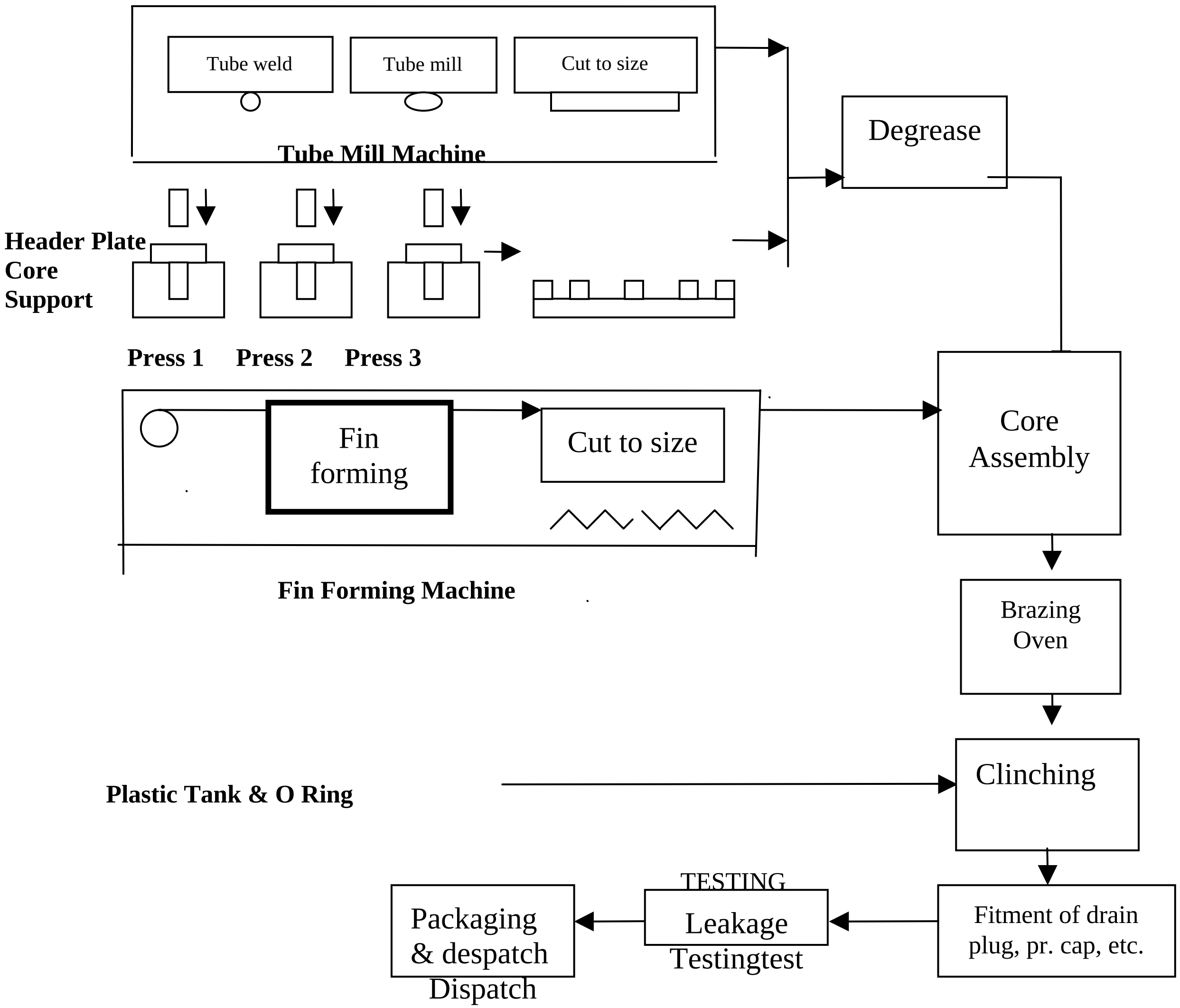
  Press, Tube Mill, Fin Forming, Degreasing,

  Core Assembly , Brazing Oven, Tank

  Clinching & Leak Testing

With this product range and facilities, TTR meets about 90% of Engine Cooling Applications

Heat Exchanger Manufacturing Process Flow Chart



Mfg process time for a single radiator 3 to 3.7 minutes

Productivity of operators are key in:

- Press
- Tank Clinching
- Testing

ENERGY CONSERVATION PLANS AND TARGETS

Energy conservation measures	Anticipated savings in Energy (Rs. Lakhs)	Approx. Investment (Rs. Lakhs)	Project Commencement & completion year
Installation of Variable AC Drive for Air Compressor	4.89	4.0	2004-2005
Installation of new high purity type reflector for fluroscent tube fitting	0.25	0.3	2004-2005
Installation of photo cell control for street lighting	0.40	1.0	2004-2005
Eliminate 5.5KW suction water pump of cooling tower by modification of return water line	0.79	0.3	2004-2005
Modification in process for degreasing of components	23.48		2004-2005
New modified air blow system for fluxing area	4.53	1.87	2004-2005
Installation of transparent polycarbonate sheets on the roof	1.0	2.5	2004-2005
Installation of Variable AC Drive for FDV	3.5	7.0	2004-2006
Installation of Variable AC Drive for Hydraulic power pack	1.5	3.5	2004-2006
Conversion of Fluxing unit from wet to dry & eliminate dryoff oven	30	12.5	2005-2006
Installation of vent ventilators	5.39	5.0	2005-2006
Addition of capacitor to improve power factor from 0.9 to 1.	1.20	0.6	2005-2006
TOTAL	**76.93**	**38.57**	

Environment & Safety

Tata Toyo Radiator Ltd is committed to the protection of the environment by prevention of pollution and continual improvement in the field of Environment Management.

The Company has received ISO 14001 certification in Jan 2003 from BVQI.

The process of implementation of systems for the improvement of the environment is going on a continual basis well before the certification under ISO 14001 was received.

We are continuously undertaking efforts to

- Minimize generation of waste
- Conservation of resources
- Recycling & re use.

The Company has installed a STP for wastewater from domestic use. It is monitored continuously as per MPCB norms.

The Company has minimized the wastage of natural resources by use of recycled STP treated water for Gardening.

Industrial Safety is an essential and integral part of each and every operation in TTR.

It is our aim and objective to attain the level of zero accidents and we strive to achieve this objective.

We have a safety committee, which is required to meet once in a fortnight to discuss causes of accidents if any and also preventive actions to be initiated. Keeping in line with our belief in participation and involvement this committee is represented by operators from all sections apart from the Management Representatives. This Committee reports to the Vice President Operations.

We now propose to expand the scope of this committee by including regular safety rounds to locate unsafe conditions, unsafe acts, strict enforcement of safety rules, use of PPE etc.

ENERGY CONSERVATION COMMITMENT AND SETUP

Tata Toyo Radiator Ltd. considers Energy saving as a multi disciplinary approach. The Company's energy profile consists of Electricity, Gas (Nitrogen), High Speed Diesel and Water also.

Budget provisions are made exclusively for Energy Projects. Energy conservation plans, policy and structure are reviewed periodically.

The importance of energy conservation is emphasised through various forums and **Six Sigma Methodology**.

ENERGY CONSERVATION POLICY

- Promote Energy Saving and Conservation of Resources
- Use of Non-conventional sources of energy
- Comply with the Energy Legislation and other regulations
- Promote use of Energy Efficient Alternatives and use of alternate fuels
- Communicate Energy Management Policy to all employees and encourage their involvement through training and participation.
- Create awareness among all employees for innovative ideas towards Conservation of energy.
- Minimize waste generation and promote disposal, reuse and recycling in an Environment friendly manner.
- To make an effort to reduce the cost continuously every year by adopting effective "Energy Management System"

Energy Reduction Project

TATA TOYO

Green Belts: Sanjay Kulkarni & Kiran Shetty

Project Duration: Aug 03 - Feb 04

Six-Sigma Project Report (Mar 04)

Our Project Team

TATA

Team Members: (alphabetically listed)

- Mr. Ghorpade
- Mr. Manikam
- Mr. Sapar
- Mr. Sukale
- Mr. Vairagi
- MR. BAGADE
- MR. KHANDARE

Process Owner: Mr. Anand Gaikwad

Green Belts: Mr. Sanjay Kulkarni, Mr. Kiran Shetty

Black Belt: Mr. S. Hemanth

Master Black Belt: Dr. Nosh Kapadia

Project Champion: Mr. Kersi Kapadia

Management Champion: Mr. R. Sundar (CEO, TTR)

Acknowledgements

This report presents the work done by the team for reducing the energy consumption and improving brazing productivity for TTR.

Energy conservation has been an integral effort for TTR since its inception. This six-sigma project complemented the on-going efforts and assisted in channeling the “energy” of all team members through a structured and systematic data approach. The team is aware that some of the issues undertaken in this project were discussed in other forums also, nevertheless, our CEO decided to undertake comprehensively all ‘potential’ issues causing energy wastage through this project.

We would like thank our management champion, Mr. R. Sundar for providing us guidance and support for moving this project forward. We would also like to express our thanks to Mr. A. Alur & Mr R. Shete. Also, our special thanks to Mr. Deepak Bhandari (Executive VP - Finance, TACO) for introducing and supporting the Six-Sigma movement during his tenure as TTR’s Director.

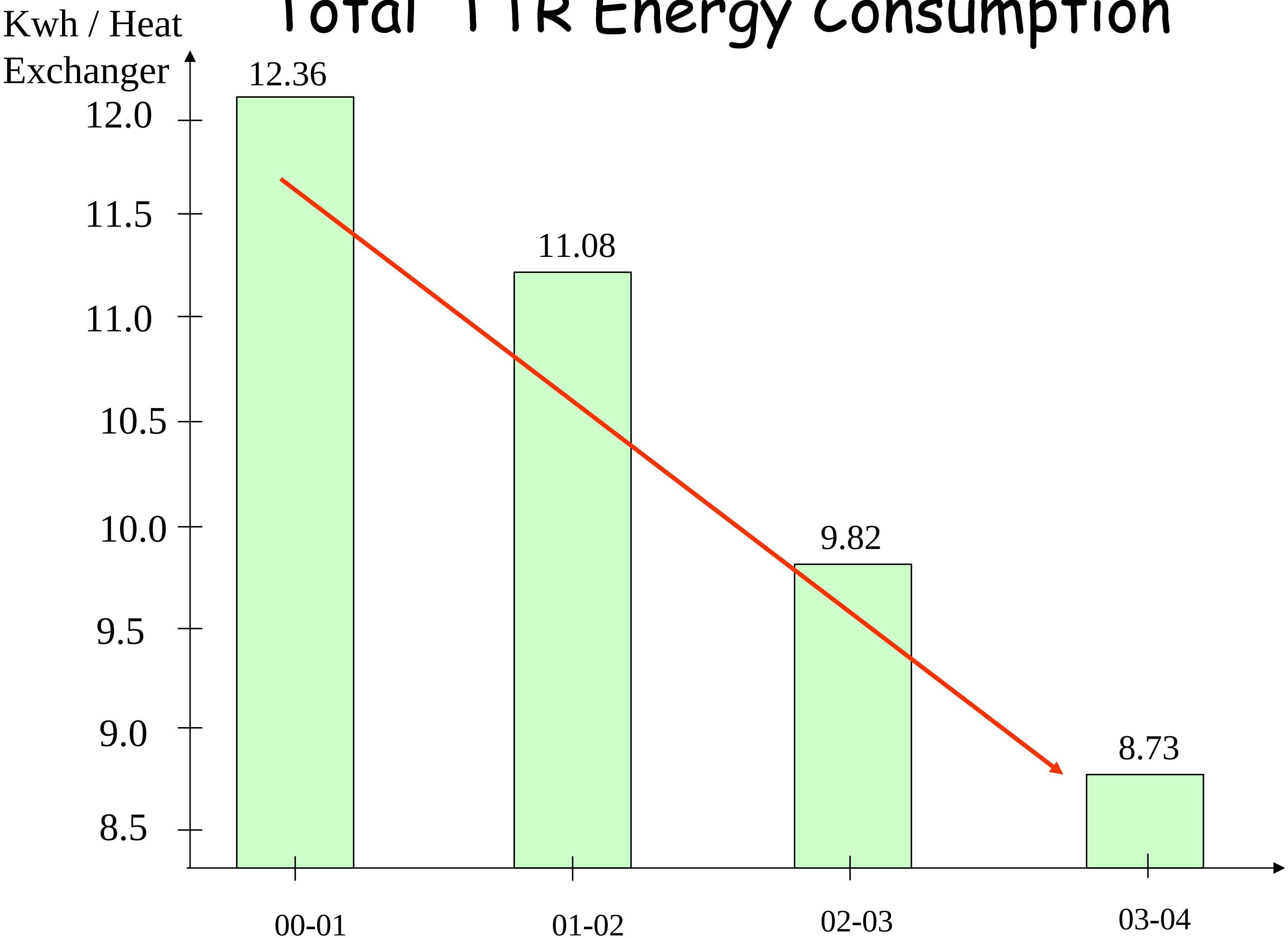
Summary of Achievements

29.3 % reduction in energy consumption levels. Energy levels were reduced from about 12.36 kwh / heat exchanger during 2000-01 to about 8.73 Kwh / heat exchanger in 2003-04 period.

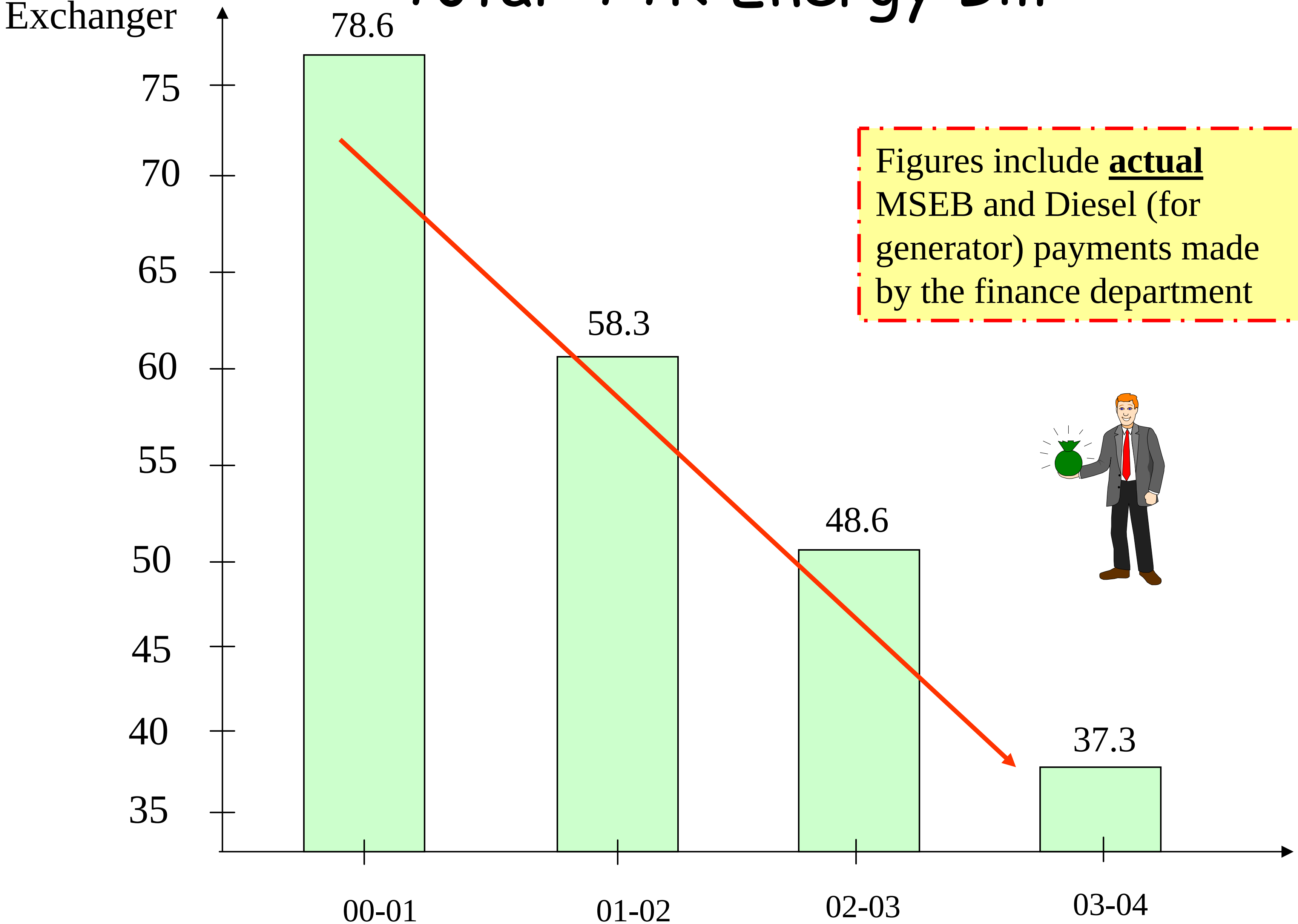
The “actual” energy cost in Rs / heat exchanger (MSEB + Diesel for generator) paid by finance department dropped from about **Rs 78.3 in 2000-01** to about **Rs 37.3 in 2003-04** – a 52 % reduction !

Achieved hard savings of **Rs 53.81 lacs from 2001 to 04**

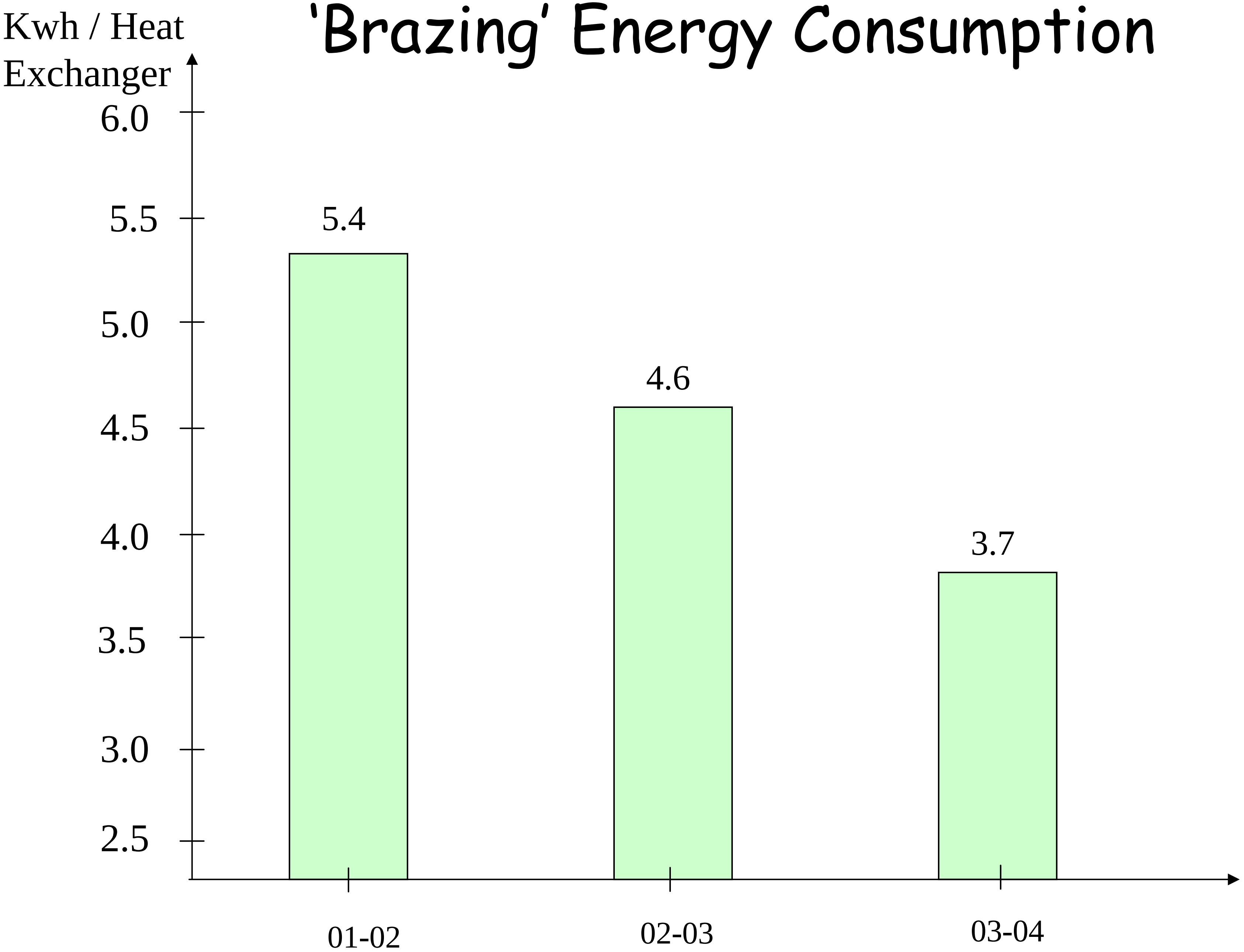
'Total' TTR Energy Consumption



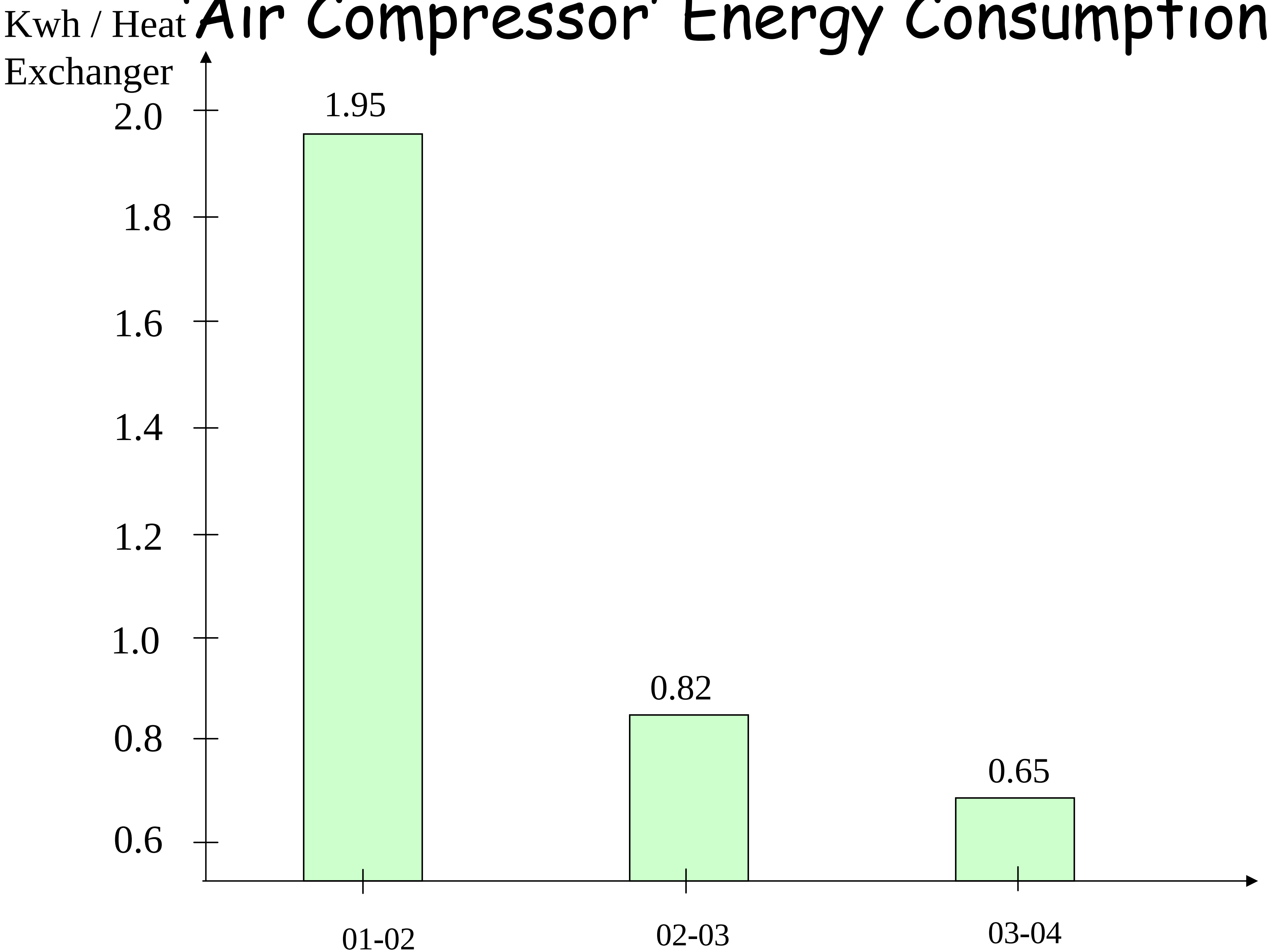
'Total' TTR Energy Bill



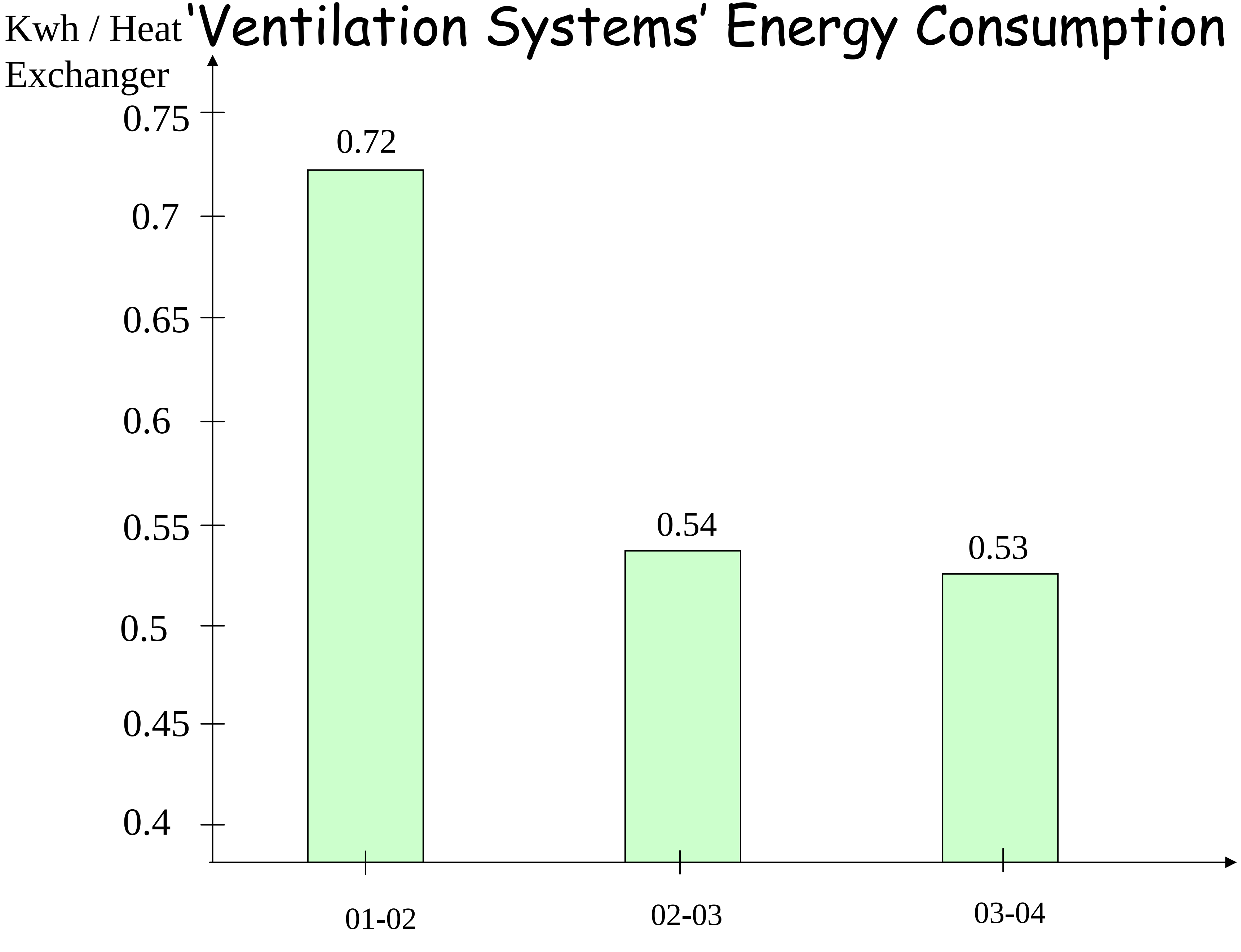
'Brazing' Energy Consumption



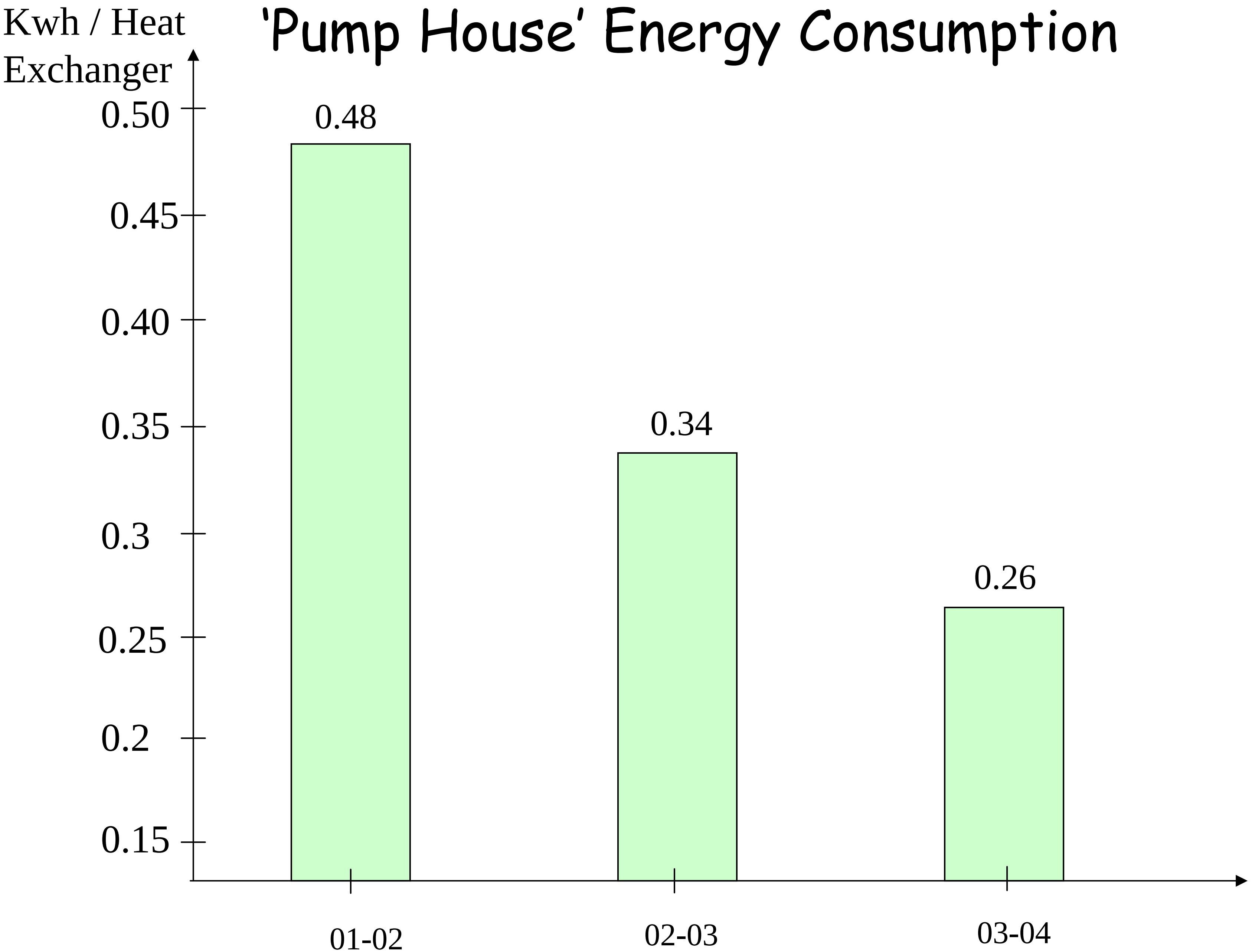
'Air Compressor' Energy Consumption



'Ventilation Systems' Energy Consumption



'Pump House' Energy Consumption



Summary of Project Achievements

Productivity Improvement:

Brazing oven productivity went up from 76 eq heat exchanger / hour in Aug 03 to 108 eq heat exchanger / hour in Feb 04.

Note

The productivity figures have been computed with change over times as part of total available time. However, downtimes (like breakdowns and planned shut downs) are excluded from the productivity calculations. Detailed calculations are available.

Six-Sigma – A Breakthrough Improvement Strategy

Six Sigma is a disciplined methodology that provides a logical sequence for driving process improvements. At TTR, we successfully used the DMAIC (Define – Measure – Analyze – Improve – Control) methodology to reduce energy consumption

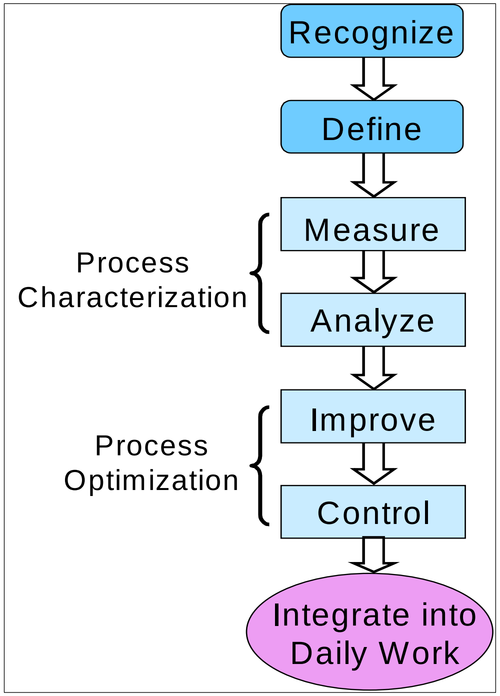
Define: Identify the process to be improved and the top critical to quality or productivity requirements (Ys)

Measure: Quantify how the process performs today and determine the improvement goal

Analyze: Identify the input variables (key X's) that affect the Ys the most

Improve: Determine solution to optimize the Ys, quantify their impact and compare to goal

Control: Implement control measures to ensure critical inputs (Xs) remain in control



Project Definition

<u>Project Statement :</u>

– The present energy consumption for "Entire TTR" is about 4577318 kwh while producing 463729 equivalent heat exchanger (HE) cores. This gives us a energy consumption level per radiator of <u>9.87 kwh / rad.</u>

Note

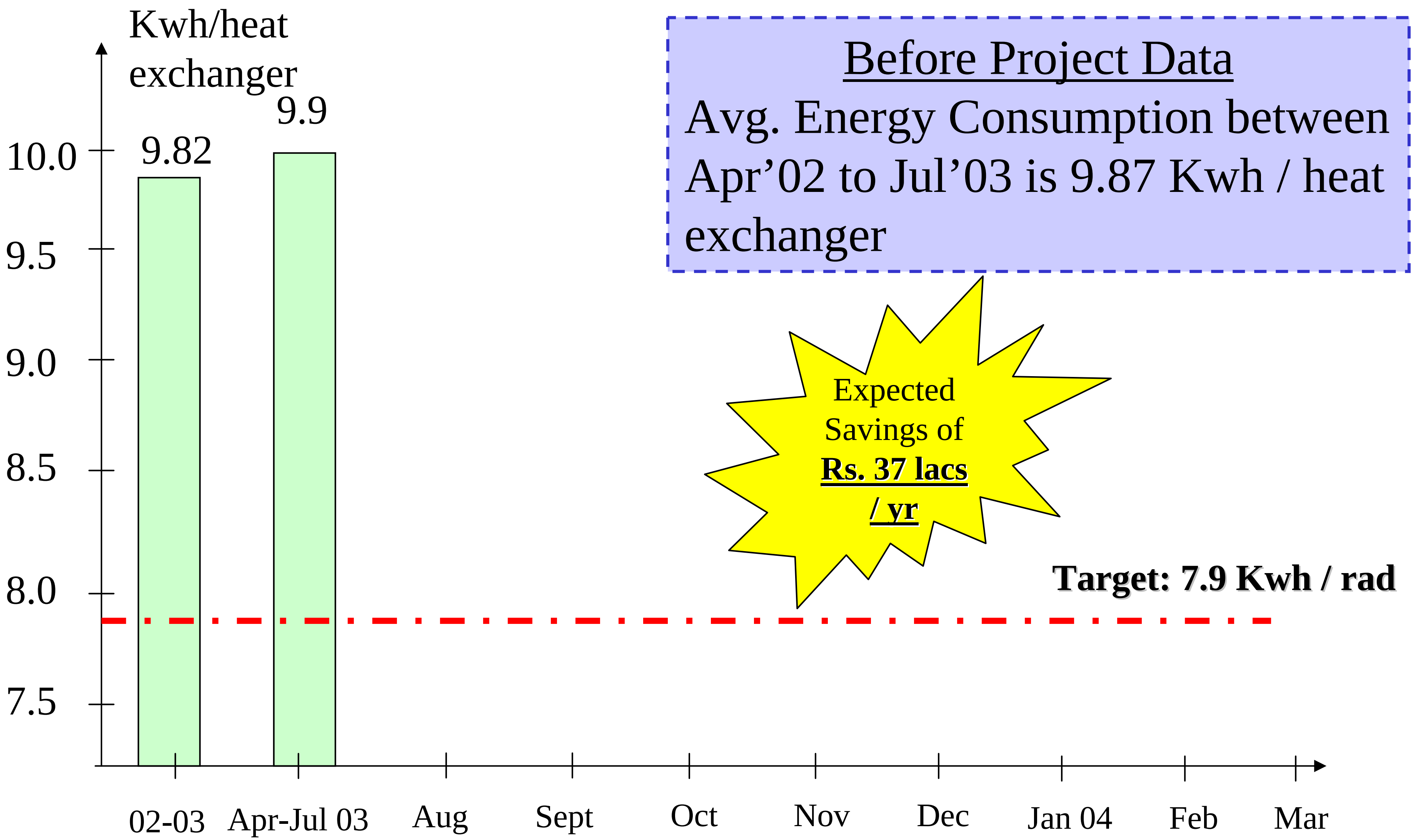
This is based on the last ***16 month*** of data April 02 to July 03 - includes MSEB and DG readings

Project Definition…

- Project Objective:
  - To reduce the energy consumption level by about 2 kwh / heat exchanger, i.e.reduce current levels from about 9.9 to 7.9 kwh / heat exchanger by 31 Dec 03. This will result in hard recurring energy savings of about **37 lacs / year.**

These figures are based on 'conservative' annual volumes (July 03 estimates) of 410,000 radiators, 24,000 Inter Coolers and 100,000 Heater Cores

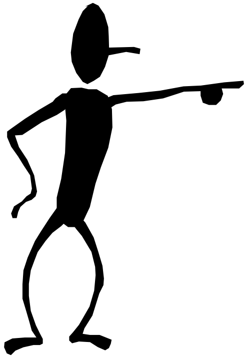
Project Definition (Measure Phase)



Project Definition...

- Expected Date to complete DMAI phases:
  On / before 30 Nov 2003

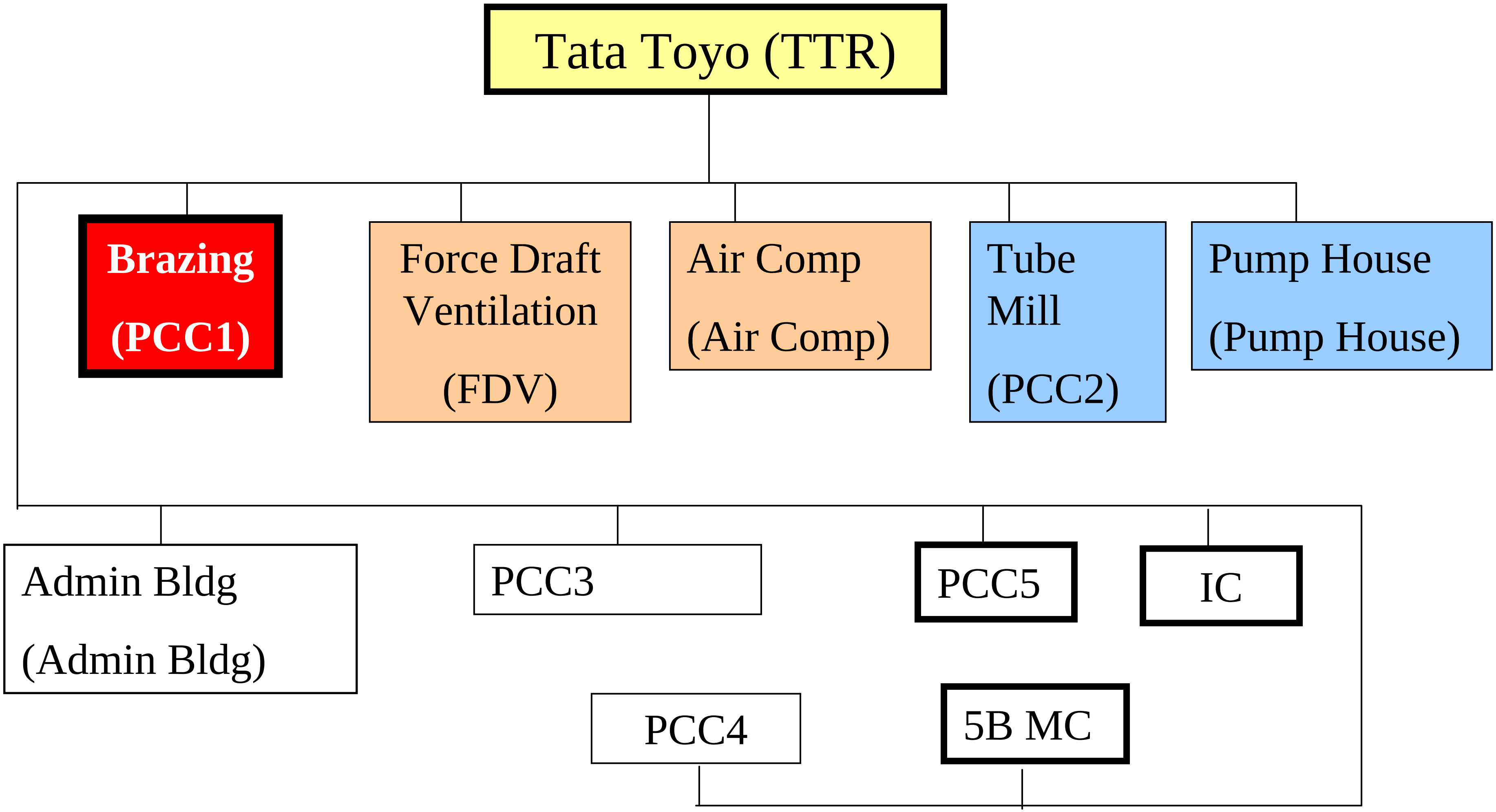
- Expected Date to complete C phase:
  On / before 31 Dec 2003



A Team Commitment

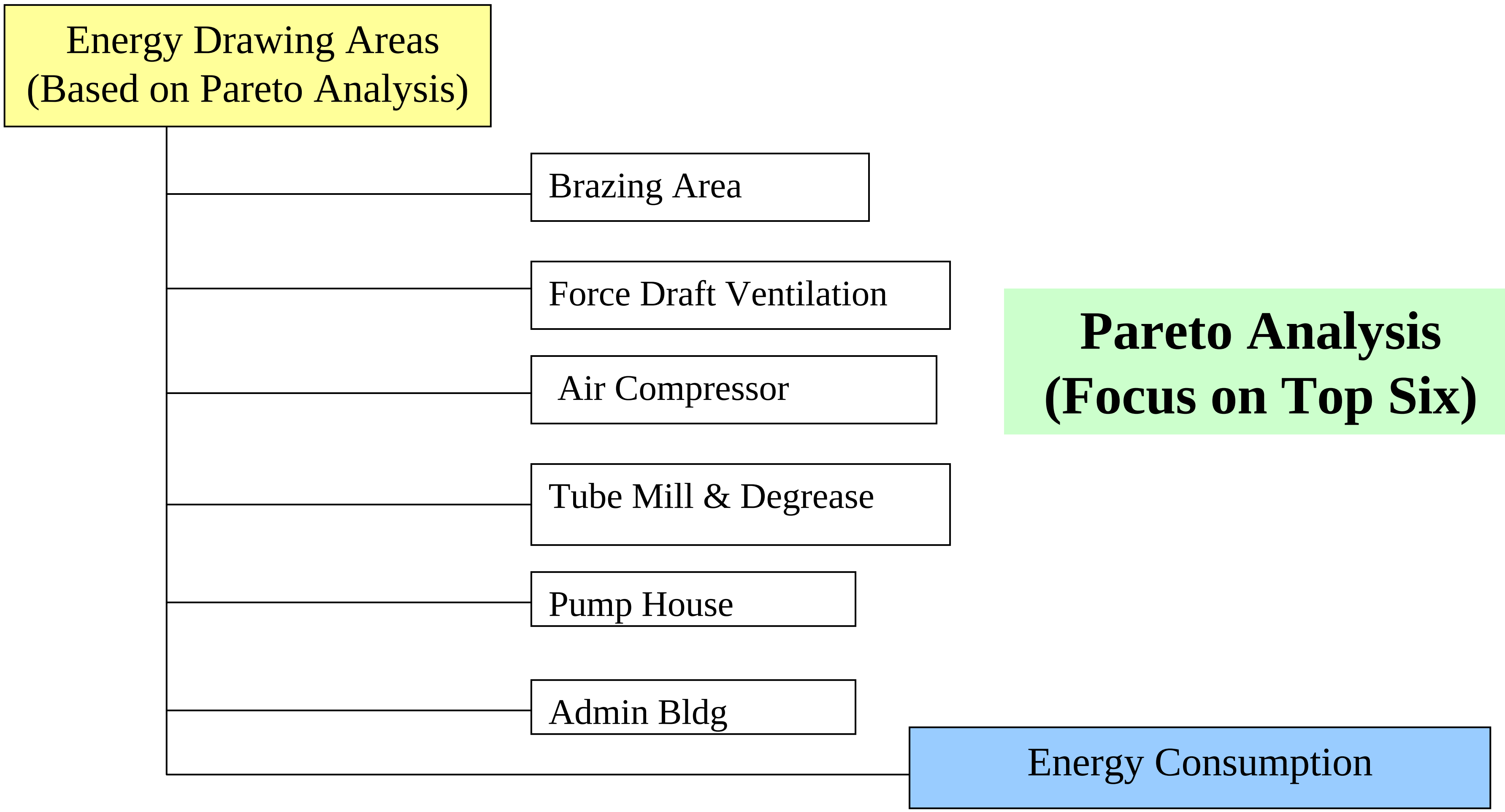
Project Focus

Main Energy Consumption Areas for TTR



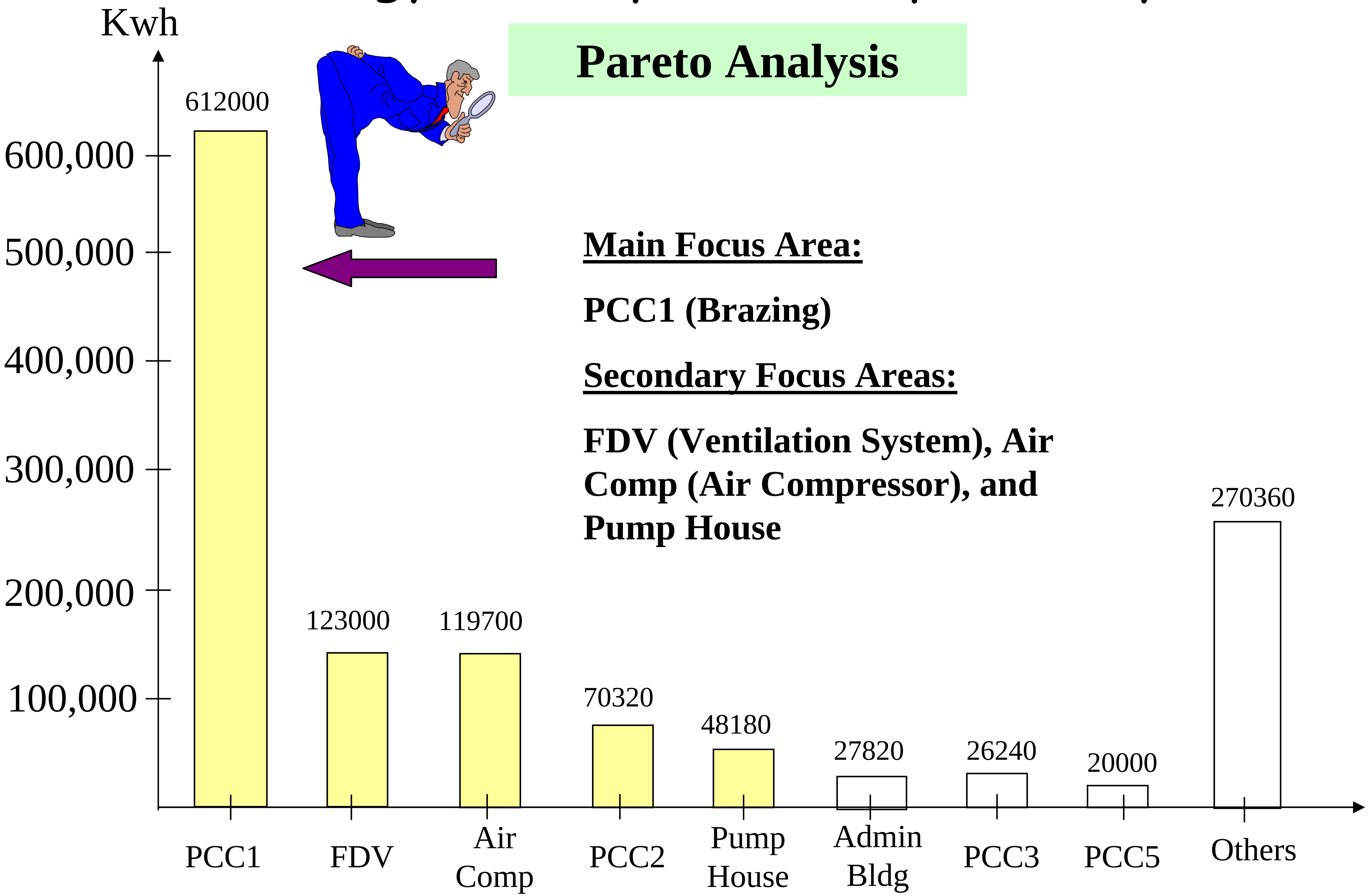
Prioritized areas of concern

Based on the analysis of data collected for April and July team short listed major areas for improvement.



Six-Sigma Measure Phase

Energy Data by Areas (April - July 03)



Pareto Analysis

<u>Main Focus Area:</u>

PCC1 (Brazing)

<u>Secondary Focus Areas:</u>

FDV (Ventilation System), Air Comp (Air Compressor), and Pump House

Updated Project objective

As seen from the pareto diagram, the team started focussing on the brazing oven, as it consumed almost 80 % of total plant’s energy.

This led to the team in identifying brazing oven productivity as a key factor in reducing energy levels.

Productivity (measured in equivalent heat exchanger per hour through the brazing oven) in August 03 was measured around 71. The team decided to increase this figure to around 90 equivalent heat exchanger per hour by Dec 03.

List of Key Causes and Counteractions

Area	Causes	Counteractions
Burnoff	• Burnoff 'ON' during heater core brazing • Inadequate utilization due to frequent temp / speed changes	• Shut off burnoff as last radiator exits before HC starts • See **"Brazing" section** (page 16)
Fluxer	• Fluxer 'ON' during heater core brazing • Inadequate utilization due to frequent temp / speed changes	• Shut off burnoff as last radiator exits before HC starts • See **"Brazing" section** (page 16)
	• Fluxer Breakdown	• Keep spare fluxer balls. Spare kit for fluxer pump
	• Fluxer nozzle setting problem	• Procure and install video camera in the fluxer area to assist the loading operator

List of Key Causes and Counteractions

Area	Causes	Counteractions
Dry Off	• Inadequate utilization due to frequent temp / speed changes	• See **“Brazing” section** (page 16)
	• Air Blower not functioning properly	• Procure bearing and other motor spares
Cooling Section	• Muffle between oven and cooling section has no insulation causing heat loss	• Insulate muffle
	• Air blower remains ‘on’ during idle condition	• Modify current circuit

List of Key Causes and Counteractions

Area	Causes	Counteractions
Brazing	• Inadequate utilization of brazing oven due to frequent speed and temperature changes • Pitch not optimized leading to lower radiator output per hour	• Commonisation of temp for all products. • Commonisation of speed and speed increase for double row cores upto truck model • Commonisation of speed for 43 mm and 65 mm intercoolers Zig zag loading of Sumo / Safari intercooler, hereby increasing output • Increase speed of 18 mm cores by checking with logger results • Decrease pitch for Sumo and Indica type radiators. This helped increase output by about 17 eq heat exchanger / hr
Production Schedule	• No systematic plan for feeding the clinching line, leading to more number of changes for the brazing oven	• Daily production schedule indicating sequence of production was developed by the team • Adhering to the scheduled plan has lead to reduction in number of changes in the brazing oven leading to better utilization of the brazing oven

List of Key Causes and Counteractions

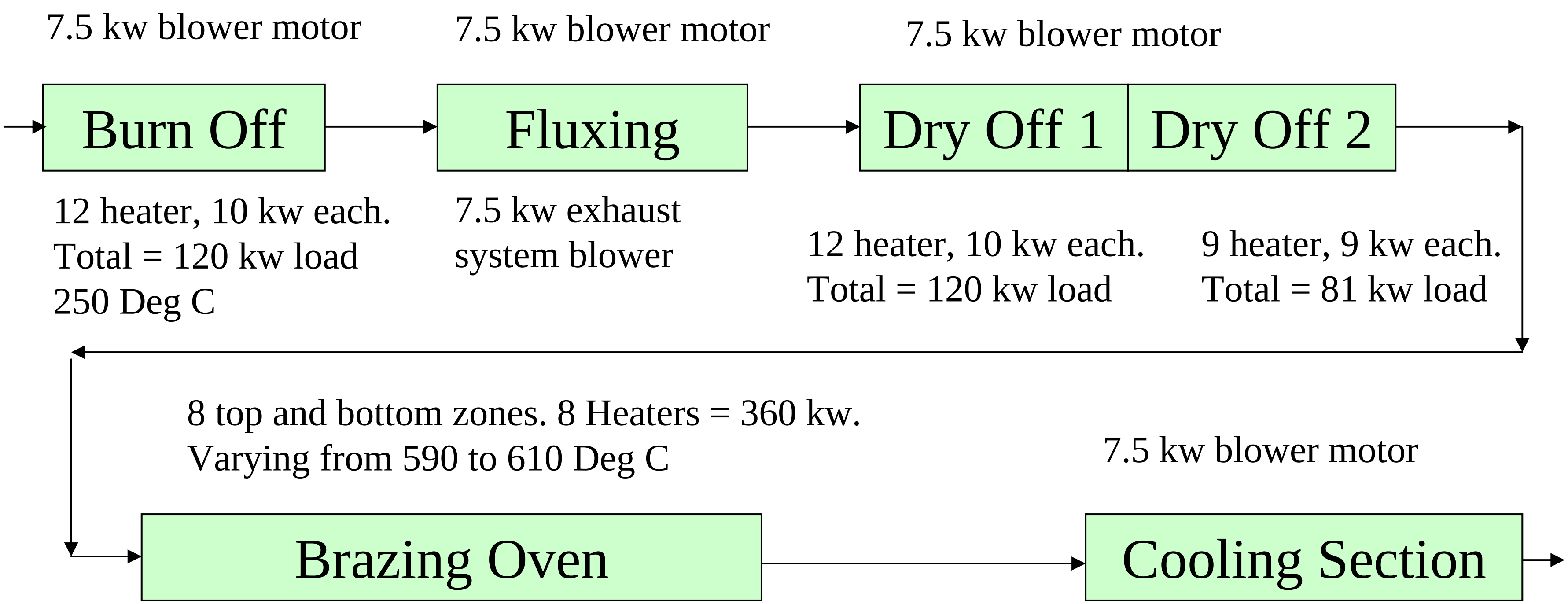
Area	Causes	Counteractions
Brazing	• Brazing conveyor running at 1400 mm/min during idle condition	• Reduced conveyor speed to idle condition reducing heat loss and switched off blower during non-brazing time (by introducing new electrical logic)
	• Core Band Shortages	• Procured new core bands
FDV	• FDV does not have a cut off timmer, thus many times FDV keeps running during the night also (when not actually needed)	• Install 6 timers on FDV (Material Dept)
	• Exhaust fans do not start automatically after power failure	• Circuit modification
Employees	• Employees involvement and awareness for energy conversation	• Generated operator awareness for energy / utility cost. Mr. Purandhare, an energy conservation expert, conducted “Energy Conservation Awareness” program on 15 Nov. About 40 to 50 employees attended this session.

List of Key Causes and Counteractions

Area	Causes	Counteractions
Air Comp	• Press drop due to leakages in air comp line • Due to inadequate brazing oven utilization, more use of comp air	• Fixed leakages • Reduced brazing oven running hours. This reduced load on air compressor
Core Assy & Clinching	• Hydraulic power packs remain "ON" during lunch and changeovers	• Completed work instructions and conduct operator awareness session for shutting power packs during lunch, tea breaks, and dinner
Pump House	• Pumps operate continuously during no-production time as the pump switches are located far away from production area (for example tube mill area)	• Provided remote switches for tube mill pumps (near machine control board)

As part of this project, approximate gains (Rs) were calculated from implementing many counteractions. Back up details are available...

Brazing Area



Product must reach 605 +/- 5 Deg C for min 3 minutes

If everything is on, total load is between 375 and 480 KW.
Running cost is between Rs 1500 to 1900 per hour

C & E Diagram for Brazing Area

Burn Off

1.) Whenever Heater Cores are brazed burn off is idle

- HCs have other operations between burn off and brazing
  - By design

2.) Inadequate utilization of burn off

- Change over of model and speed (20 min needed for change of speed)
- Fluxing change over not ready (start of shift) - ideal burn off

3.) Burn off insulation wear out - not checked since we started

Brazing Area

Listing Potential Causes (Xs)

- After a lot of continued deliberations the team identified potential 'causes' of high energy consumption for the areas listed in the previous slides.

The team is aware that some of the Xs have been discussed in other forums also, nevertheless, the team decided to list comprehensively all 'potential' causes currently existing for energy wastage. Wherever possible, the team has attempted to quantify the losses also.

Data for Burn Off...

Burn off Idle When Heater Cores (HC) are Brazed:

About 2 hours per day of HC brazing + 1 hr temp up and down + 0.5 hr for radiator out

(3.5 hrs / day) * 26 days / month = 91 hrs per month burn off is idle

With 120 kw total load with 0.6 pdf = 72 kw final load

Thus, 91 hrs * 72 kw = 6552 kwh loss / month

= 3744 kwh * Rs 4 * 12 months = **3.14 lacs / year loss**

Inadequate Utilization of Burn Off Due to Frequent Speed Change:

About 210 speed changes per month and 20 idle mins / change

210 * (20min / 60) * 120 * 0.6 * Rs 4 * 12 months = **Rs 2.14 lacs/yr**

Note: If we reduce current speed changes by half, savings ~ 1 lac / yr

C & E Diagram for Brazing Area

Fluxer

1.) Whenever Heater Cores are being brazed fluxer is idle

HCs haveother operations between burnoff and brazing

By design

2.) Inadequate utilization of burn off

Change over of model and speed (20 min needed for change of speed)

3.) Fluxer Area Breakdown stops line

Flux pipe / Spray Nozzle choke up

Flux not getting cleaned - proper equipment not available

Fluxer ball get stuck in nozzle - balls break - pieces get stuck

Imported balls not available - making do with domestic (Material Dept Help)

Brazing Area

C & E Diagram for Brazing Area

Fluxer

3.) Fluxer Breakdown stops line (contd.)

- Air blower breakdown
  - Bearings to be procured
- Fluxer pump breakdown
  - Inadequate preventive maintenance
    - Spares kit to be procured

Fluxer Nozzle setting waste time

- Operator at ‘in’ position cannot see till feedback is received from ‘out’ operator
  - Display system (TV/Camera) has not been procured (

Brazing Area

Data for Fluxer...

Fluxer Breakdown:

Actual logged breakdown is about 3.5 hrs / month

Delays of about 15 minutes occur everyday which are not logged

Total stoppages = (3.5 + 6.5) hrs / month ~ 10 hrs per month

With a total load of Rs 1700 / hr for the entire brazing area

Thus, 10 * 1700 * 12 = **Rs 2.04 lacs / yr**

Fluxer Nozzle Setting Problem

About 6.5 hrs / month are lost due to this problem

6.5 * 1900 * 12 = **Rs 1.5 lacs / yr**

Data for Fluxer...

Fluxer Idle When Heater Cores are Brazed:

About 2 hours per day of heater core brazing

(2 hrs / day) * 26 days / month = 52 hrs per month fluxer is idle

With 7.5 kw total load with 0.6 pdf = 4.5 kw final load

Thus, 52 hrs * 4.5 kw = 234 kwh loss / month

= 234 kwh * Rs 4 * 12 months = **0.11 lacs / year loss**

Inadequate Utilization of Fluxer Due to Frequent Speed Change:

About 210 speed changes per month and 20 idle mins / change

210 * (20min / 60) * 7.5 * 0.6 * Rs 4 * 12 months = **Rs 0.15 lacs/yr**

Note: If we reduce current speed changes by half, savings ~ 0.075 lac / yr

C & E Diagram for Brazing Area

Dry Off

1.) Air Blower Not Working Properly (900 mm instead of 2200 mm of water

Bearing to be procured

2.) Inadequate utilization of Dry off

Change over of model and speed (20 min needed for change of speed)

Brazing Area

C & E Diagram for Brazing Area

Brazing Oven

1.) Conveyor running continuously (during idle condition), causing heat / energy loss

2.) Conveyor not insulated causing heat / energy loss

3.) Frequent change over of models / speed of conveyor

Product mix not optimized. Brazing oven speed changes to be optimized

4.) Core band shortages - idle brazing oven

Awaiting procurement of core band for new models

5.) Nitrogen shortages (every month 6 to 8 hours lost)

Supplier delivery not per schedule (bullet n/a)

Brazing Area

Data for Brazing Oven...

Inadequate Utilization of Brazing Oven Due to Frequent Speed Change:

About 210 speed changes per month and 20 idle mins / change

*Dry off load is 360 kw * 0.6 pdf = 216 kw*

210 * (20min / 60) * 216 * Rs 4 * 12 months = **Rs 7.25 lacs/yr**

Note: If we reduce current speed changes by half, savings ~ 3 lac / yr

Core Band Shortages - brazing oven remains idle:

~ 24 hrs / month loss is assumed, 24 * Rs 1700 * 12 = **Rs 4.9 lacs/yr**

Nitrogen Shortages:

About 6 to 8 hrs every month

6 * Rs 1700 * 12 = **Rs 1.22 lacs / yr**

C & E Diagram for Brazing Area

Cooling Section

1.) Muffle between brazing oven and cooling section is exposed causing heat loss

2.) Air Blower on even when brazing is not on

No auto cut off switch

Data for Air Blower is on continuously:

On Sundays = 24 hrs loss * 4 / month * 5.5 kw * 12 months * Rs 4 = Rs 0.25 lacs/ yr

Brazing Area

C & E Diagram for FDV

FDV

1.) No Specific plan schedule for running FDV

No timer for FDV shut off

Timer to be procured (Material Dept Help)

2.) No System to switch blower on / off based on temperature

No temperature indicator / controller

3.) Improvement in ventilation

Exhaust fans do not come on automatically after power failure

High Energy Consumption

Data for FDV...

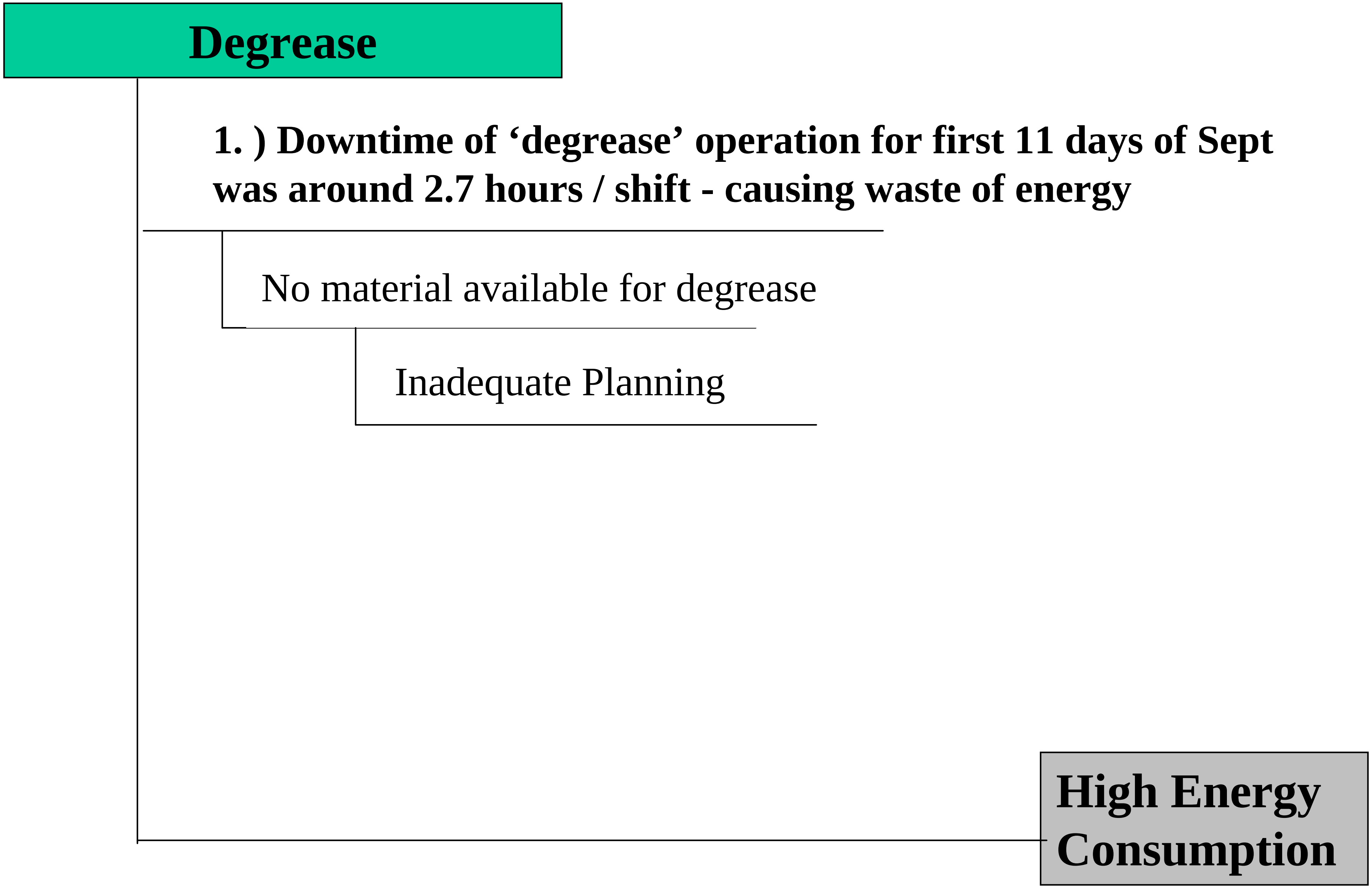
Timer for FDV shut off to be procured:

About 2 hrs / day wasted per FDV motor as timer cut off is not available

5 motors of 18.5 kw with a pdf of 0.7 will give us:

(2 hrs/day)*(5 motors)*(18.5*0.7)*26days*12months*Rs 4 = 1.6 lacs / yr

C & E Diagram for Degrease



Data for Degrease...

Degrease Operation:

Load or No-Load, following equipment are always on:

Oil circulating pumps: 3 pumps * 2.2 kw = 6.6 kw

Booster pump = 3.7 kw

Trap = 3.7 kw

Vacuum pump = 1.5 kw

Water circulation pump = 4 pumps * 2.25 kw = 9 kw

Total Load = 24.5 kw

2 shift operation, 2.7 hrs / shift waste = 3440 kw wasted / month

Loss = 3440*Rs 4* 12 = **Rs 1.65 / yr**

C & E Diagram for Air Compressor

Air Compressor

1.) Big Compressor (75 kw, 500 cfm) is used even for low loads (for example: third shift, Sundays etc)

- Unavailability of small (25 kw, 125 cfm) compressor - to be procured (Material Dept Help)

2.) Excessive Use of Air Compressor

- Pressure drop due to leakages in compressed air line in the plant
  - Leakages in FRL unit in press
  - Leakages in pneumatic cylinder
    - Moisture in air damages seals
      - Water in compressor not drained
  - Leakages from GI piping joints
  - Leakages from tubing - tubes worn out

High Energy Consumption

Data Air Compressor...

Big Compressor (75 KW), existing:

Third Shift Running: 7 hrs * 305 days with 0.6 load factor

Cost of Running 3rd Shift = 7*305*(75*0.6)*Rs 4 = Rs 3.83 lacs/yr

Sunday Running: 7 hrs * 52 days with 0.5 load factor

Cost of Running Sunday = 7*52*(75*0.5)*Rs 4 = Rs 0.54 lacs/yr

Small Compressor (22 KW), proposed (Cost Rs 3 lacs):

Third Shift Running: 7 hrs * 305 days with 0.8 load factor

Cost of Running 3rd Shift = 7*305*(22*0.8)*Rs 4 = Rs 1.5 lacs/yr

Sunday Running: 7 hrs * 52 days with 0.6 load factor

Cost of Running Sunday = 7*52*(22*0.6)*Rs 4 = Rs 0.19 lacs/yr

SAVINGS / YR = Rs 2.68 lacs. Pay back is about 1.1 years

Data Air Compressor...

Excessive Use of Compressed Air due to leakages:

Assuming just 5 % of compressed air been wasted due to leakages

5 % of 75 kw compressor = 3.75 kw wasted

3.75 kw * 24 hrs * 26 days * 12 months * Rs 4 = **Rs 1.12 lacs / yr**

C & E Diagram for Core Assy and Clinching

Core Assy & Clinching

1.) All hydraulic packs keep working during change over and breaks wasting energy

Auto cut off switches to be procured (Material Dept Help)

High Energy Consumption

Data Core Assembly and Clinching...

All packs in core assembly running during change over and breaks:

About 1.25 hrs / shift packs run idle in core assembly

6 packs of 7.5 kw each with pdf of 0.8 will give us:

(1.25 hrs/shift*3)*(6 packs)*(7.5*0.8)*26days*12months*Rs 4 = Rs. 1.7 lacs / yr

All packs in clinching area running during change over and breaks:

About 1.25 hrs / shift packs run idle in clinching

2 packs of 3.7 kw each with pdf of 0.8 will give us:

(1.25 hrs/shift*3)*(2 packs)*(3.7*0.8)*26days*12months*Rs 4 = Rs. 0.27 lacs / yr

C & E Diagram for Communication Gap

Communication Lag Between Production and Maintenance

1.) Time loss between problem identification and maintenance person attending the problem

Production person cannot find the maintenance quickly

Maintenance personnel locating mechanism not available

High Energy Consumption

Data for Communication Gap...

About 5 mins per day is lost (at a minimum) when production person in all areas (with production stopped) cannot locate maintenance personnel

780kw * 1 * 5 min / 60 min * 26 * Rs 4 * 12 = **Rs 0.8 lacs / yr**

C & E Diagram for Admin Bldg

Admin Building

1.) Electric heating elements used to warm food in canteen

Solar heating system proposal to be restudied

2.) Staff leaves lights / AC etc on after work hours

3.) Security forgets to switch of lights / AC / fans etc after work hrs

High Energy Consumption

Data for Admin Building...

Electric element is used in canteen to heat food

Assuming 2 hrs in morning, 3.5 hrs for lunch, and 2 hrs for dinner

7.5 hrs electric heating of 3 kw is used in canteen

7.5 hrs * 3 kw * 30 days * 12 months * Rs 4 = **Rs 0.32 lacs / year**

List of Key Input Variables with estimated losses and proposed counteractions

Area	Causes	Losses (lac/yr)	Counteraction / costs
Burnoff	• Burnoff idle when HCs are brazed	3.14	Shut off burnoff as last radiator exits before HC starts (SSK, immediate)
	• Inadequate utilization due to frequent speed change	2.14	Kiran
Fluxer	• Fluxer idle when HCs are brazed	0.11	Shut off burnoff as last radiator exits before HC starts (SSK, immediate)
	• Inadequate utilization due to frequent speed change	0.15	Kiran
	• Fluxer Breakdown	2.04	Keep spare fluxer balls Spare kit for fluxer pump (Material Dept Help)
	• Fluxer nozzle setting problem	1.5	Install TV / Camera (budgeted) to be procured (Material Dept Help)

List of Key Input Variables with estimated losses and proposed counteractions

Area	Causes	Losses (lac/yr)	Counteraction / Cost
Dry Off	• Inadequate utilization due to speed change	4.05	Kiran
	• Air Blower not functioning properly	0.75	Bearing + New Air Blower + Motor as spares need to be procured (Material Dept Help)
Brazing	• Inadequate utilization due to frequent speed changes	7.25	Kiran
	• Conveyor running continiously (during idle condition)	Ravi	
	• Conveyor not insulated causing heat loss	Ravi	
	•		
	• Core Band Shortages	4.9	Procure new core bands (part of planing system) (Material Dept Help)
	• Nitrogen Shortages	1.22	(Material Dept Help)

List of Key Input Variables with estimated losses and proposed counteractions

Area	Causes	Losses (lac/yr)	Counter
Cooling Section	• Muffle exposed between oven and cooling section	Ravi	
	• Air blower remains ‘on’ even when brazing is not ‘on’	0.25	Modify current circuit (SSK)
FDV	• Timer to shut FDV not yet procured	1.6	Install 6 timers on FDV(Material Dept Help) 6 * Rs 5000 + 10,000 install = Rs 0.4 lac
	• Exhaust fans do not start automatically after power failure	n/a	Circuit modification (SSK) – immediate Rs 5000

List of Key Input Variables with estimated losses and proposed counteractions

Area	Causes	Losses (lac/yr)	Counter
Degrease	• Down time is about 2.7 hr/shift due material shortages	1.65	Kiran to plan
Air Comp	• Small Comp yet to be procured	2.68	(Material Dept Help), Cost: 3 lacs
	• Press drop due to leakages in air comp line	1.12	Fix leakages (RNS/SSK), Cost 0.25 lacs
Core Assy & Clinching	• Core assy packs running without auto cut off	1.7	Procure and install cut off switches for both core assy and clinching area • 8 switches * Rs 5000 / switch + 10,000 installation = Rs 0.5 lacs (SSK /RNS)
	• Clinching packs running without auto cut off	0.27	

List of Key Input Variables with estimated losses and proposed counteractions

Area	Causes	Losses (lac/yr)	Counteractions / Cost
Communication	• Communication gap / delay between production and maintenance	0.8	Pagers to be provided to maintenance personnel (SSK / RNS / KW)
Admin Bldg	• Electric element used (in canteen for heating food)	0.32	Restudy solar system proposal (RNS / SSK) Cost: Rs 0.65 lacs
	• Lights / AC remain 'on' after work hours	0.32	Awareness – all employees

Counteractions - Action Item Worksheet

The progress of the action items were tracked through a detailed action item worksheet.

This action item work sheet was reviewed in the Six-Sigma CEO review meeting held every 15 days during the course of this project. This meeting was very instrumental in giving direction to the project and helped the project move forward.

A Sample of the Action Item Work Sheet is shown on the next page...

Action Item Work Sheet (A Sample)

ENERGY PROJECT

Main task/sub task	Responsibility	Support	Start date	End date
I.) Minimize Converyor Speed and Temp Changes	Kiran	SSK/MMK/SH	1-Oct	31-Oct
a.) Study different combinations of speed and temp settings for 1512 & Indica D.			1-Oct	31-Oct
b.) Validate study for other models also at the optimised settings				15-Nov
c.) Quantify benefits of the optimization study	Kiran	SSK/[illegible]MK/SH	[illegible]-Oct	31-Oct
d.) Standardize set up. Modify process sheets and work instructions			15[illegible]ct	31-Oct
2.) Burnoff / Fluxer Shut Off				
a.) Shut Burn Off & Fluxer as last radiator exits before HC starts	Sanj[illegible]	AG	1-Oct	15-Oct
b.) Visual Control and Work Instructions	Sanj[illegible]	AG	1-Oct	31-Oct
3.) Order Spare Fluxer [illegible]ails				
a.) PO to be releas[illegible]	Alu[illegible]	KPK / RS	15-Oct	1-Nov
4.) Spare Kit for Fl[illegible]				
a.) PO to be released	Alur	KPK / RS	15-Oct	1-Nov
5.) Install TV / Camera for F[illegible]xer Monitoring	Sanjay	RNS	15-Oct	31-Oct
6.) Spares for 'Dry Off' Air Blower				
a.) Bearing, Air Blower, Motor	Alur	KPK / RS	15-Oct	5-Nov
7.) Procure Core Bands				
a.) Finalize quantity required	Alur	KPK / RS	15-Oct	30-Nov
b.) PO release				

Sample

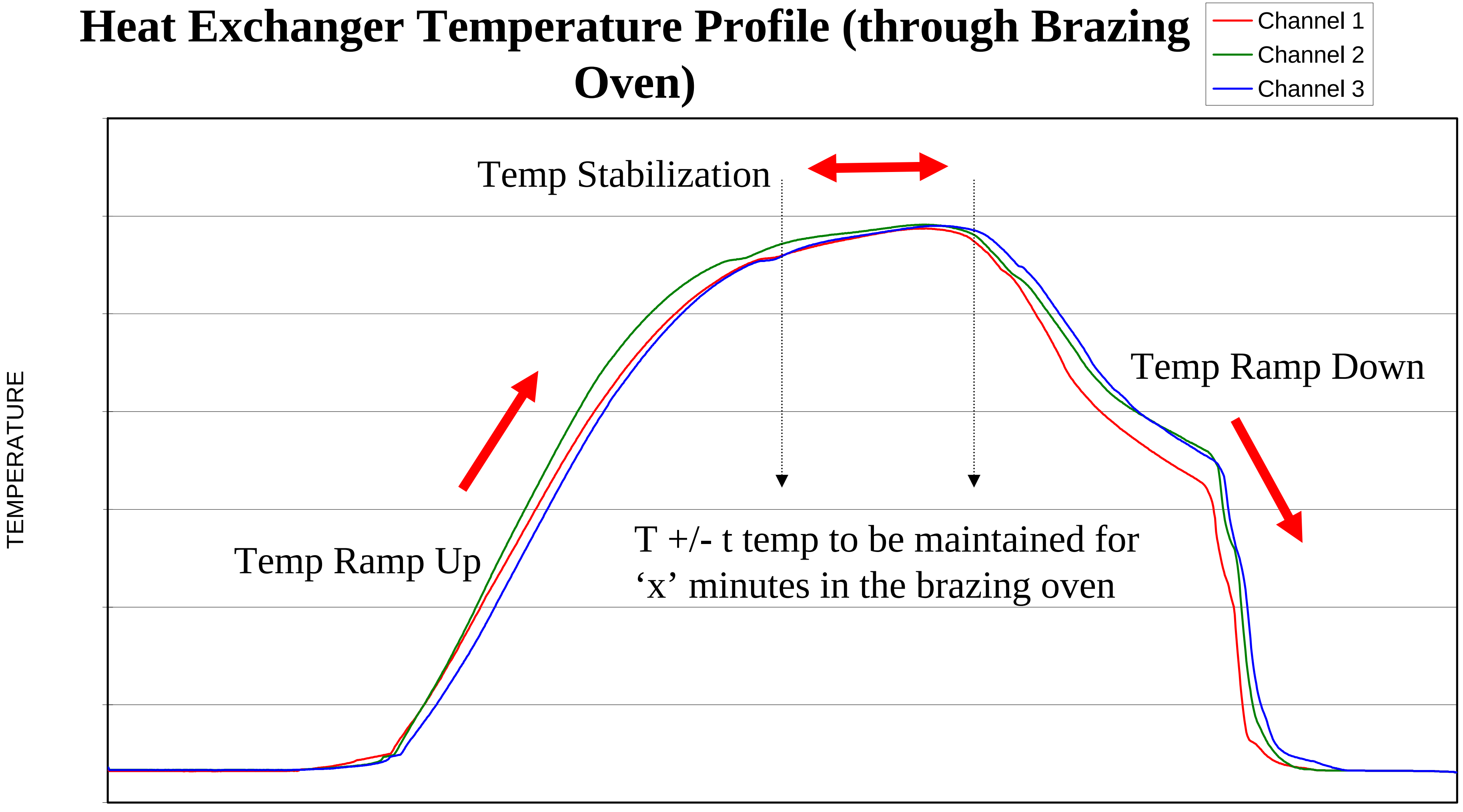
Speed and Temperature Commonisation Experiments

For improving brazing oven utilization around 25 planned experiments were done over a period of about a month. Heat exchanger cores with temperature loggers (profilers) connected to them were passed through the brazing oven for recording the temperature that the core was actually attaining during the entire experimental brazing run. Brazing temperatures and speed of the conveyor were systematically varied and the actual radiator temperatures (on three places on the radiator) were measured and analyzed.

Through these experiments, we successfully commonised temp and speed profiles for about 80 % of heat exchanger manufactured by us. This along with other improvement actions, led to a 30 % improvement in brazing productivity.

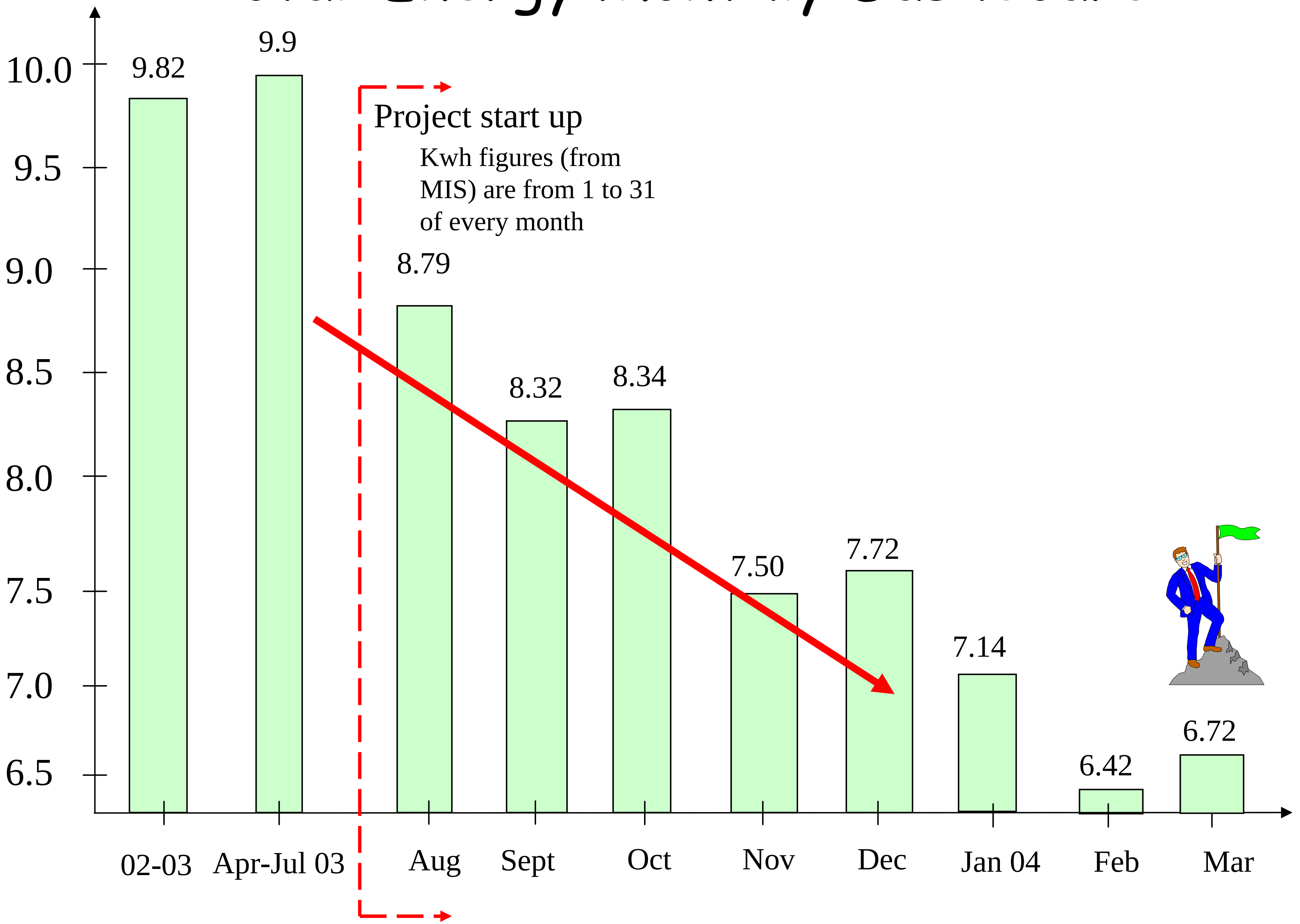
The following page presents an illustrative sample of the temperature profile that the temperature logger tracked for one of our experiments…..

Heat Exchanger Temperature Profile (through Brazing Oven)

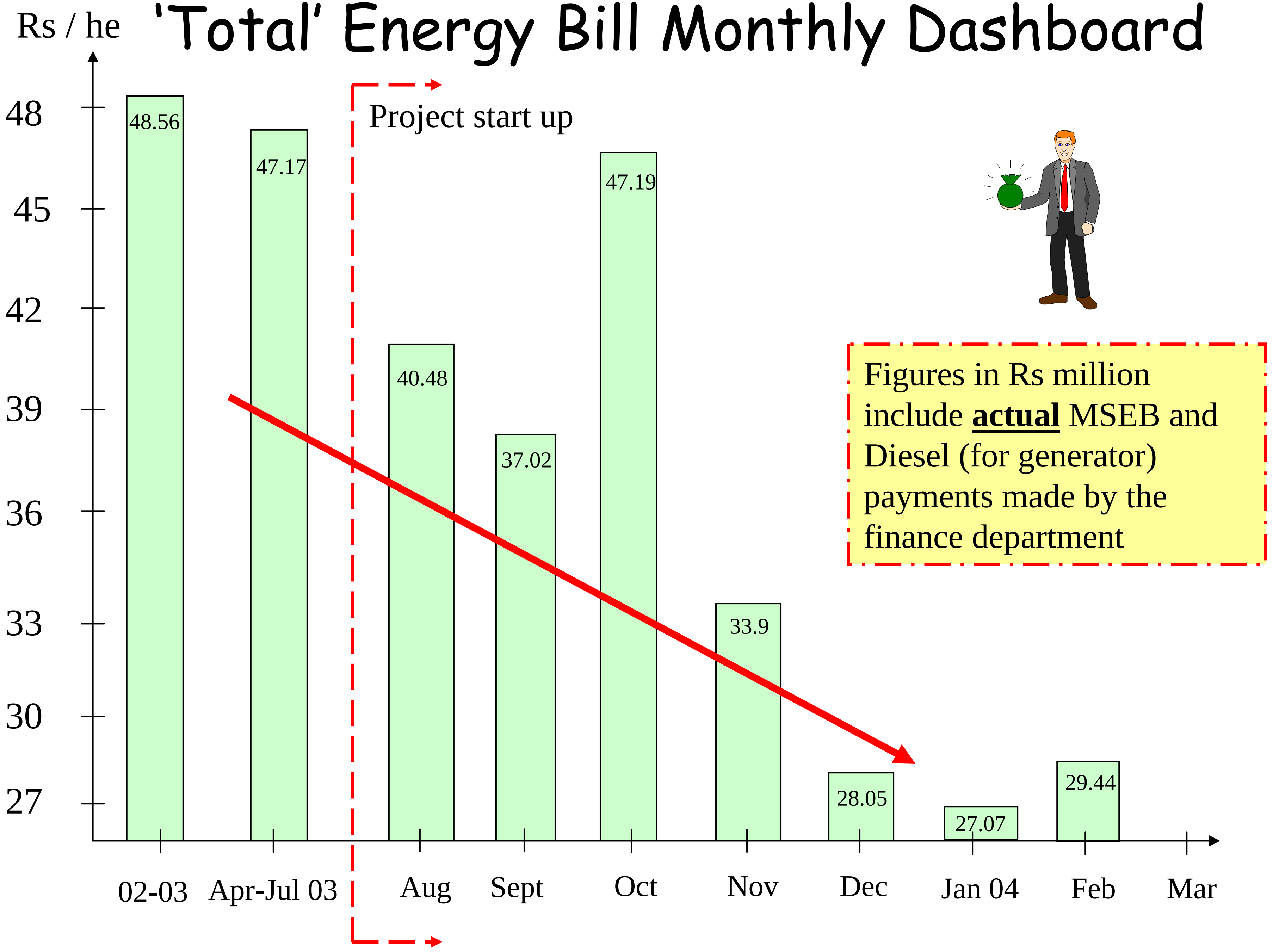


For proprietary reasons the actual data has not been shown

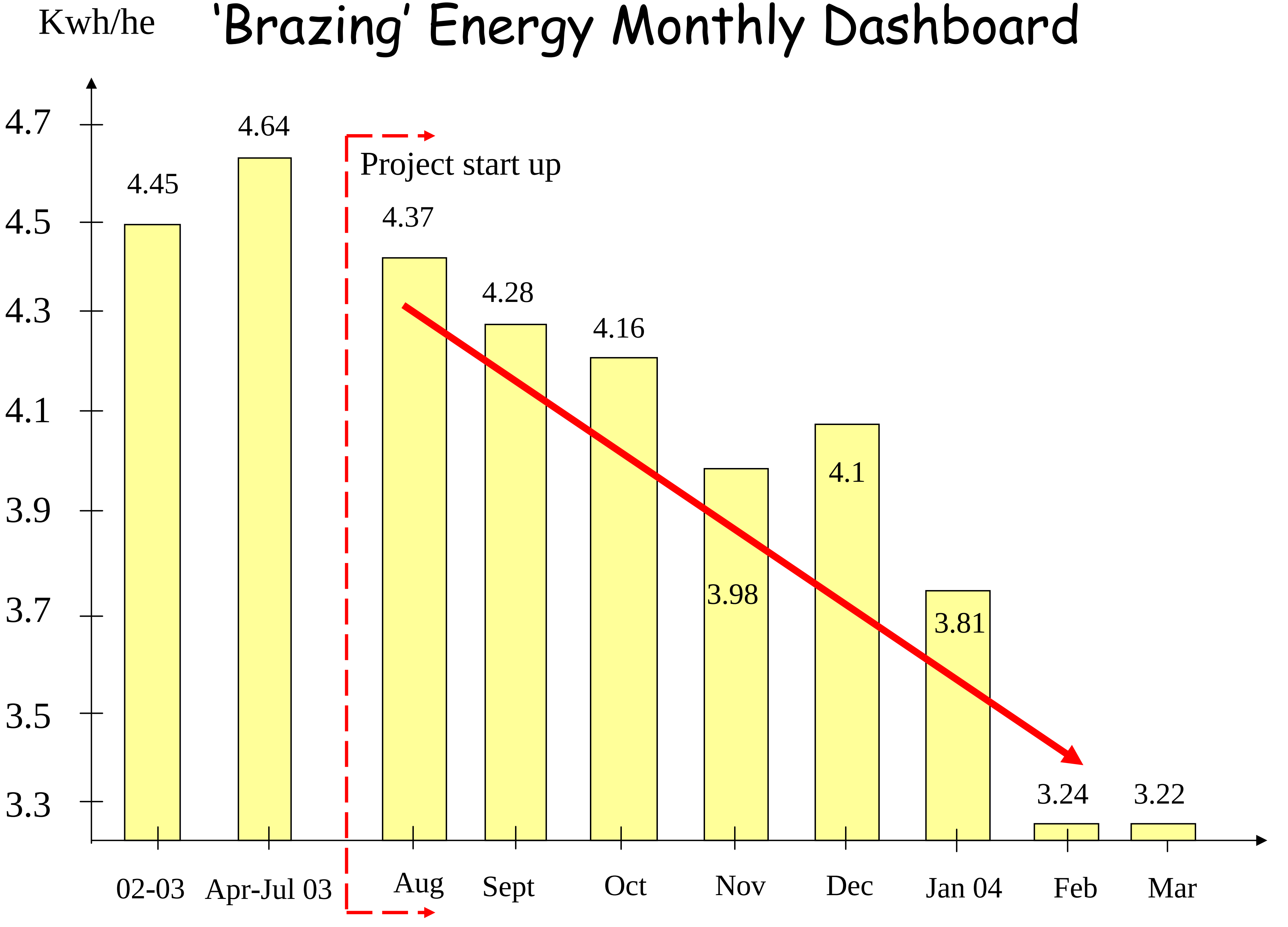
'Total' Energy Monthly Dashboard



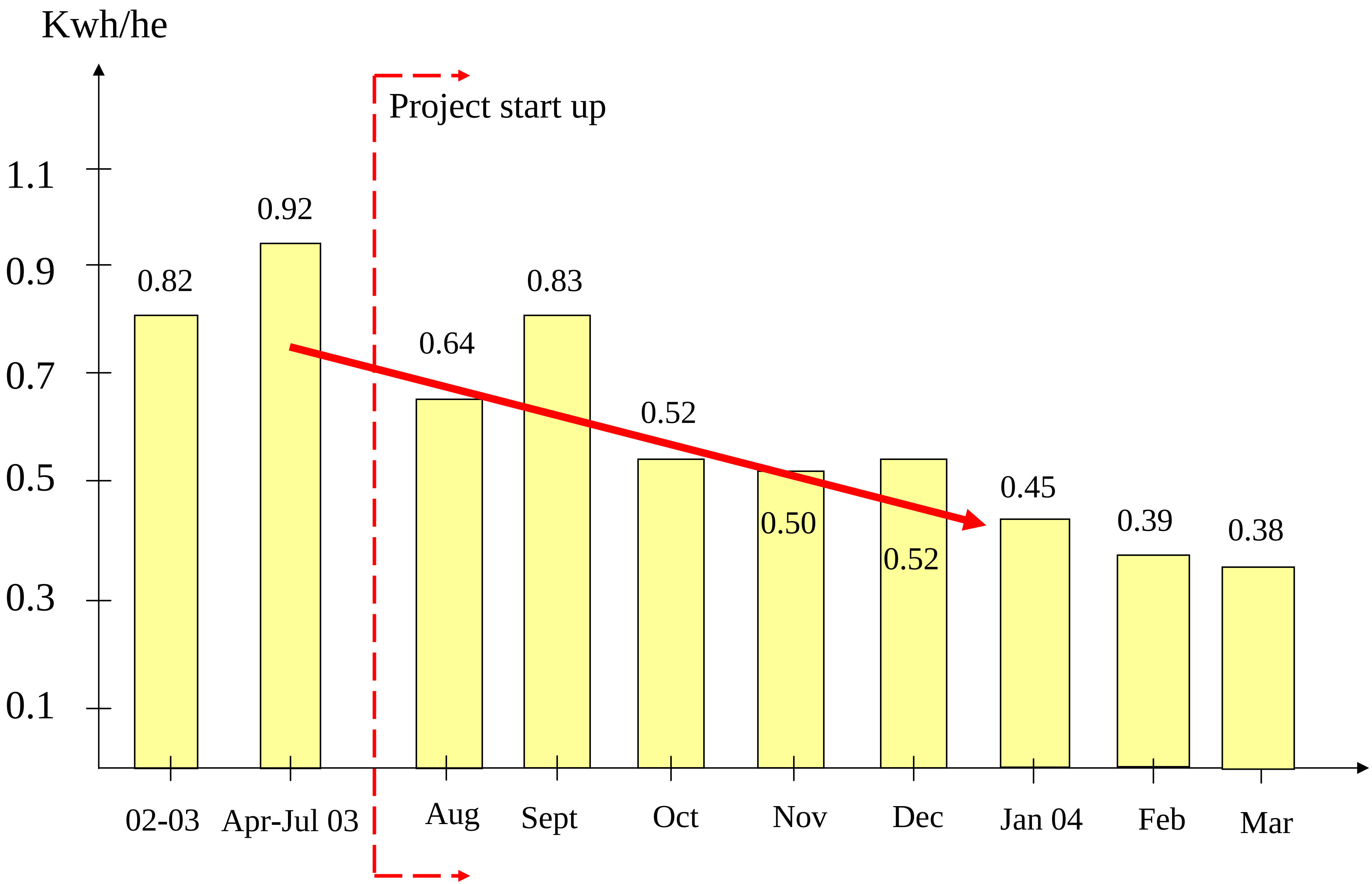
'Total' Energy Bill Monthly Dashboard



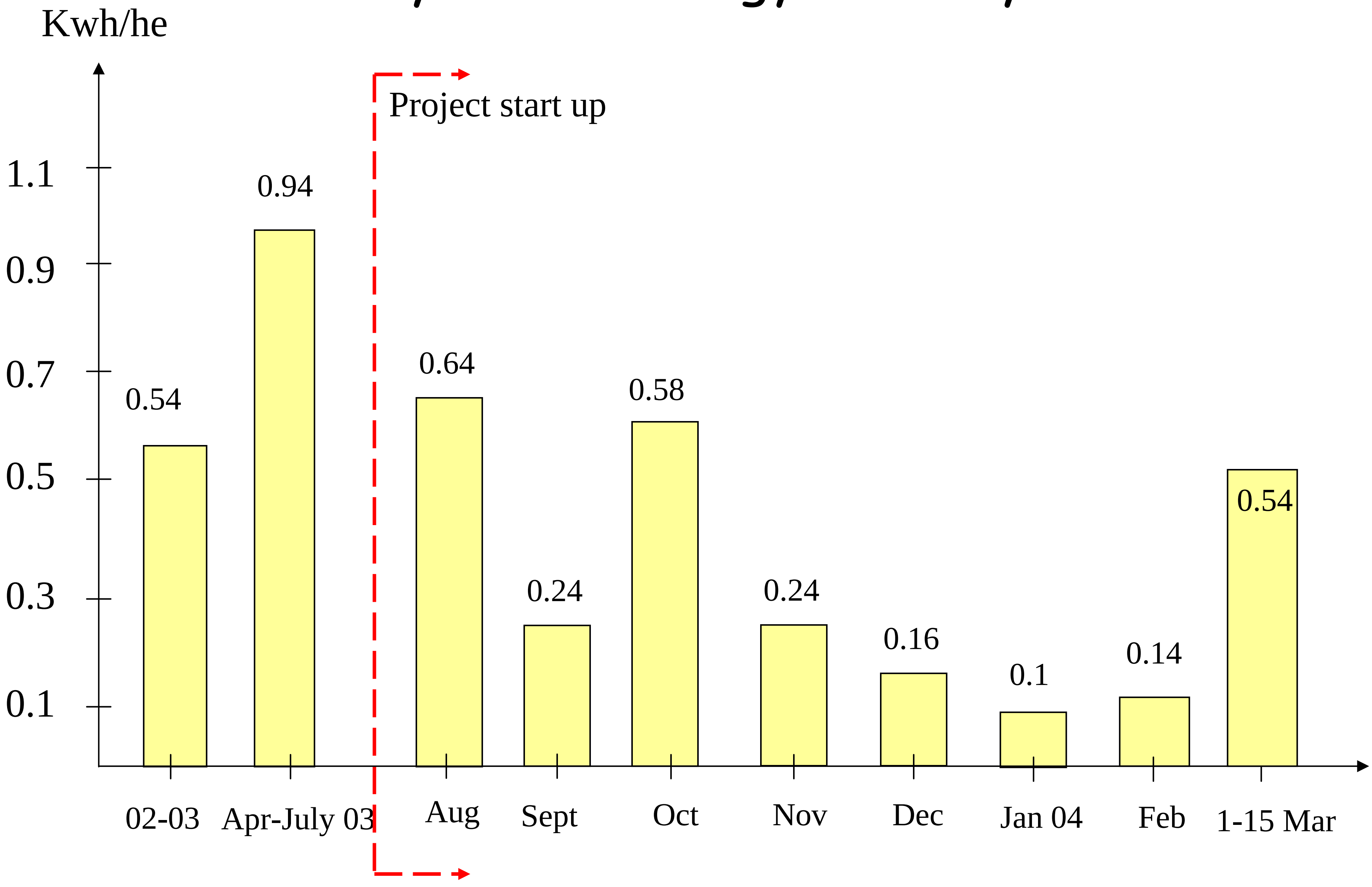
'Brazing' Energy Monthly Dashboard



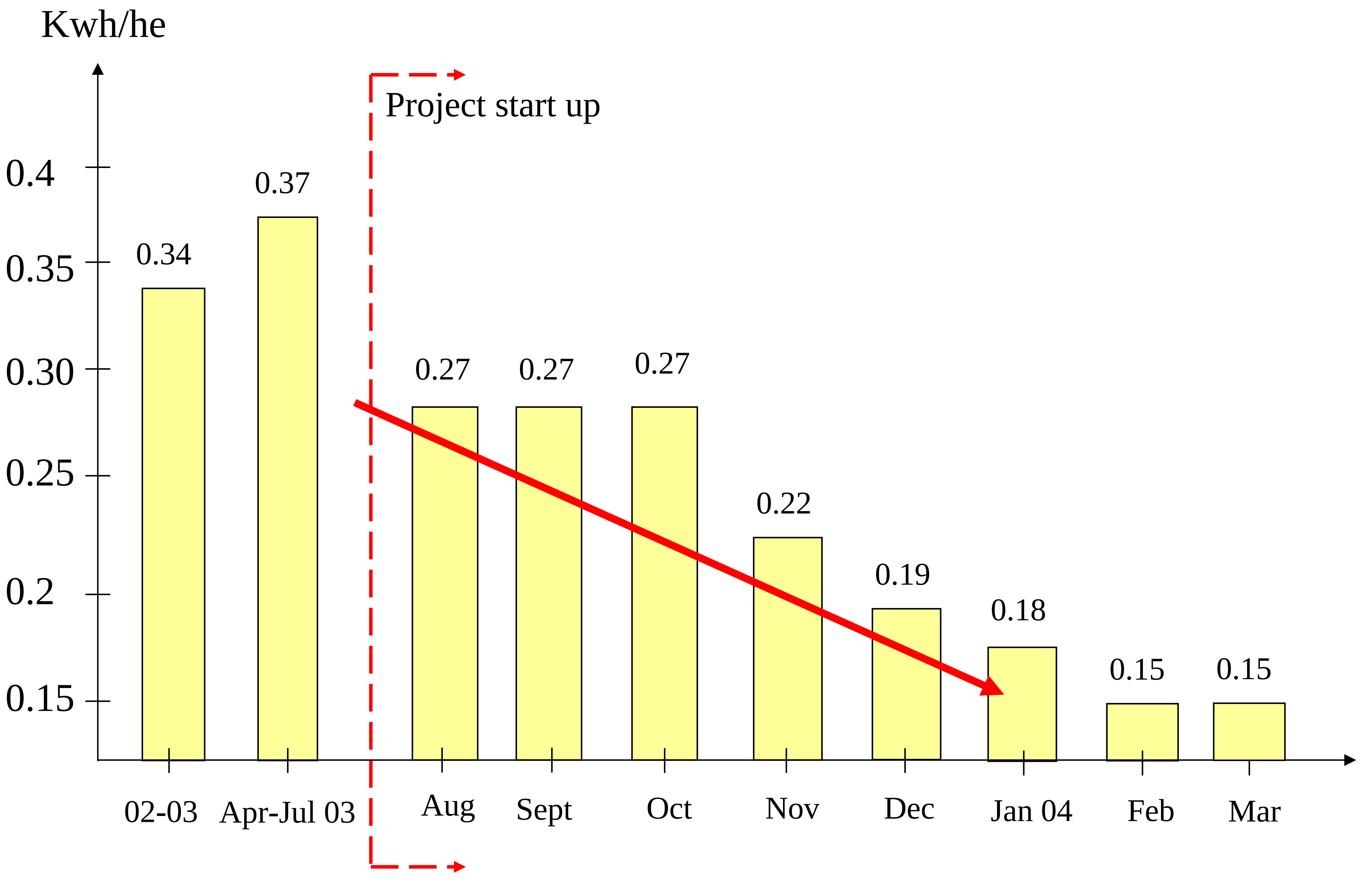
'Air Compressor' Energy Monthly Dashboard



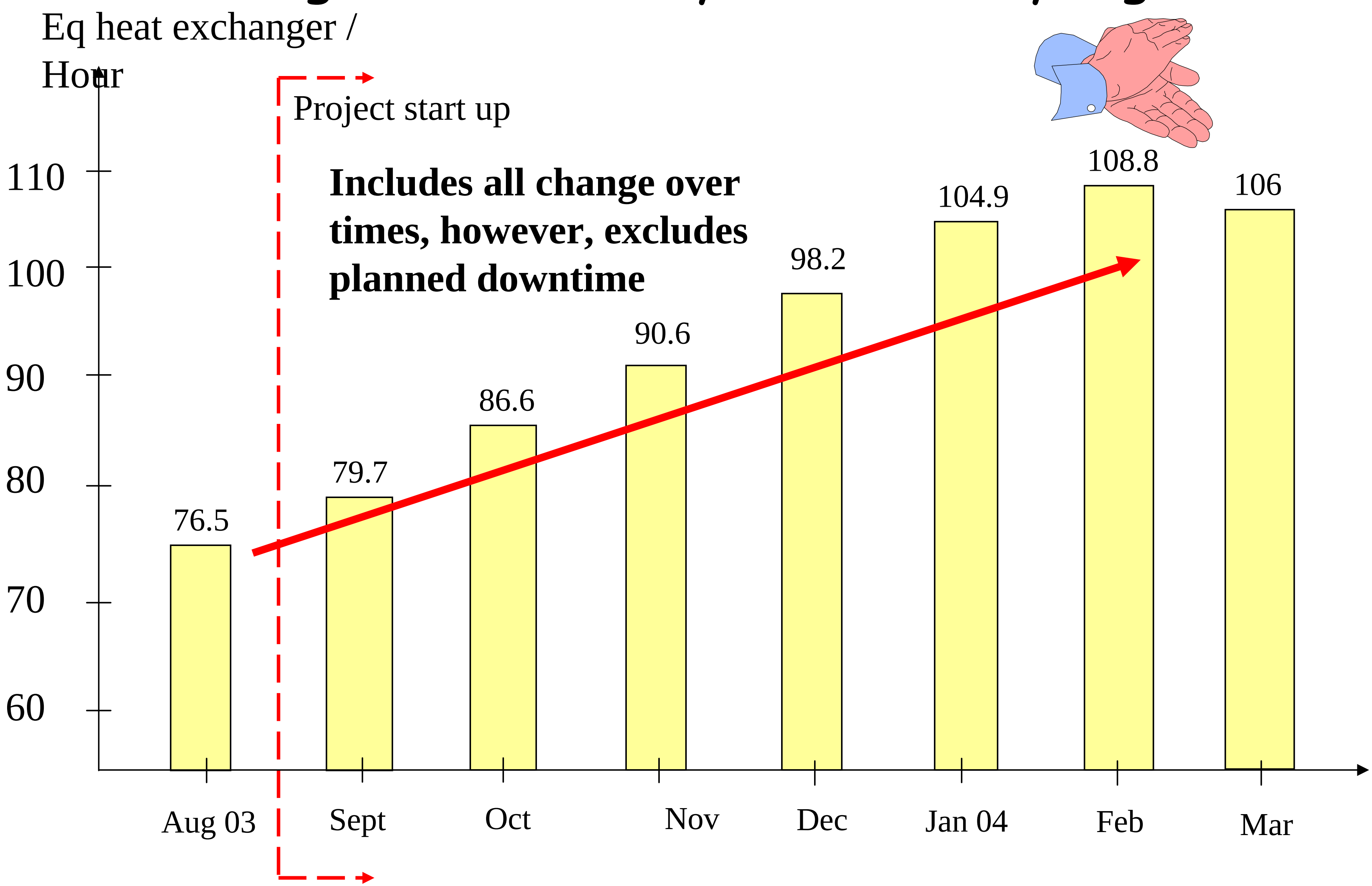
'Ventilation Systems' Energy Monthly Dashboard



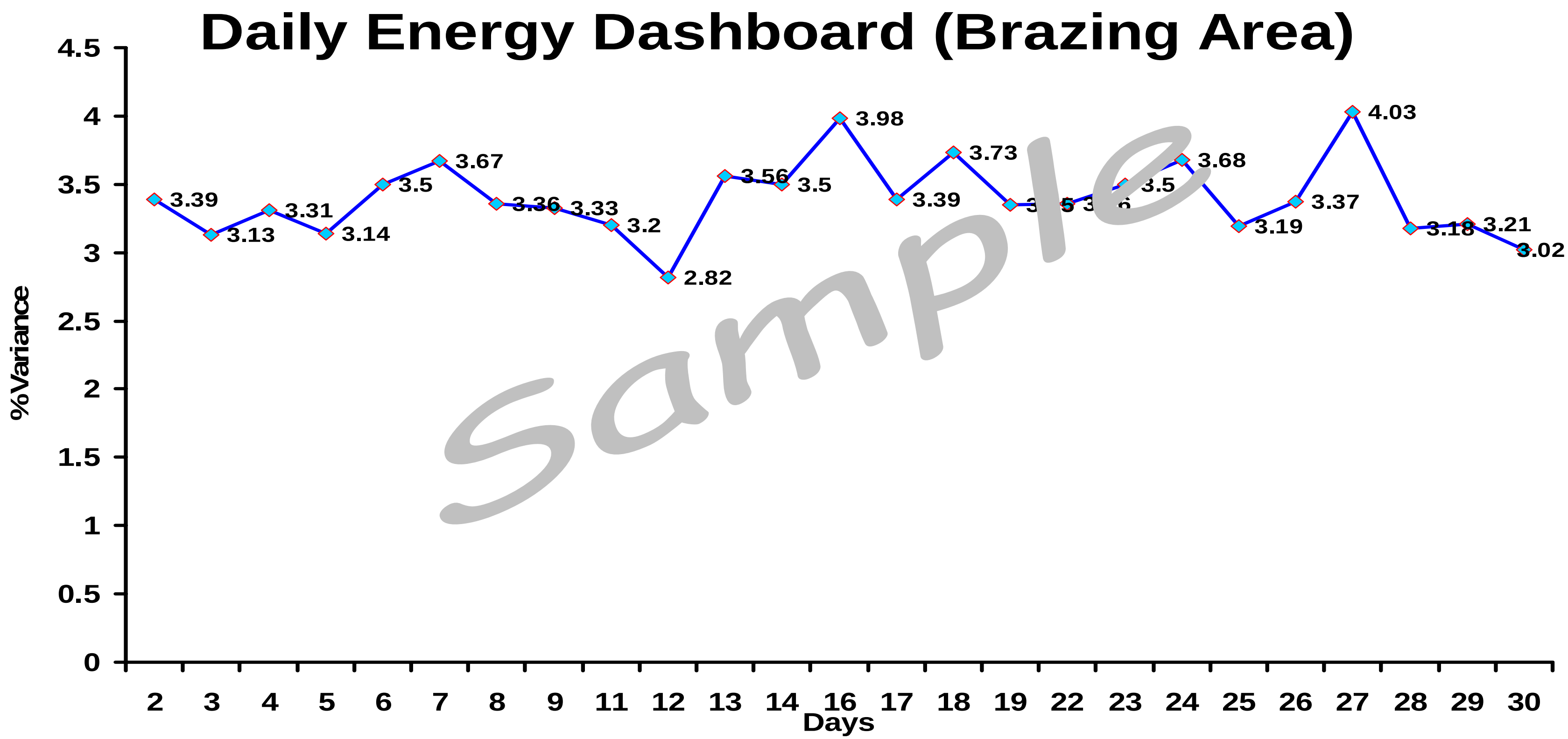
‘Pump House’ Energy Monthly Dashboard



'Brazing Oven' Monthly Productivity Figures



Six-Sigma - Control Phase



Sample

Daily monitoring of energy levels has been started in the brazing area as part of the control phase. Total number of radiators produced along with total kwh consumed during the day is used to calculate kwh / eq rad for brazing. This chart is maintained by the shop. This chart gives real time signals to shop if the energy levels go beyond set norms. Also, we are 'closely' monitoring energy levels for FDV, Air Comp, Tube Mill, and Pump House

Summary of Achievements

29.3 % reduction in energy consumption levels. Energy levels were reduced from about 12.36 kwh / heat exchanger during 2000-01 to about 8.73 Kwh / heat exchanger in 2003-04 period.

The “actual” energy cost in Rs / heat exchanger (MSEB + Diesel for generator) paid by finance department dropped from about **Rs 78.3 in 2000-01** to about **Rs 37.3 in 2003-04** – a 52 % reduction !

Achieved hard savings of **Rs 53.81 lacs from 2001 to 04**

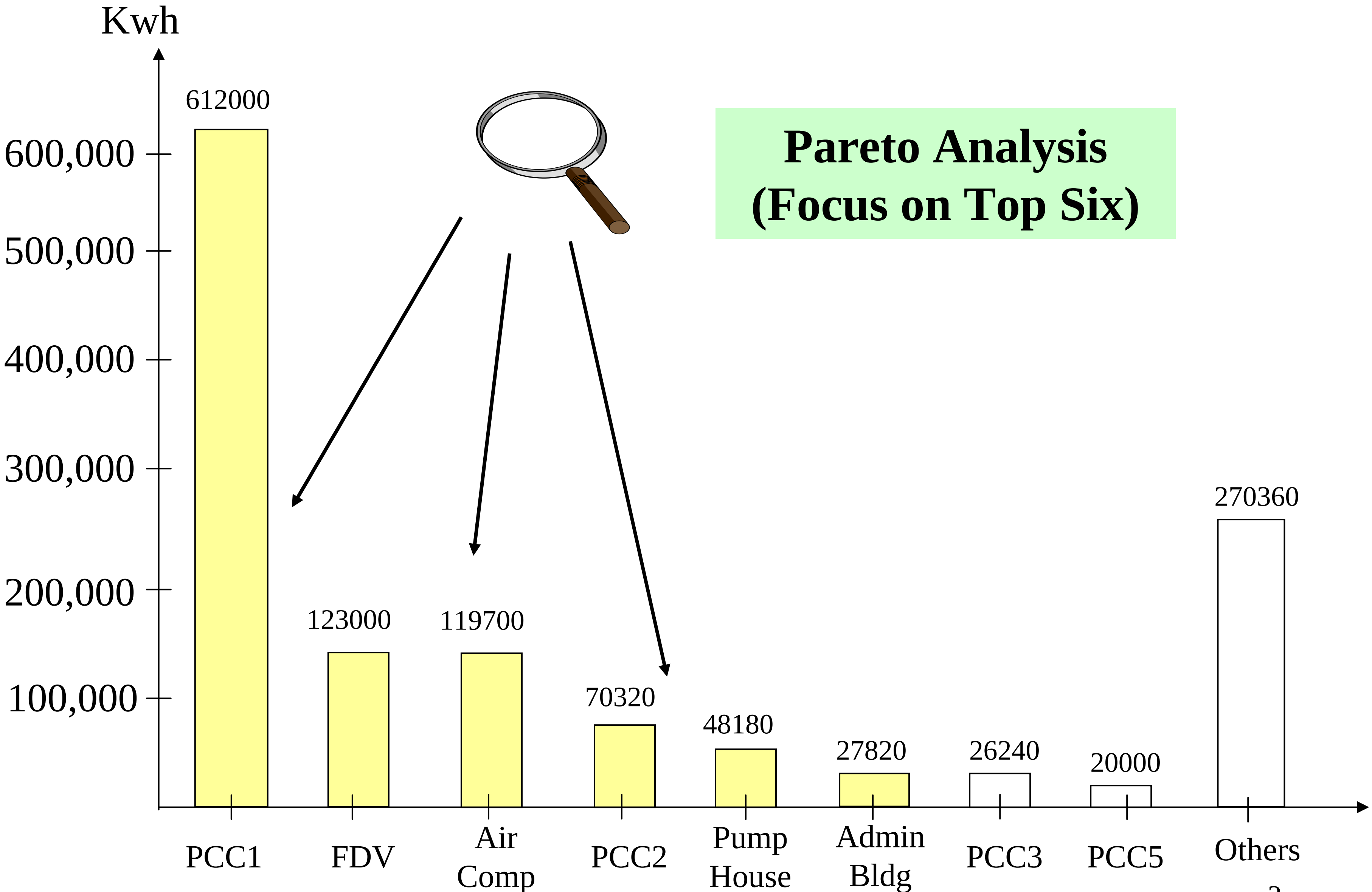
SIX SIGMA
"Analyze" Phase

Energy Reduction Project

Tata Toyo, Pune

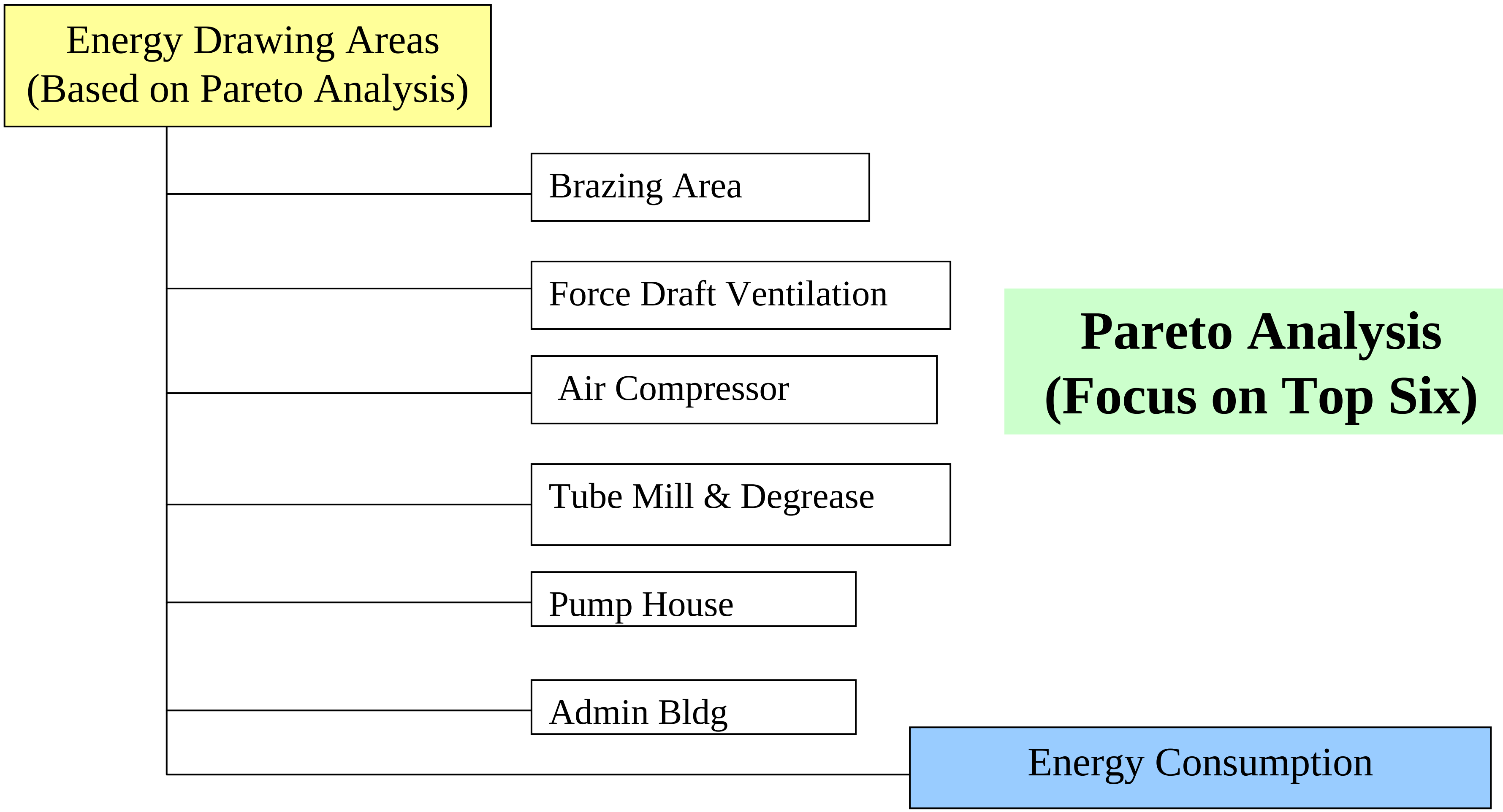
7 Oct 03

Energy Data by Areas (April - July 03)

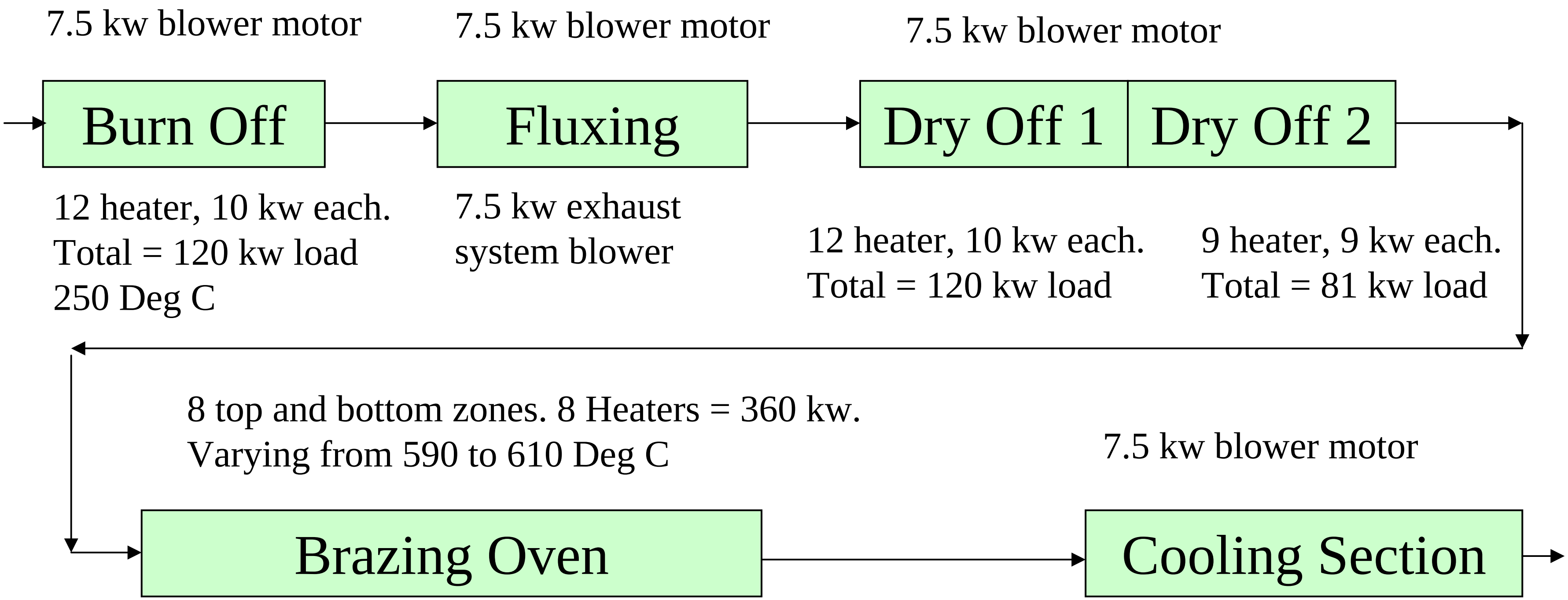


Prioritized areas of concern

Based on the analysis of data collected for April and July team short listed major areas for improvement.



Brazing Area



Product must reach 605 +/- 5 Deg C for min 3 minutes

If everything is on, total load is between 375 and 480 KW.
Running cost is between Rs 1500 to 1900 per hour

Listing Potential Causes (Xs)

- After a lot of continued deliberations the team identified potential ‘causes’ of high energy consumption for the areas listed in the previous slides.

The team is aware that some of the Xs have been discussed in other forums also, nevertheless, the team decided to list comprehensively all ‘potential’ causes currently existing for energy wastage. Wherever possible, the team has attempted to quantify the losses also.

C & E Diagram for Brazing Area

Burn Off

1.) Whenever Heater Cores are brazed burn off is idle

- HCs have other operations between burn off and brazing
  - By design

2.) Inadequate utilization of burn off

- Change over of model and speed (20 min needed for change of speed)
- Fluxing change over not ready (start of shift) - ideal burn off

3.) Burn off insulation wear out - not checked since we started

Brazing Area

Data for Burn Off...

Burn off Idle When Heater Cores (HC) are Brazed:

About 2 hours per day of HC brazing + 1 hr temp up and down + 0.5 hr for radiator out

(3.5 hrs / day) * 26 days / month = 91 hrs per month burn off is idle

With 120 kw total load with 0.6 pdf = 72 kw final load

Thus, 91 hrs * 72 kw = 6552 kwh loss / month

= 3744 kwh * Rs 4 * 12 months = **3.14 lacs / year loss**

Inadequate Utilization of Burn Off Due to Frequent Speed Change:

About 210 speed changes per month and 20 idle mins / change

210 * (20min / 60) * 120 * 0.6 * Rs 4 * 12 months = **Rs 2.14 lacs/yr**

Note: If we reduce current speed changes by half, savings ~ 1 lac / yr

C & E Diagram for Brazing Area

Fluxer

1.) Whenever Heater Cores are being brazed fluxer is idle

- HCs haveother operations between burnoff and brazing
  - By design

2.) Inadequate utilization of burn off

- Change over of model and speed (20 min needed for change of speed)

3.) Fluxer Area Breakdown stops line

- **Flux pipe / Spray Nozzle choke up**
  - Flux not getting cleaned - proper equipment not available
- **Fluxer ball get stuck in nozzle - balls break - pieces get stuck**
  - Imported balls not available - making do with domestic (Material Dept Help)

Brazing Area

C & E Diagram for Brazing Area

Fluxer

3.) Fluxer Breakdown stops line (contd.)

- Air blower breakdown
  - Bearings to be procured (Material Dept Help)
- Fluxer pump breakdown
  - Inadequate preventive maintenance
    - Spares kit to be procured (Material Dept Help)

Fluxer Nozzle setting waste time

- Operator at ‘in’ position cannot see till feedback is received from ‘out’ operator
  - Display system (TV/Camera) has not been procured (Material Dept Help)

Brazing Area

Data for Fluxer...

Fluxer Idle When Heater Cores are Brazed:

About 2 hours per day of heater core brazing

(2 hrs / day) * 26 days / month = 52 hrs per month fluxer is idle

With 7.5 kw total load with 0.6 pdf = 4.5 kw final load

Thus, 52 hrs * 4.5 kw = 234 kwh loss / month

= 234 kwh * Rs 4 * 12 months = **0.11 lacs / year loss**

Inadequate Utilization of Fluxer Due to Frequent Speed Change:

About 210 speed changes per month and 20 idle mins / change

210 * (20min / 60) * 7.5 * 0.6 * Rs 4 * 12 months = **Rs 0.15 lacs/yr**

Note: If we reduce current speed changes by half, savings ~ 0.075 lac / yr

Data for Fluxer...

Fluxer Breakdown:

Actual logged breakdown is about 3.5 hrs / month

Delays of about 15 minutes occur everyday which are not logged

Total stoppages = (3.5 + 6.5) hrs / month ~ 10 hrs per month

With a total load of Rs 1700 / hr for the entire brazing area

Thus, 10 * 1700 * 12 = **Rs 2.04 lacs / yr**

Fluxer Nozzle Setting Problem

About 6.5 hrs / month are lost due to this problem

6.5 * 1900 * 12 = **Rs 1.5 lacs / yr**

C & E Diagram for Brazing Area

Dry Off

1.) Air Blower Not Working Properly (900 mm instead of 2200 mm of water

Bearing to be procured (Material Dept Help)

2.) Inadequate utilization of Dry off

Change over of model and speed (20 min needed for change of speed)

Brazing Area

Data for Dry Off...

Inadequate Utilization of Dry Off Due to Frequent Speed Change:

About 210 speed changes per month and 20 idle mins / change

*Dry off load is 201 kw * 0.6 pdf = 120.6 kw*

210 * (20min / 60) * 125.4 * Rs 4 * 12 months = **Rs 4.05 lacs/yr**

Note: If we reduce current speed changes by half, savings ~ 2 lac / yr

Air Blower not Working Properly (900 mm instead of 2000 mm):

Assuming 2.5 kw excess energy is used by blower due to improper functioning

2.5 kw * 24 hr * 26 days * 12 months * Rs 4 = **Rs 0.75 lacs / yr**

C & E Diagram for Brazing Area

Brazing Oven

1.) Conveyor running continuously (during idle condition), causing heat / energy loss

2.) Conveyor not insulated causing heat / energy loss

3.) Frequent change over of models / speed of conveyor

Kiran's project

Product mix not optimized. Brazing oven speed changes to be optimized

4.) Core band shortages - idle brazing oven

Awaiting procurement of core band for new models

5.) Nitrogen shortages (every month 6 to 8 hours lost)

Supplier delivery not per schedule (bullet n/a)

Brazing Area

Data for Brazing Oven...

Inadequate Utilization of Brazing Oven Due to Frequent Speed Change:

About 210 speed changes per month and 20 idle mins / change

*Dry off load is 360 kw * 0.6 pdf = 216 kw*

210 * (20min / 60) * 216 * Rs 4 * 12 months = **Rs 7.25 lacs/yr**

Note: If we reduce current speed changes by half, savings ~ 3 lac / yr

Core Band Shortages - brazing oven remains idle:

~ 24 hrs / month loss is assumed, 24 * Rs 1700 * 12 = **Rs 4.9 lacs/yr**

Nitrogen Shortages:

About 6 to 8 hrs every month

6 * Rs 1700 * 12 = **Rs 1.22 lacs / yr**

C & E Diagram for Brazing Area

Cooling Section

1.) Muffle between brazing oven and cooling section is exposed causing heat loss (Ravi's help needed)

2.) Air Blower on even when brazing is not on

No auto cut off switch

Data for Air Blower is on continuously:

On Sundays = 24 hrs loss * 4 / month * 5.5 kw * 12 months * Rs 4 = Rs 0.25 lacs/ yr

Brazing Area

C & E Diagram for FDV

FDV

1.) No Specific plan schedule for running FDV

No timer for FDV shut off

Timer to be procured (Material Dept Help)

2.) No System to switch blower on / off based on temperature

No temperature indicator / controller

3.) Improvement in ventilation

Exhaust fans do not come on automatically after power failure

High Energy Consumption

Data for FDV...

Timer for FDV shut off to be procured:

About 2 hrs / day wasted per FDV motor as timer cut off is not available

5 motors of 18.5 kw with a pdf of 0.7 will give us:

(2 hrs/day)*(5 motors)*(18.5*0.7)*26days*12months*Rs 4
= 1.6 lacs / yr

C & E Diagram for Degrease

Degrease

1.) Downtime of 'degrease' operation for first 11 days of Sept was around 2.7 hours / shift - causing waste of energy

No material available for degrease

Inadequate Planning

High Energy Consumption

Data for Degrease...

<u>Degrease Operation:</u>

Load or No-Load, following equipment are always on:

Oil circulating pumps: 3 pumps * 2.2 kw = 6.6 kw

Booster pump = 3.7 kw

Trap = 3.7 kw

Vacuum pump = 1.5 kw

Water circulation pump = 4 pumps * 2.25 kw = 9 kw

Total Load = 24.5 kw

2 shift operation, 2.7 hrs / shift waste = 3440 kw wasted / month

Loss = 3440*Rs 4* 12 = **Rs 1.65 / yr**

C & E Diagram for Air Compressor

Air Compressor

- **1.) Big Compressor (75 kw, 500 cfm) is used even for low loads (for example: third shift, Sundays etc)**
  - Unavailability of small (25 kw, 125 cfm) compressor - to be procured (Material Dept Help)
- **2.) Excessive Use of Air Compressor**
  - Pressure drop due to leakages in compressed air line in the plant
    - Leakages in FRL unit in press
    - Leakages in pneumatic cylinder
      - Moisture in air damages seals
        - Water in compressor not drained
    - Leakages from GI piping joints
    - Leakages from tubing - tubes worn out

High Energy Consumption

Data Air Compressor...

Big Compressor (75 KW), existing:

Third Shift Running: 7 hrs * 305 days with 0.6 load factor

Cost of Running 3rd Shift = 7*305*(75*0.6)*Rs 4 = Rs 3.83 lacs/yr

Sunday Running: 7 hrs * 52 days with 0.5 load factor

Cost of Running Sunday = 7*52*(75*0.5)*Rs 4 = Rs 0.54 lacs/yr

Small Compressor (22 KW), proposed (Cost Rs 3 lacs):

Third Shift Running: 7 hrs * 305 days with 0.8 load factor

Cost of Running 3rd Shift = 7*305*(22*0.8)*Rs 4 = Rs 1.5 lacs/yr

Sunday Running: 7 hrs * 52 days with 0.6 load factor

Cost of Running Sunday = 7*52*(22*0.6)*Rs 4 = Rs 0.19 lacs/yr

SAVINGS / YR = Rs 2.68 lacs. Pay back is about 1.1 years

Data Air Compressor...

Excessive Use of Compressed Air due to leakages:

Assuming just 5 % of compressed air been wasted due to leakages

5 % of 75 kw compressor = 3.75 kw wasted

3.75 kw * 24 hrs * 26 days * 12 months * Rs 4 = **Rs 1.12 lacs / yr**

C & E Diagram for Core Assy and Clinching

Core Assy & Clinching

1.) All hydraulic packs keep working during change over and breaks wasting energy

Auto cut off switches to be procured (Material Dept Help)

High Energy Consumption

Data Core Assembly and Clinching...

All packs in core assembly running during change over and breaks:

About 1.25 hrs / shift packs run idle in core assembly

6 packs of 7.5 kw each with pdf of 0.8 will give us:

(1.25 hrs/shift*3)*(6 packs)*(7.5*0.8)*26days*12months*Rs 4
= Rs. 1.7 lacs / yr

All packs in clinching area running during change over and breaks:

About 1.25 hrs / shift packs run idle in clinching

2 packs of 3.7 kw each with pdf of 0.8 will give us:

(1.25 hrs/shift*3)*(2 packs)*(3.7*0.8)*26days*12months*Rs 4
= Rs. 0.27 lacs / yr

C & E Diagram for Communication Gap

Communication Lag Between Production and Maintenance

1.) Time loss between problem identification and maintenance person attending the problem

Production person cannot find the maintenance quickly

Maintenance personnel locating mechanism not available

High Energy Consumption

Data for Communication Gap...

About 5 mins per day is lost (at a minimum) when production person in all areas (with production stopped) cannot locate maintenance personnel

780kw * 1 * 5 min / 60 min * 26 * Rs 4 * 12 = **Rs 0.8 lacs / yr**

C & E Diagram for Admin Bldg

Admin Building

1.) Electric heating elements used to warm food in canteen

Solar heating system proposal to be restudied

2.) Staff leaves lights / AC etc on after work hours

3.) Security forgets to switch of lights / AC / fans etc after work hrs

High Energy Consumption

Data for Admin Building...

Electric element is used in canteen to heat food

Assuming 2 hrs in morning, 3.5 hrs for lunch, and 2 hrs for dinner

7.5 hrs electric heating of 3 kw is used in canteen

7.5 hrs * 3 kw * 30 days * 12 months * Rs 4 = **Rs 0.32 lacs / year**

List of Key Input Variables with estimated losses and proposed counteractions

Area	Causes	Losses (lac/yr)	Counteraction / costs
Burnoff	• Burnoff idle when HCs are brazed	3.14	Shut off burnoff as last radiator exits before HC starts (SSK, immediate)
	• Inadequate utilization due to frequent speed change	2.14	Kiran
Fluxer	• Fluxer idle when HCs are brazed	0.11	Shut off burnoff as last radiator exits before HC starts (SSK, immediate)
	• Inadequate utilization due to frequent speed change	0.15	Kiran
	• Fluxer Breakdown	2.04	Keep spare fluxer balls Spare kit for fluxer pump (Material Dept Help)
	• Fluxer nozzle setting problem	1.5	Install TV / Camera (budgeted) to be procured (Material Dept Help)

List of Key Input Variables with estimated losses and proposed counteractions

Area	Causes	Losses (lac/yr)	Counteraction / Cost
Dry Off	• Inadequate utilization due to speed change	4.05	Kiran
	• Air Blower not functioning properly	0.75	Bearing + New Air Blower + Motor as spares need to be procured (Material Dept Help)
Brazing	• Inadequate utilization due to frequent speed changes	7.25	Kiran
	• Conveyor running continiously (during idle condition)	Ravi	
	• Conveyor not insulated causing heat loss	Ravi	
	•		
	• Core Band Shortages	4.9	Procure new core bands (part of planing system) (Material Dept Help)
	• Nitrogen Shortages	1.22	(Material Dept Help)

List of Key Input Variables with estimated losses and proposed counteractions

Area	Causes	Losses (lac/yr)	Counter
Cooling Section	• Muffle exposed between oven and cooling section	Ravi	
	• Air blower remains 'on' even when brazing is not 'on'	0.25	Modify current circuit (SSK)
FDV	• Timer to shut FDV not yet procured	1.6	Install 6 timers on FDV(Material Dept Help) 6 * Rs 5000 + 10,000 install = Rs 0.4 lac
	• Exhaust fans do not start automatically after power failure	n/a	Circuit modification (SSK) – immediate Rs 5000

List of Key Input Variables with estimated losses and proposed counteractions

Area	**Causes**	**Losses (lac/yr)**	**Counter**
Degrease	• Down time is about 2.7 hr/shift due material shortages	1.65	Kiran to plan
Air Comp	• Small Comp yet to be procured	2.68	(Material Dept Help), Cost: 3 lacs
	• Press drop due to leakages in air comp line	1.12	Fix leakages (RNS/SSK), Cost 0.25 lacs
Core Assy & Clinching	• Core assy packs running without auto cut off	1.7	Procure and install cut off switches for both core assy and clinching area • 8 switches * Rs 5000 / switch + 10,000 installation = Rs 0.5 lacs (SSK /RNS)
	• Clinching packs running without auto cut off	0.27	

List of Key Input Variables with estimated losses and proposed counteractions

Area	Causes	Losses (lac/yr)	Counteractions / Cost
Communication	• Communication gap / delay between production and maintenance	0.8	Pagers to be provided to maintenance personnel (SSK / RNS / KW)
Admin Bldg	• Electric element used (in canteen for heating food)	0.32	Restudy solar system proposal (RNS / SSK) Cost: Rs 0.65 lacs
	• Lights / AC remain ‘on’ after work hours	0.32	Awareness – all employees

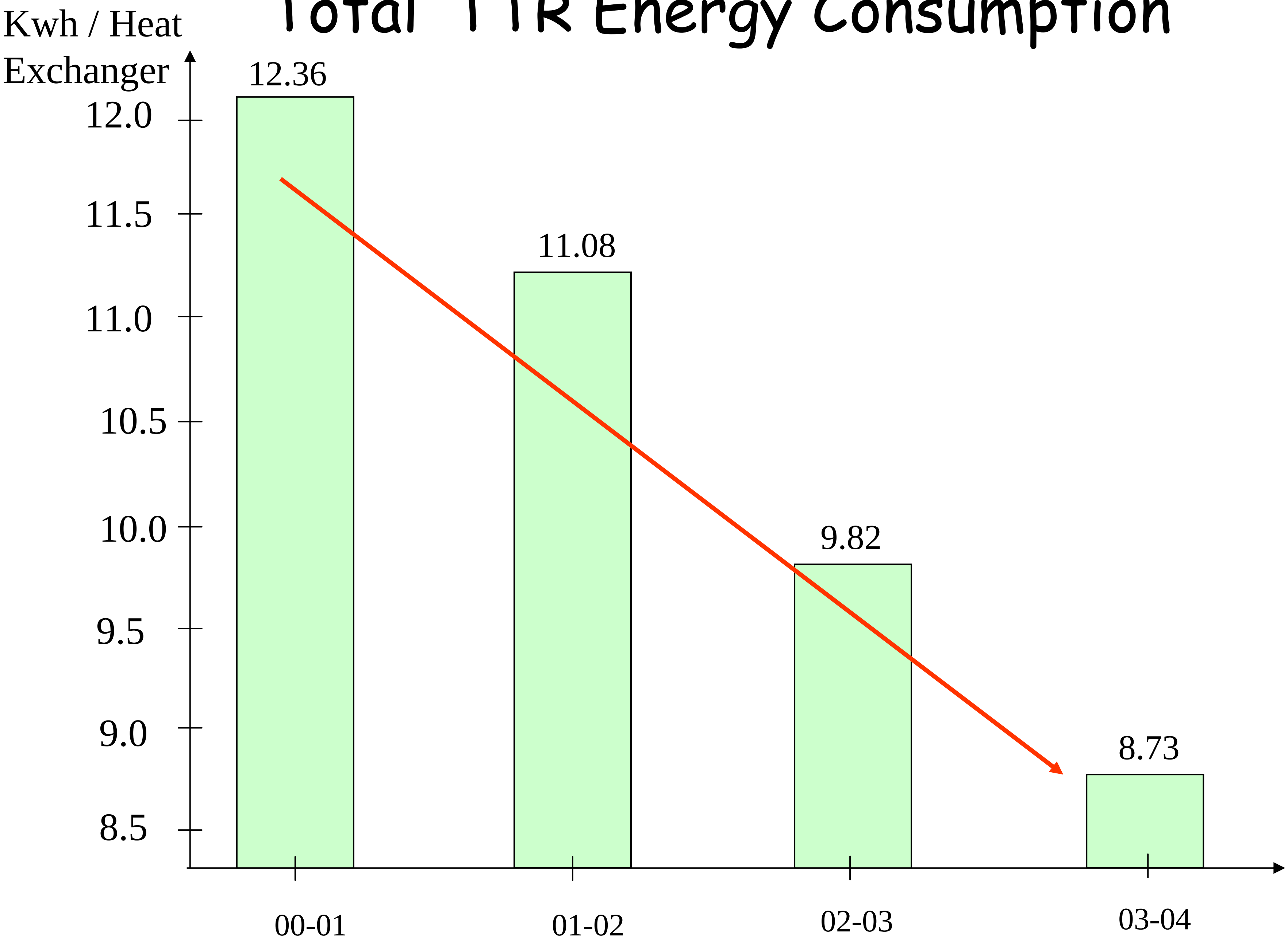
ENERGY CONSUMPTION

There has been a steady decrease in the Electrical consumption per equivalent heat exchanger due to the implementation of various energy conservation measures.

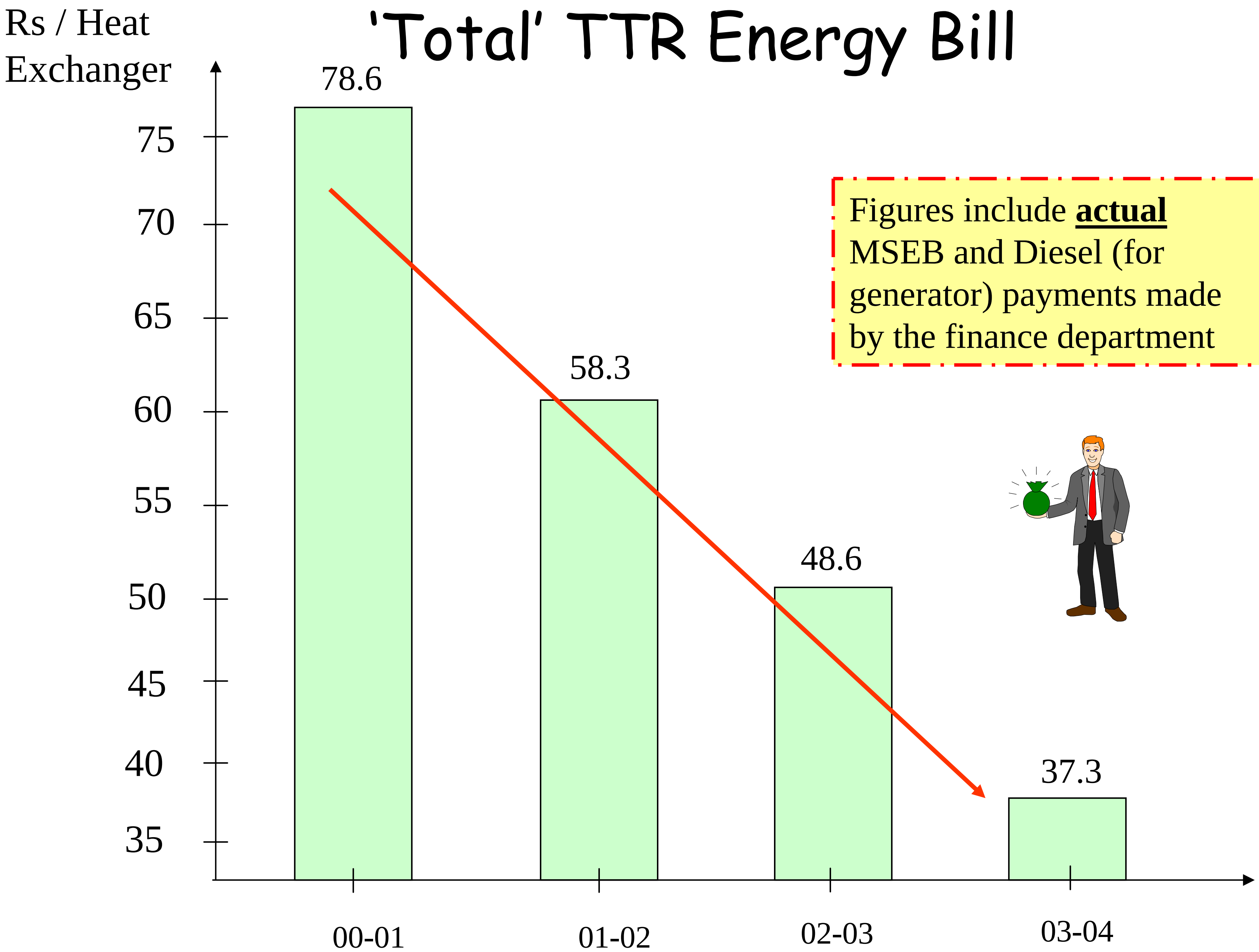
DESCRIPTION	UNIT	2001-2002	2002-2003	2003-2004
Annual Equivalent Vehicle production	Nos. in Lacs	2.07	3.31	5.13
Total Electrical Energy Consumption / annum	KWH in Lacs	22.94	32.6	44.8
KWH / Equivalent heat exchangers	KWH	11.08	9.82	8.73
Energy Cost / Eq. Heat Exchangers	Rs.	58.3	46.6	37.3

YEAR	Electricity		
	Consumption (KWH/Eq heat exchanger)	**% reduction**	Cost in Rs./ heat exchanger
2001-2002	11.08	10.36	58.3
2002-2003	9.82	11.38	48.6
2003-2004	8.73	11.10	37.3

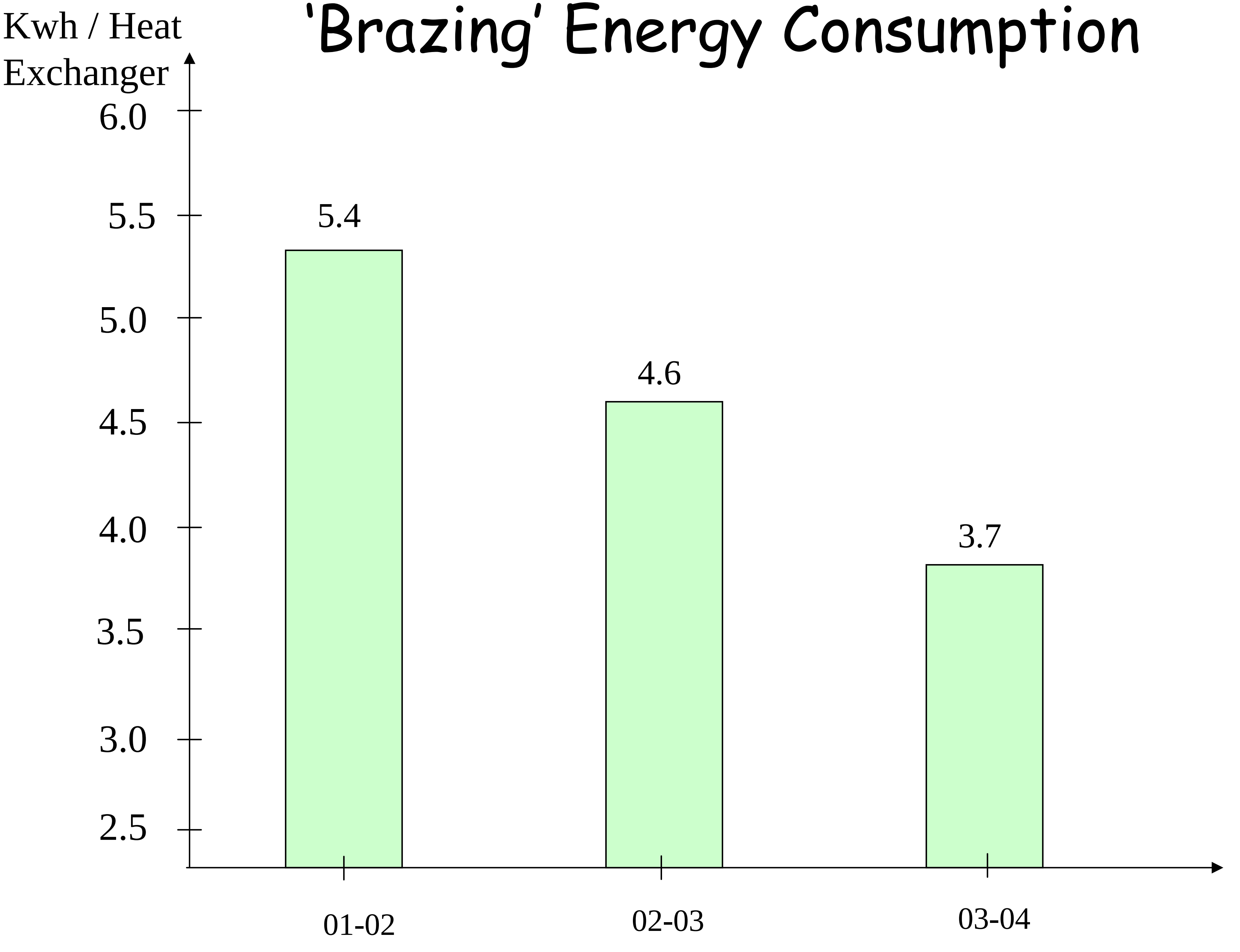
'Total' TTR Energy Consumption



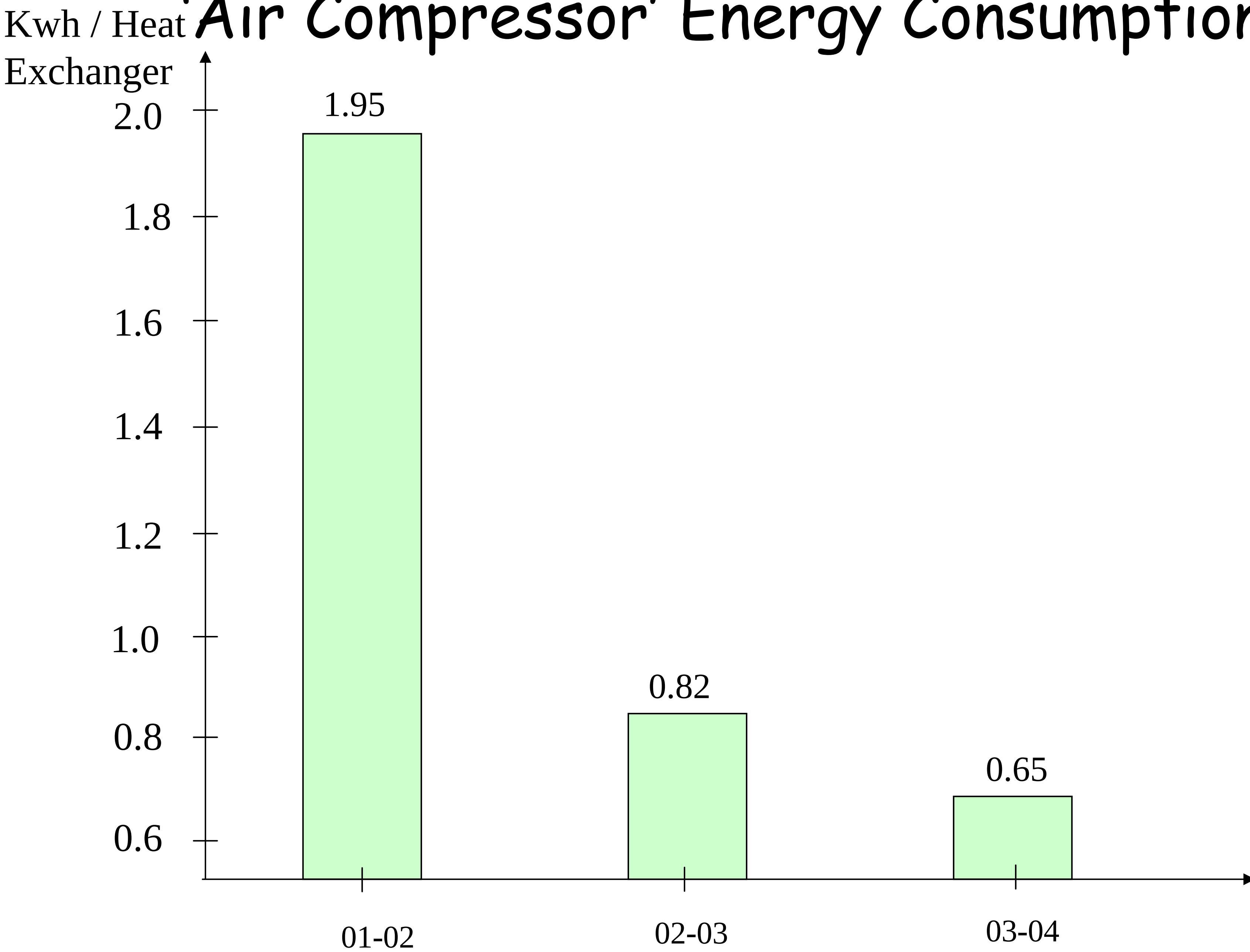
'Total' TTR Energy Bill



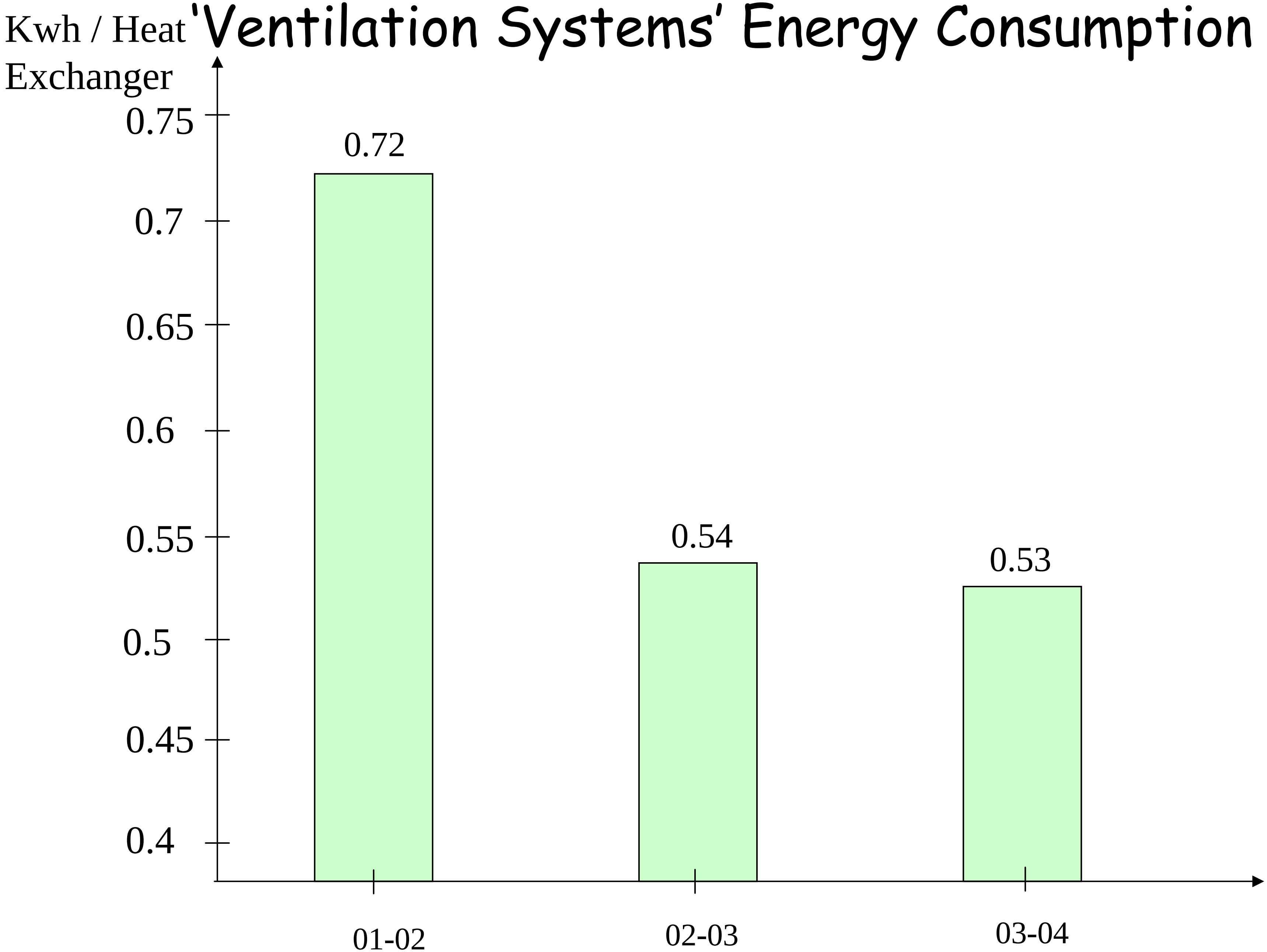
'Brazing' Energy Consumption



'Air Compressor' Energy Consumption



'Ventilation Systems' Energy Consumption



'Pump House' Energy Consumption