Power Generation

Power Quality Issues & Solution

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June 25, 2010




Flow of the presentation

- Company Overview
- Power Quality Issues present in Industry
- Solution to address Power Quality Issues
- Case Study
- List of Customers

Cummins Inc.

Engine Business | **Distribution Business**

Power Generation Business

Power Generation | Generator Technologies

Components Business

Emission Solutions | Filtration | Turbo Technologies | Fuel Systems

HQ in Columbus, Indiana since 1919

37,800 employees worldwide

R&D:$329 million

Cummins Business Services

Operations in 190 Countries

50 manufacturing locations

550 distributor locations

5,200 dealer locations

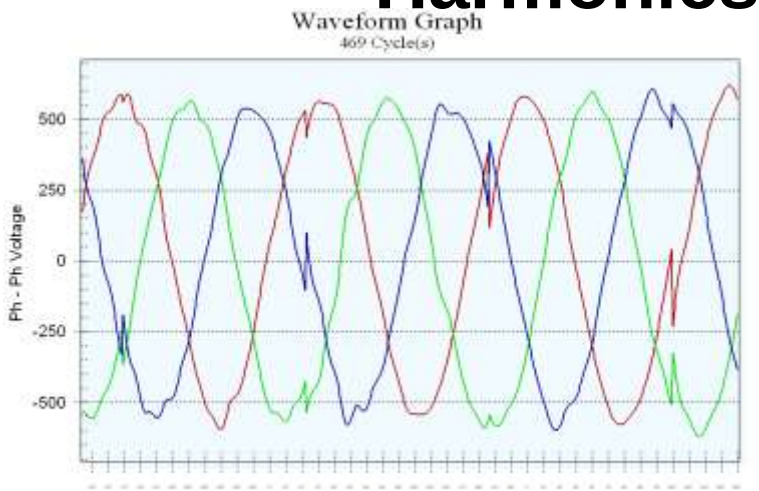
Making people's lives better by unleashing the Power of Cumm

Power Generation

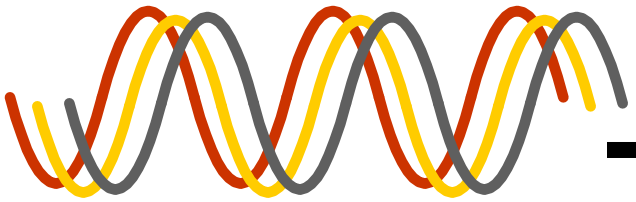
Power Quality issues present in the industry

- DG is oversized or undersized resulting in High Fuel Consumption or DG not taking load.
- Modernization of Industries brought in lot of Electronic Controls i.e Linear Loads to Non Linear Loads
- While they increase productivity it also brings with it increased Harmonic Levels.
- In order to maximize PF incentives, source side PF improvement is attempted through Fixed capacitors or APFC or slow response Thyristorized systems.

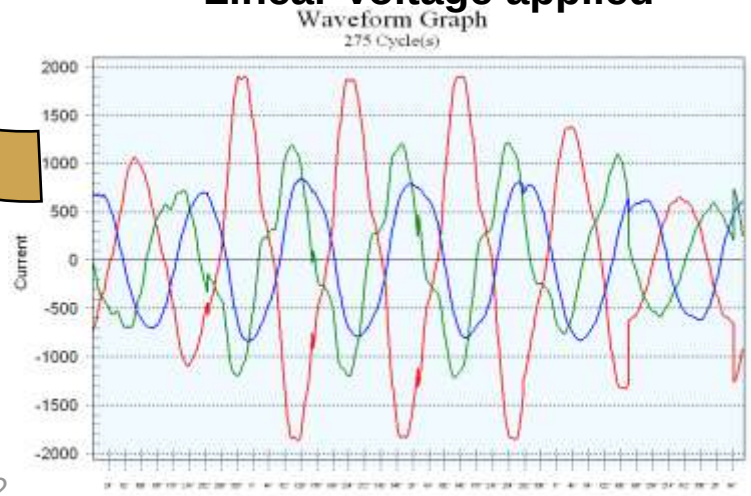
Harmonics Generation



Voltage to other circuits and the pollution circulates



Linear Voltage applied



Non Linear Load

Non Linear Loads draw non linear Current From a linear source

I Harmonic

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Power Quality issues present in the industry.. Continued

- While PF improvement devices maximize PF Incentive, PF under low load, fast changing loads, unbalanced loads were found either low lagging or leading.

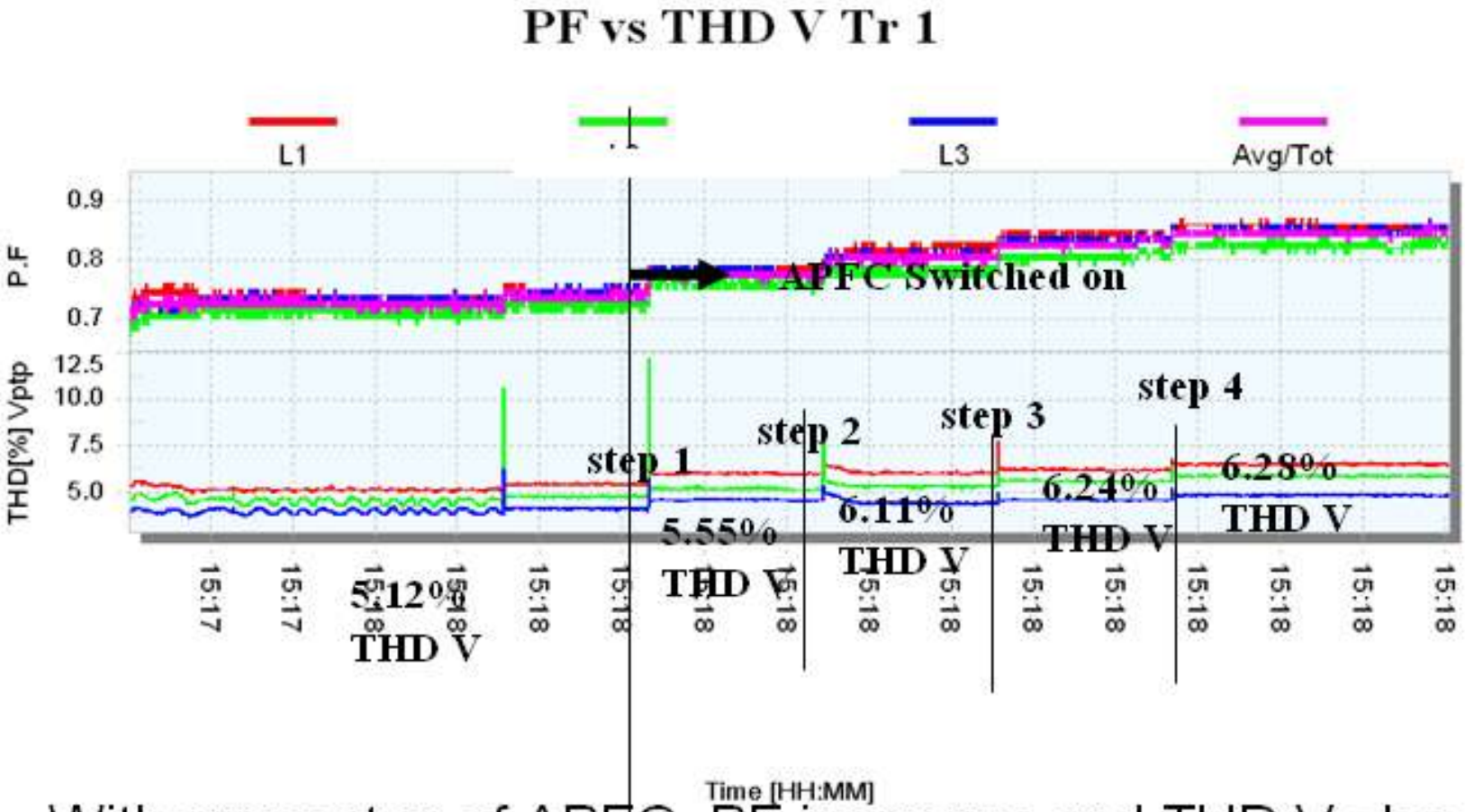
- In addition, improper method of capacitor switching is seen to generate Harmonics. We have case studies to support this.

- Predominant Harmonic orders are 3^{rd}, 5^{th} and 7^{th} . Rest of the harmonic orders are either absent or negligible. Treatment to these harmonic order will suffice to curtail THD levels.

Power Quality issues present in the industry.. Continued

- Unbalanced loading conditions are prevailing in the industry.
- We had noted that equally distributed single phase loads across three phases are not necessarily a balanced load.
- When one single phase load trips, the load becomes unbalanced calling for Unbalanced PF compensation. We have case studies supporting this.

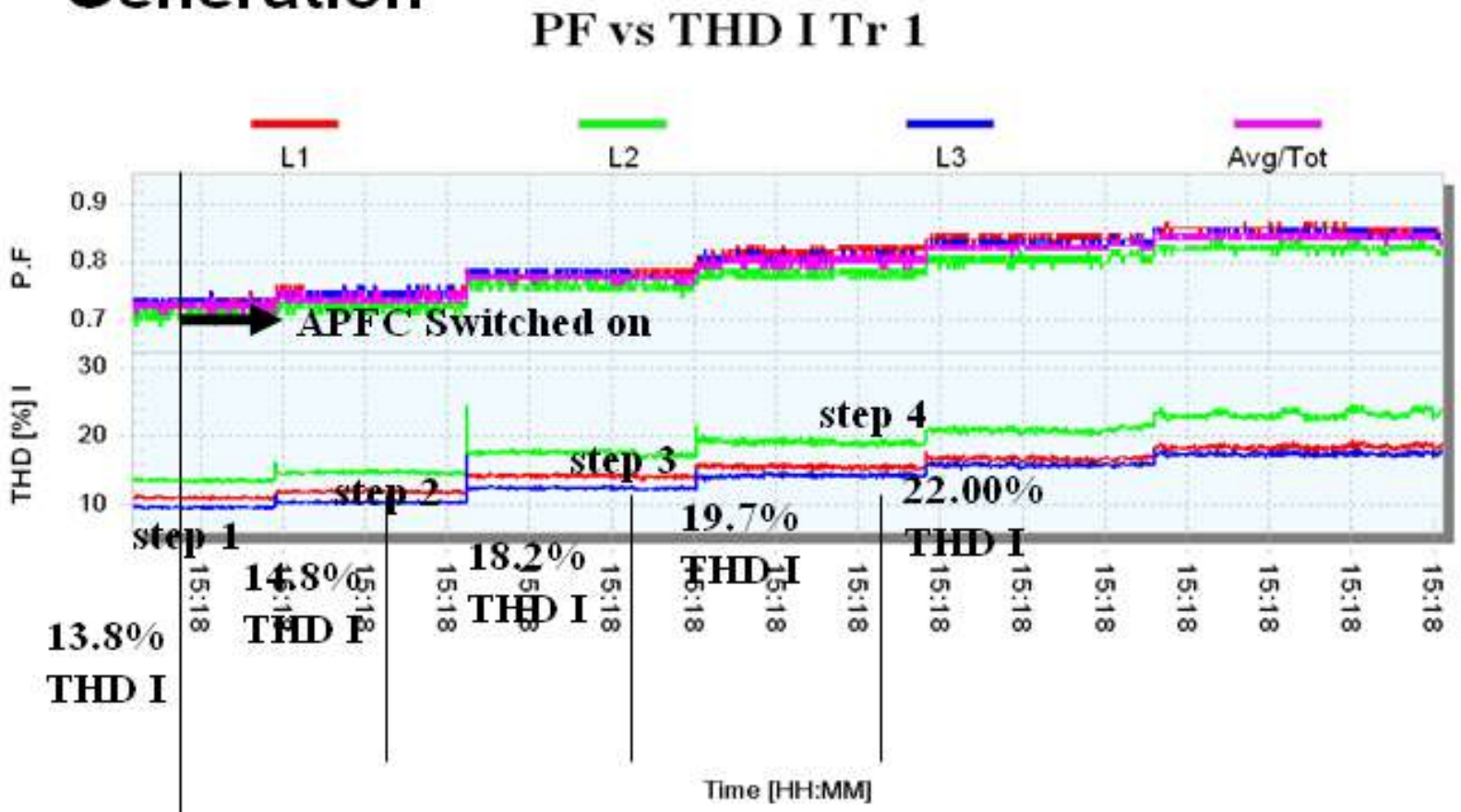
Impact of normal APFC & HARMONICS Generation



With every step of APFC, PF improves and THD V also increases.% THD V increased from 5.12% to 6.28 % on application of 200 kVAr Balanced APFC.

Power Generation

Impact of normal APFC & HARMONICS Generation



With every step of APFC, PF improves and THD I also increases. % THD I increased from 13.8% to 22% on application of 200 kVAr Balanced APFC.

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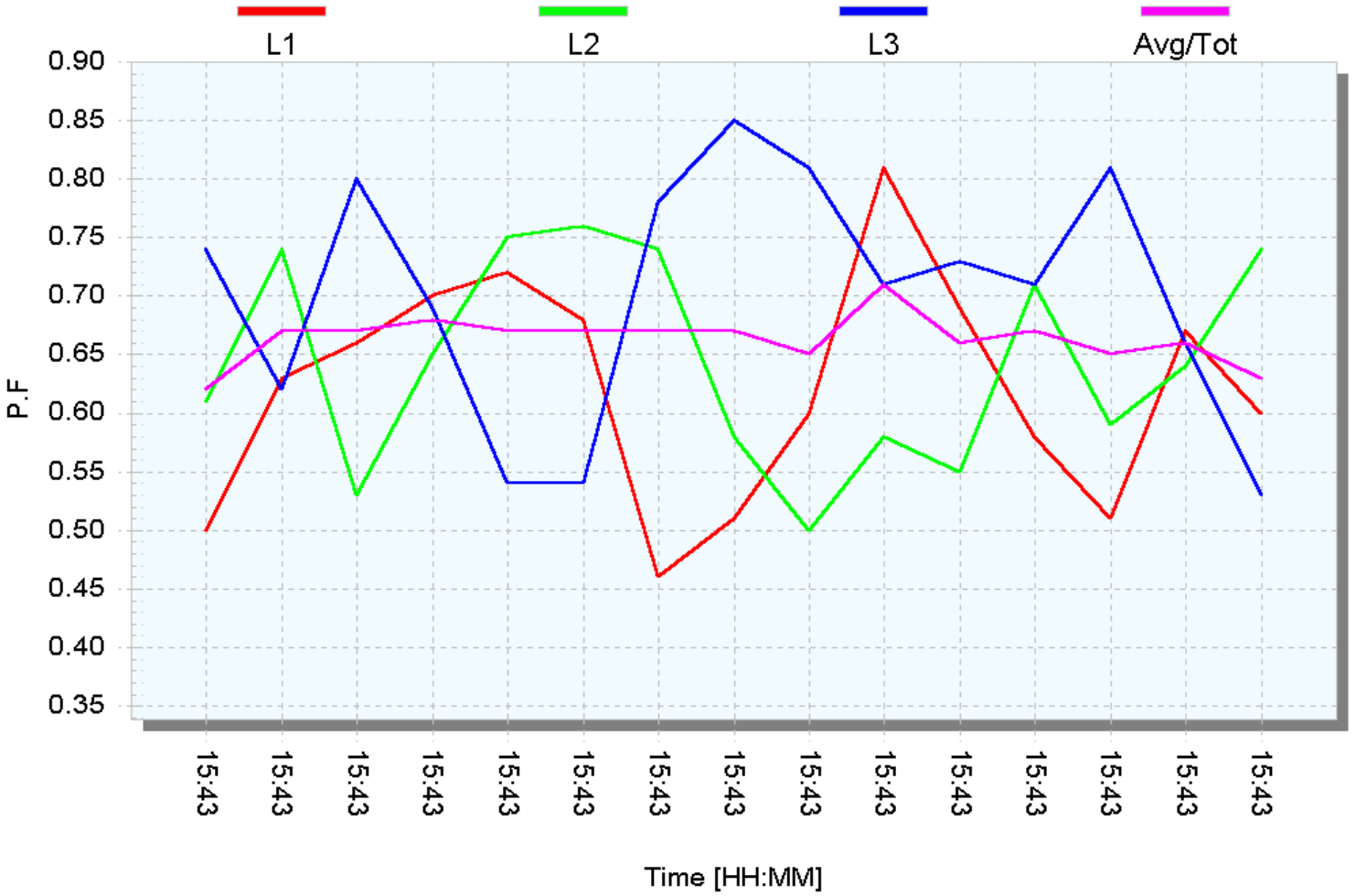
Power Quality issues present in the industry.. Continued

In effect, following are the effects of High Harmonics

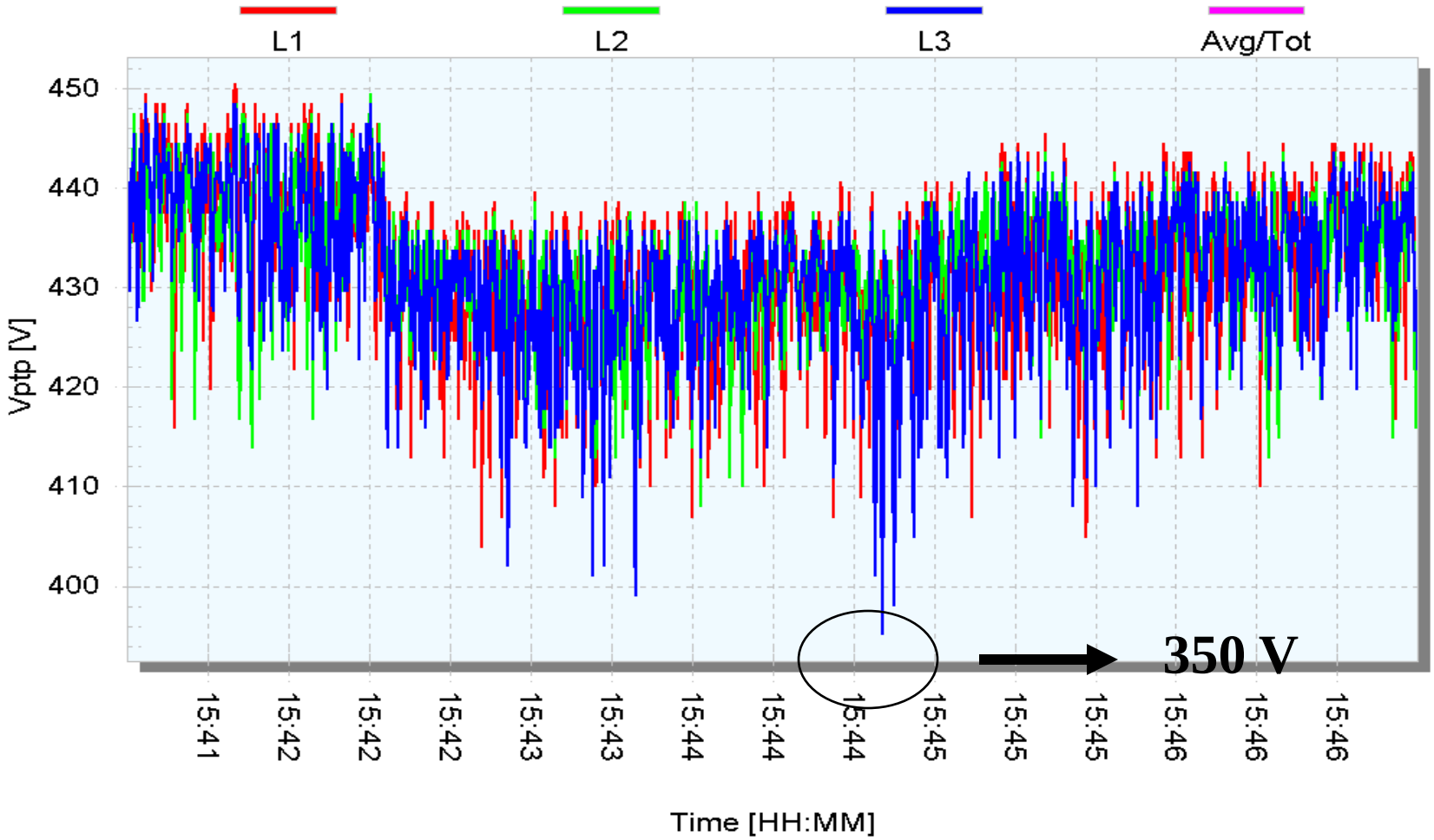
- Cable overheating in undersized cables.
- Cable line loss in oversized cables.
- Nuisance tripping of Breakers.
- Resonance blow up of Capacitors.
- Damage to Power Transformer.
- Malfunctioning of Electronic Controls and devices
- Transformer/motor heating, Iron Losses

Snapshots for Unbalanced Spot Welding



PF is unbalanced across all the three phases and changes in 20 ms.

Snapshot for Unbalanced Spot Welding



Impact of Unbalanced load even on an Infinite bus

Solution

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Solution

The Solution should provide

- ✓Cycle to Cycle Compensation In 20 milliseconds
- ✓Transient free switching,
- ✓Curtailing harmonics to desired levels
- ✓Compatible to run on both **DG and EB supply.**
- ✓Maintain Unity Power Factor under Unbalanced loading conditions

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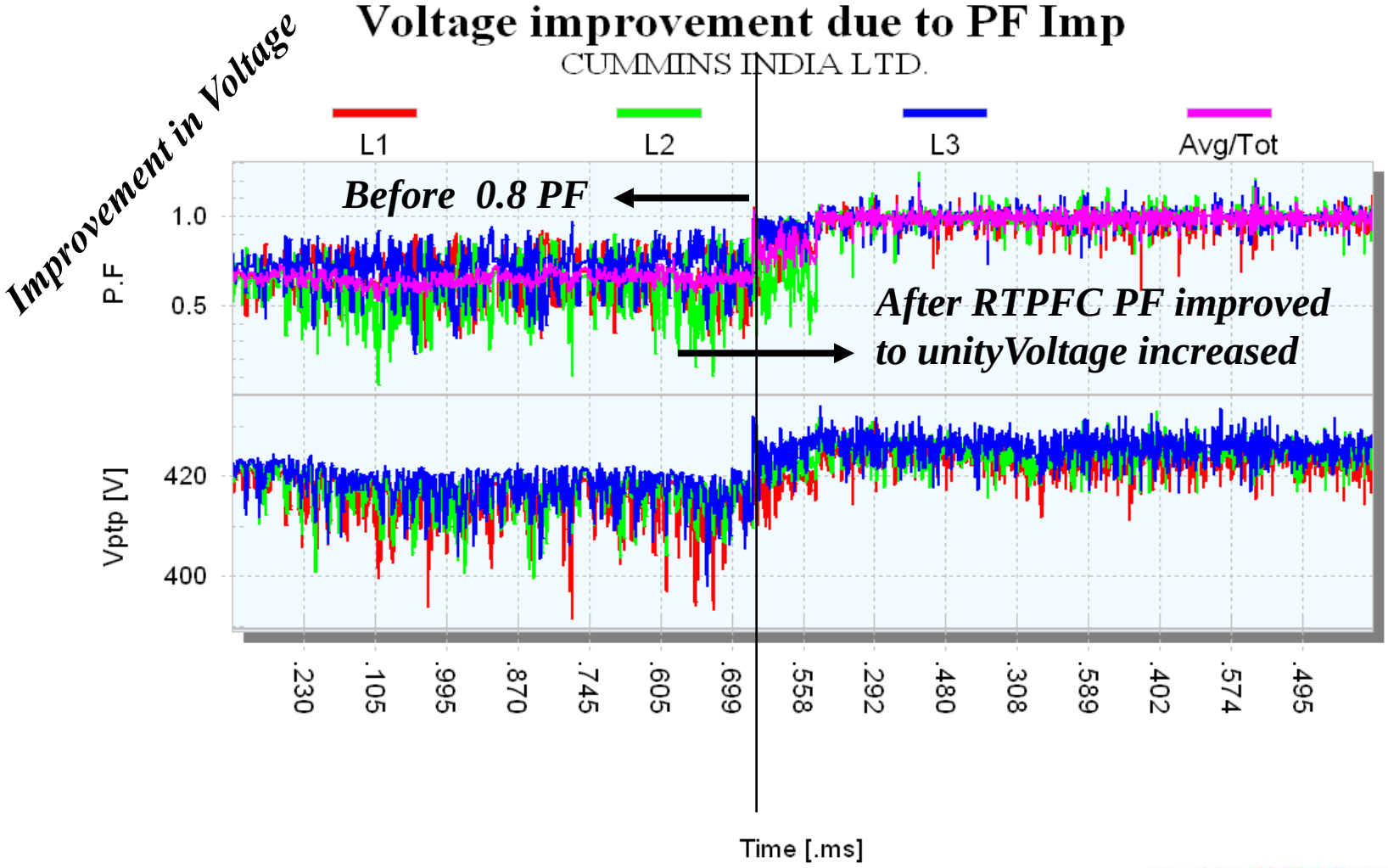
Solution

- ✓Transient-Free Solid-state Capacitors Switching
- ✓Energy Savings
- ✓Harmonic Filtration
- ✓Prevention of Voltage drops
- ✓Reduction of Voltage Flickering
- ✓Comprehensive Power Quality Analyzer
- ✓Self testing and comprehensive reporting fea e

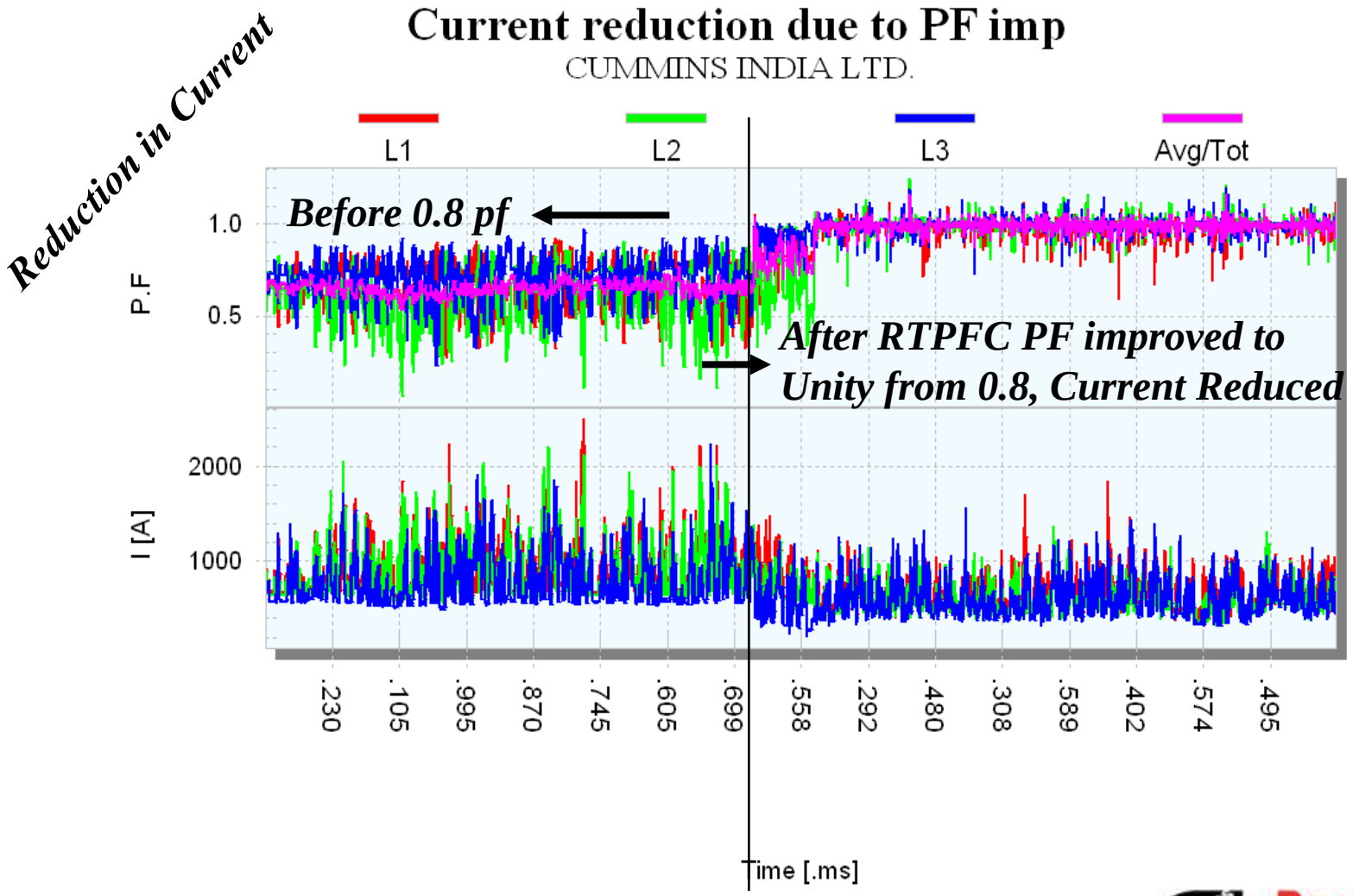
Standards & Quality Assurance

- Quality Assurance
  - ISO 9001 (The New Revision - 2000)
- EMC
  - EN 50081-2
  - EN 50082-2
  - EN 55011
  - EN 61000-4-2/3/4/5
  - ENV50204
  - ENV50141
- CE Mark
  - Low Voltage Directive 73/23/EEC am. 93/68
  - Machinery Directive 98/37/EC art. 4(2)
- Safety Standards
  - EN 61010-1
  - EN 60439-1
  - EN 60204
  - UL 508

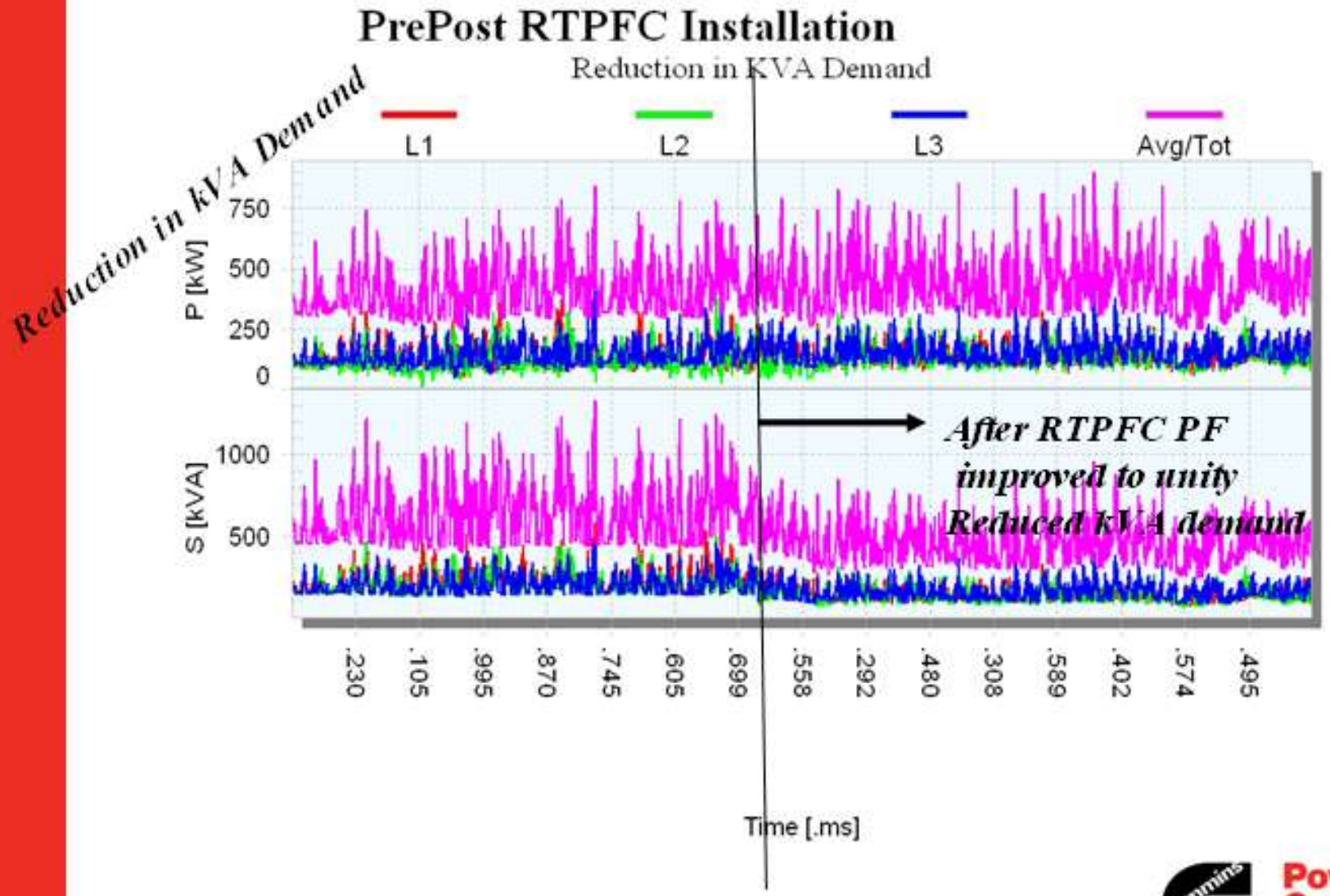
RTPFC Solution



RTPFC Solution



RTPFC Solution



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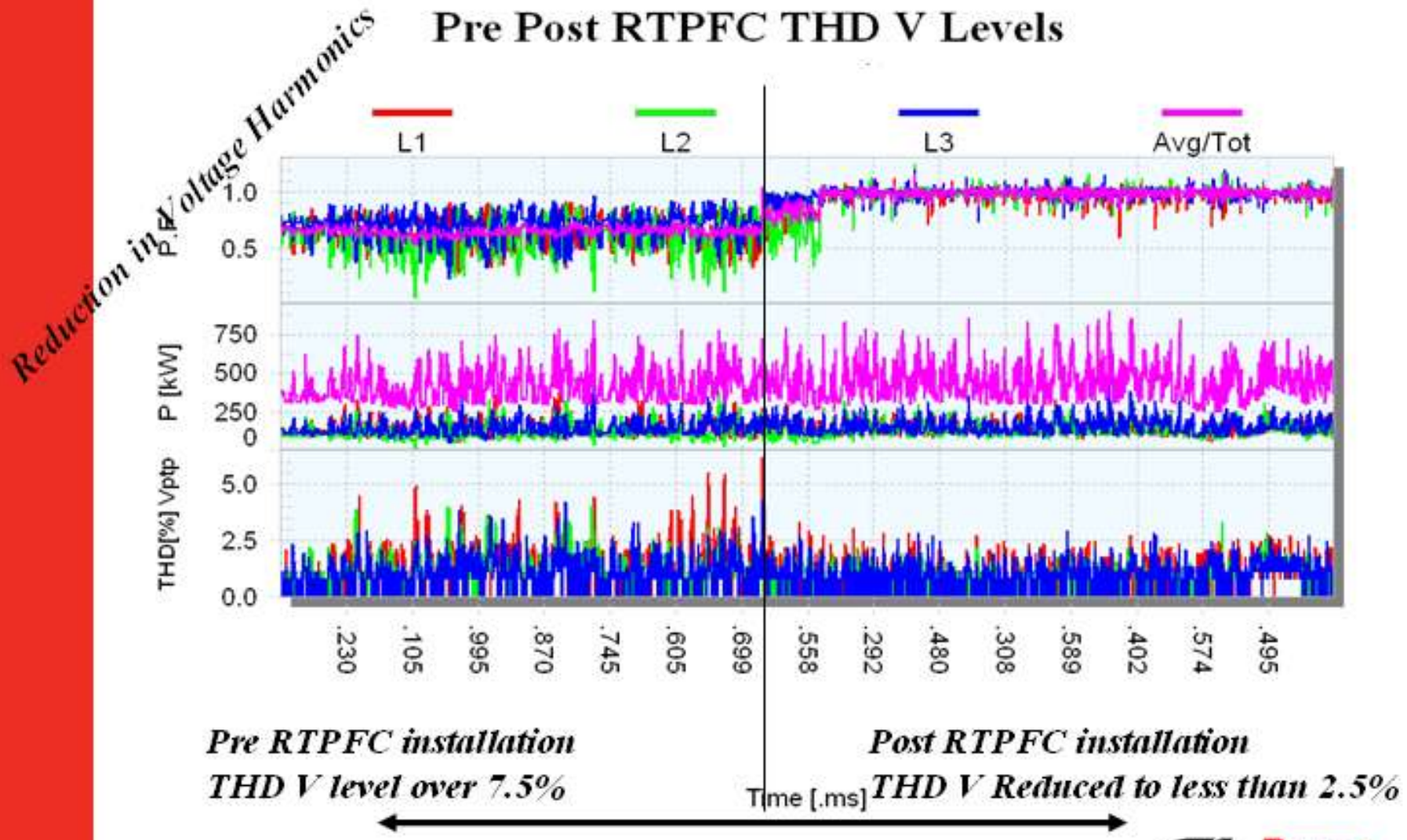
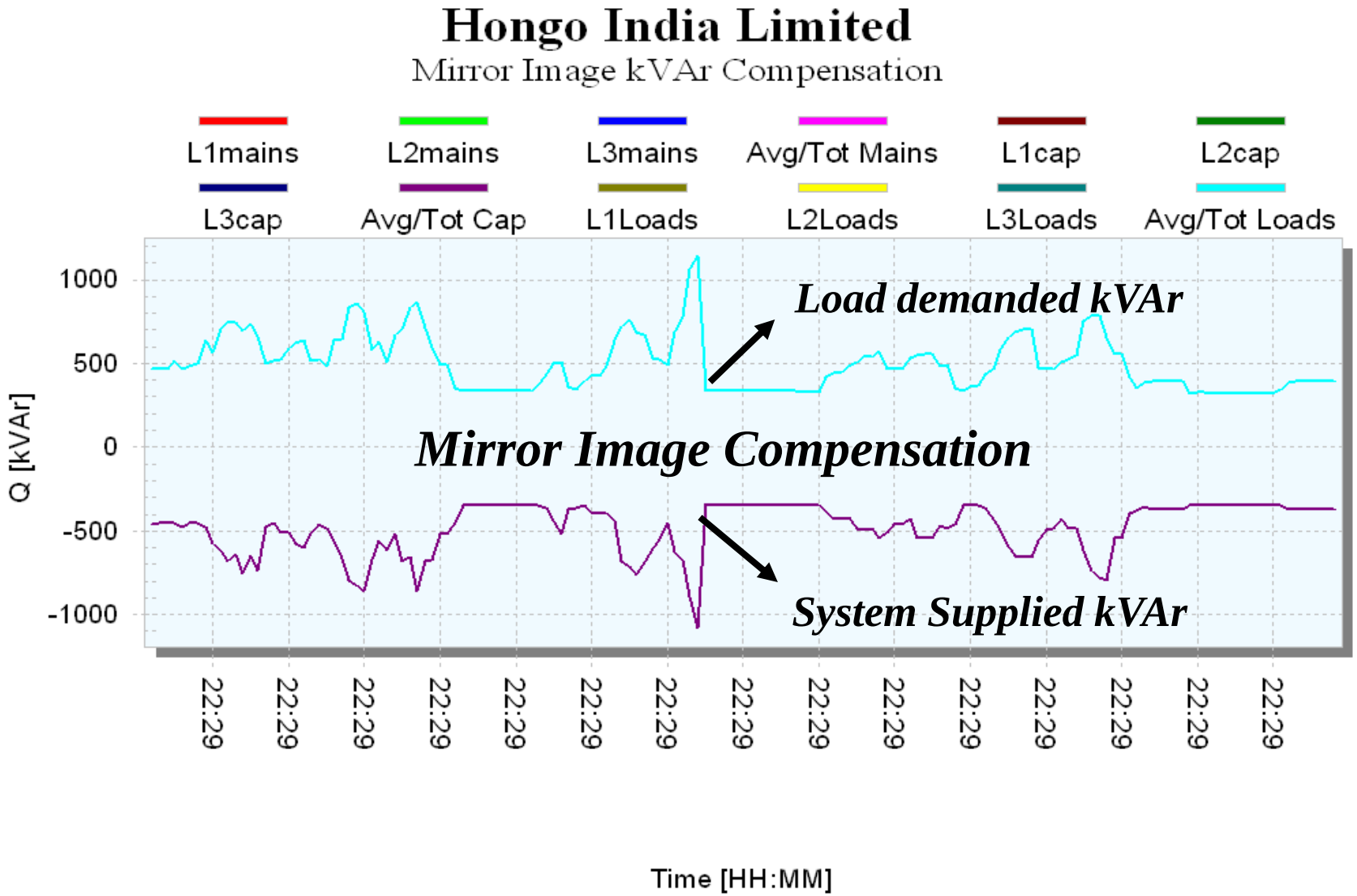
RTPFC Solution



Power Generation


Hongo India Limited
Mirror Image kVAr Compensation
L1mains
L2mains
L3mains
Avg/Tot Mains
L1cap
L2cap
L3cap
Avg/Tot Cap
L1Loads
L2Loads
L3Loads
Avg/Tot Loads
1000
500
0
-500
-1000
Q [kVAr]
Load demanded kVAr
Mirror Image Compensation
System Supplied kVAr
22:29
Time [HH:MM]

Case Study

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Methodology Followed

- Production and Energy Data received from Plant was analyzed using – CUSUM technique, a well established tool of Bureau of Energy Efficiency (BEE), India.

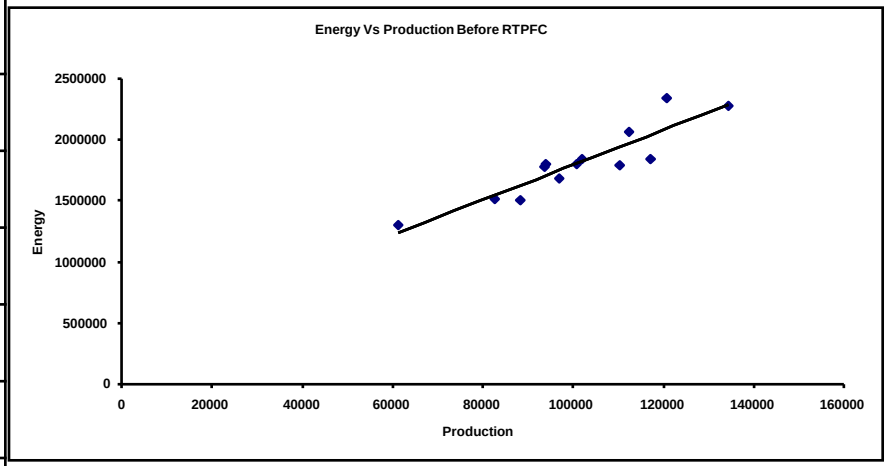
Executive Summary

- Total Savings in Energy post installation of RTPFC: 9%
- Energy Cost per Unit dropped by 7.37% per Unit even when:
  - Drop in Production Volume.
  - Increase in utilization of High cost energy DG
  - Increase in Diesel price
  - Drop in utilization of Low cost energy EB
- Other tangible benefits like Reduction in Cycle time, Welding rejections, welding machine downtime/uptime not accounted.

Analysis

Month	Prod	Eact
July06	61205	1303751
Aug-06	82655	1512340
Sep-06	110245	1795224
Oct-06	97020	1688488
NOV-06	117120	1843952
Dec-06	88330	1507272
Jan-07	134534	2276128
Feb-07	120788	2343806
Mar-07	112472	2065897
Apr-07	101865	1841640
May-07	100799	1799892
June-07	93969	1795969
July-07	93725	1777226

Energy Cost Vs Production figures for the period till installation of RTPFC was plotted in scatter plot and best fit line was drawn.



Equation for the line was derived as
Y(energy) =
14.271 x (Prod) + 368420

Analysis – Continued…

	Month	Eact	Ecal
Pre RTPFC	July06	1303751	1241877
	Aug-06	1512340	1547990
	Sep-06	1795224	1941726
	Oct-06	1688488	1752992
	NOV-06	1843952	2039840
	Dec-06	1507272	1628977
	Jan-07	2276128	2288355
	Feb-07	2343806	2092186
	Mar-07	2065897	1973508
	Apr-07	1841640	1822135
	May-07	1799892	1806923
	June-07	1795969	1709452
	July-07	1777226	1705969
Post RTPFC	Aug-07	1721564	1838804
	Sep-07	1453928	1696194
	Oct-07	1620710	1992117
	Nov-07	1503560	1672775
	Dec-07	989013	1205386
	Jan-08	1450791	1682651
	Feb-08	1479763	1606643
	Mar-08	1446009	1580099
	Apr-08	1461991	1535374
	May-08	1533731	1682351
	Jun-08	1702382	1841130
	Jul-08	1594907	1708866
	Aug-08	1765992	1710122
	Sep-08	1929941	1916281
	Oct-08	1414761	1468728
	Nov-08	1314192	1430639

Using the equation Y(energy) = 14.271x(Prod) +368420, Optimum energy cost (Ecalc) for the reported production levels was calculated.

Power Generation

Analysis – Continued…

Difference between actual energy cost and Calculated Energy cost month wise was arrived at

	Month	Eact	Ecal	Eac-Ecal
Pre RTPFC	July06	1303751	1241877	61874
	Aug-06	1512340	1547990	-35650
	Sep-06	1795224	1941726	-146502
	Oct-06	1688488	1752992	-64504
	NOV-06	1843952	2039840	-195888
	Dec-06	1507272	1628977	-121705
	Jan-07	2276128	2288355	-12226
	Feb-07	2343806	2092186	251620
	Mar-07	2065897	1973508	92389
	Apr-07	1841640	1822135	19504
	May-07	1799892	1806923	-7030
	June-07	1795969	1709452	86517
	July-07	1777226	1705969	71256
Post RTPFC	Aug-07	1721564	1838804	-117240
	Sep-07	1453928	1696194	-242266
	Oct-07	1620710	1992117	-371407
	Nov-07	1503560	1672775	-169215
	Dec-07	989013	1205386	-216373
	Jan-08	1450791	1682651	-231860
	Feb-08	1479763	1606643	-126881
	Mar-08	1446009	1580099	-134090
	Apr-08	1461991	1535374	-73383
	May-08	1533731	1682351	-148620
	Jun-08	1702382	1841130	-138748
	Jul-08	1594907	1708866	-113960
	Aug-08	1765992	1710122	55870
	Sep-08	1929941	1916281	13660
	Oct-08	1414761	1468728	-53967
	Nov-08	1314192	1430639	-116447

Analysis – Continued…

Month wise Cumulative Sum of Energy Savings is then arrived at

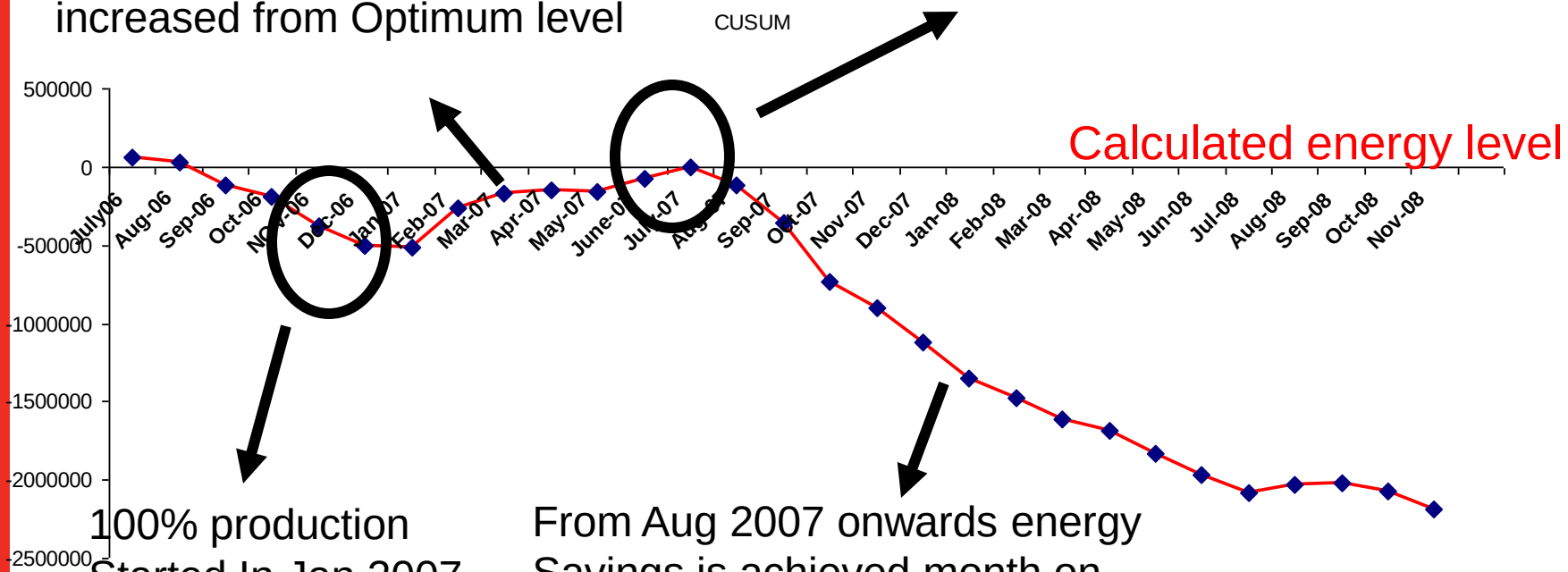
	Month	Eact	Ecal	Eac-Ecal	CUSUM
Pre RTPFC	July06	1303751	1241877	61874	61874
	Aug-06	1512340	1547990	-35650	26224
	Sep-06	1795224	1941726	-146502	-120278
	Oct-06	1688488	1752992	-64504	-184782
	NOV-06	1843952	2039840	-195888	-380670
	Dec-06	1507272	1628977	-121705	-502375
	Jan-07	2276128	2288355	-12226	-514602
	Feb-07	2343806	2092186	251620	-262981
	Mar-07	2065897	1973508	92389	-170593
	Apr-07	1841640	1822135	19504	-151088
	May-07	1799892	1806923	-7030	-158119
	June-07	1795969	1709452	86517	-71602
	July-07	1777226	1705969	71256	-345
Post RTPFC	Aug-07	1721564	1838804	-117240	-117585
	Sep-07	1453928	1696194	-242266	-359850
	Oct-07	1620710	1992117	-371407	-731258
	Nov-07	1503560	1672775	-169215	-900473
	Dec-07	989013	1205386	-216373	-1116846
	Jan-08	1450791	1682651	-231860	-1348706
	Feb-08	1479763	1606643	-126881	-1475586
	Mar-08	1446009	1580099	-134090	-1609676
	Apr-08	1461991	1535374	-73383	-1683060
	May-08	1533731	1682351	-148620	-1831680
	Jun-08	1702382	1841130	-138748	-1970428
	Jul-08	1594907	1708866	-113960	-2084388
	Aug-08	1765992	1710122	55870	-2028518
	Sep-08	1929941	1916281	13660	-2014858
	Oct-08	1414761	1468728	-53967	-2068826
	Nov-08	1314192	1430639	-116447	-2185273

Analysis - Continued

Month wise Cumulative Sum (CUSUM) was plotted in a graph

From Jan 2007 energy consumption increased from Optimum level

RTPFC installed in July 2007



100% production Started In Jan 2007

From Aug 2007 onwards energy Savings is achieved month on month

We will quantify energy saved in the next slide

Power Generation

Analysis - Continued

Month	Eac-Ecal
Aug-07	-117240
Sep-07	-242266
Oct-07	-371407
Nov-07	-169215
Dec-07	-216373
Jan-08	-231860
Feb-08	-126881
Mar-08	-134090
Apr-08	-73383
May-08	-148620
Jun-08	-138748
Jul-08	-113960
Aug-08	55870
Sep-08	13660
Oct-08	-53967
Nov-08	-116447
	-2184928

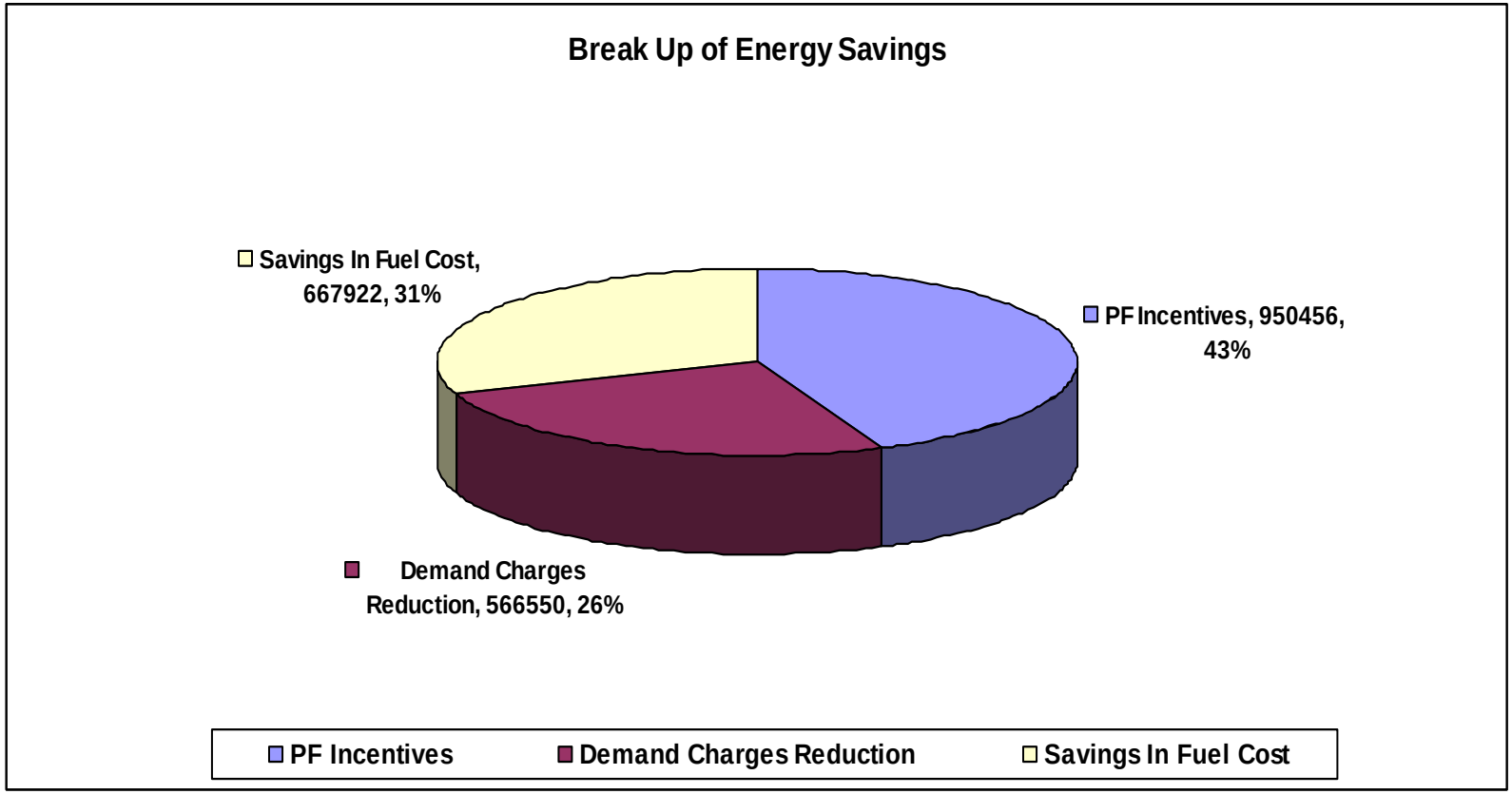
Energy saved Since installation of RTPFC, on account of

1. PF incentive
2. Diesel Savings
3. Demand Reduction
4. kWhr Energy

Break up details in next slide

Power Generation

Break Up of Energy Savings



Adverse Factors

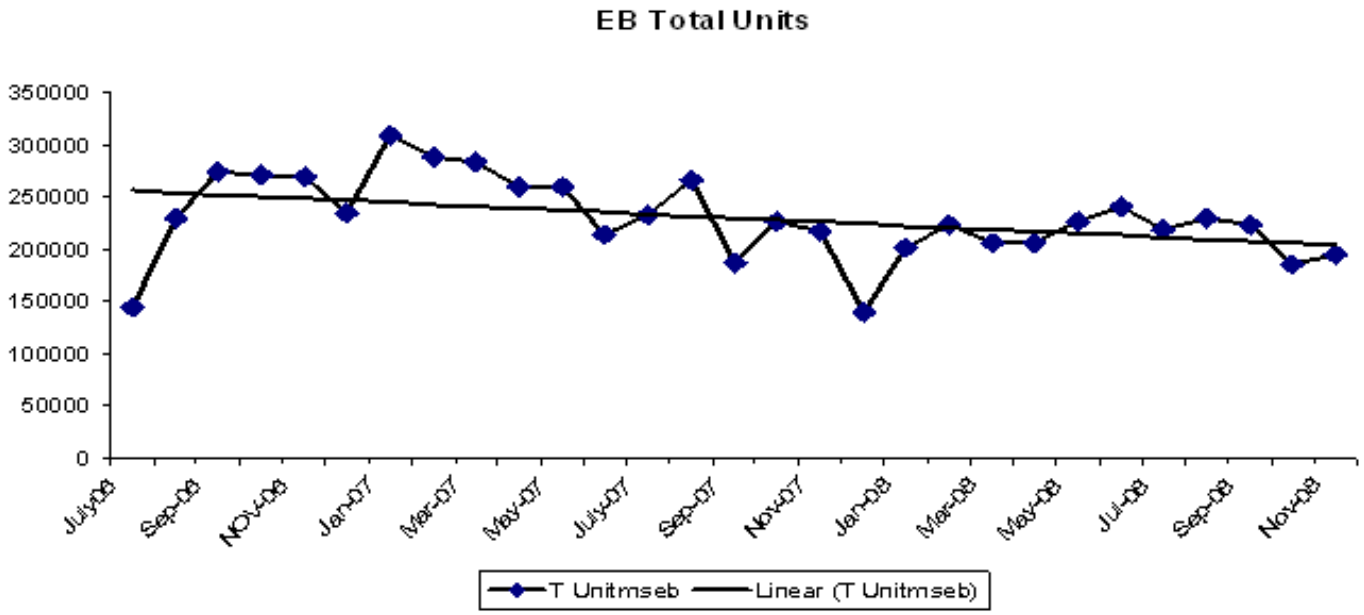
- The savings could have been more, however, following factors contributed to restrict it.

- EB Charges kVA demand on last 11 months average and not on actual recorded in a month. Despite of reduction of the demand to 600 kVA level, customer had to pay for 855 kVA to EB, almost for 8 months.

- The production dipped from an average 1L Units per month to about 85000 per month and was expected to reduce further.

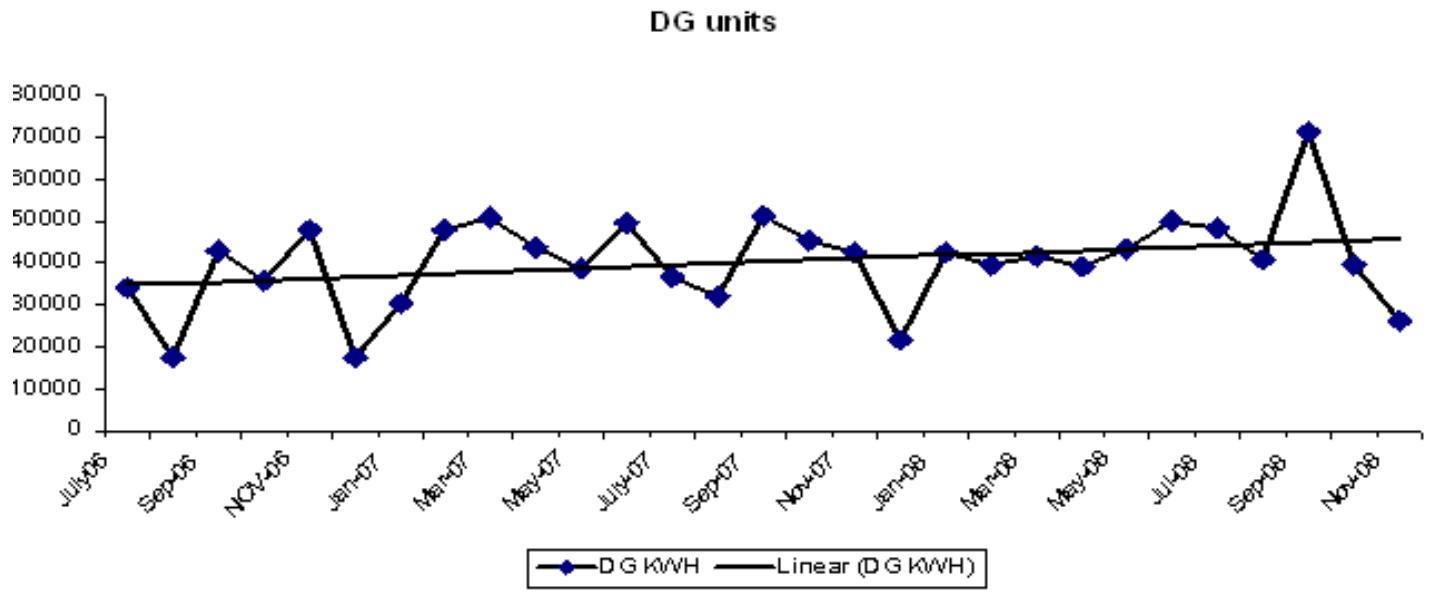
- EB energy utilization reduced, while DG utilization increased. Details in next two slides.

EB Power Utilization



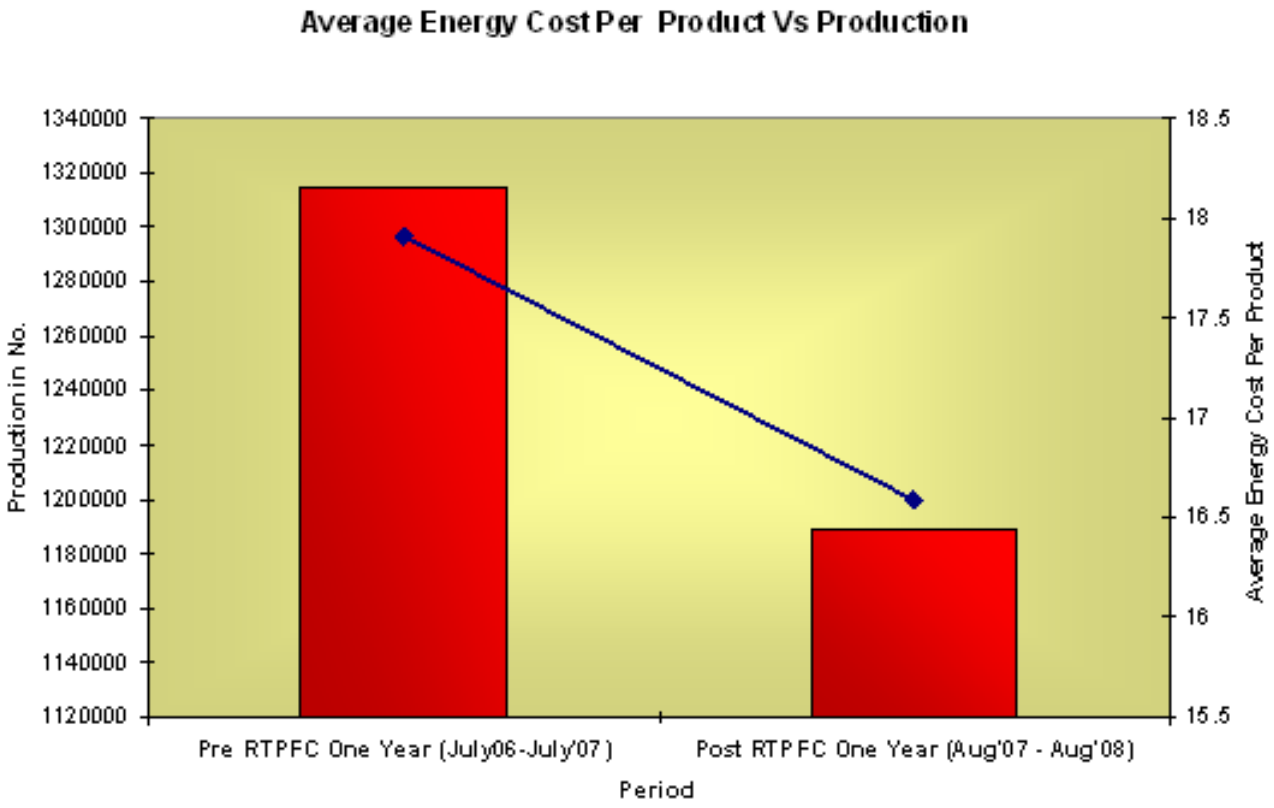
Post installation of RTPFC, usage of EB Power which is cheaper on per unit charges, decreased due to poor availability of Power from EB. This has impacted the energy cost per Unit adversely.

DG Utilization



Post installation of RTPFC, due to poor power availability from EB, DG utilization increased. With diesel cost rising, it must have adversely affected the Energy Cost / Unit due to very high charges per unit power.

Reduction in Energy Cost (EB + DG)/Unit



Despite of adverse factors mentioned earlier, the average Energy Cost (EB+DG) per Unit has reduced by 7.37% due to RTPFC installation.

Post RTPFC Installation in Honda Siel Cars

POST IMPLEMENTATION OF PHASE II

Case Study From : M/s Honda Siel Cars India Ltd.

- We could now run our weld shop on 2x 2000 kVA DG sets in isolate mode.
- Production losses are minimized to a greater extent during state power outage.
- In addition, we could maintain our power factor close to unity at our State Power Transformer End.

Resulting in Production output increase by 6-8%
i.e. 4800 car / year could be produced additionally in the absence of State Electricity Supply

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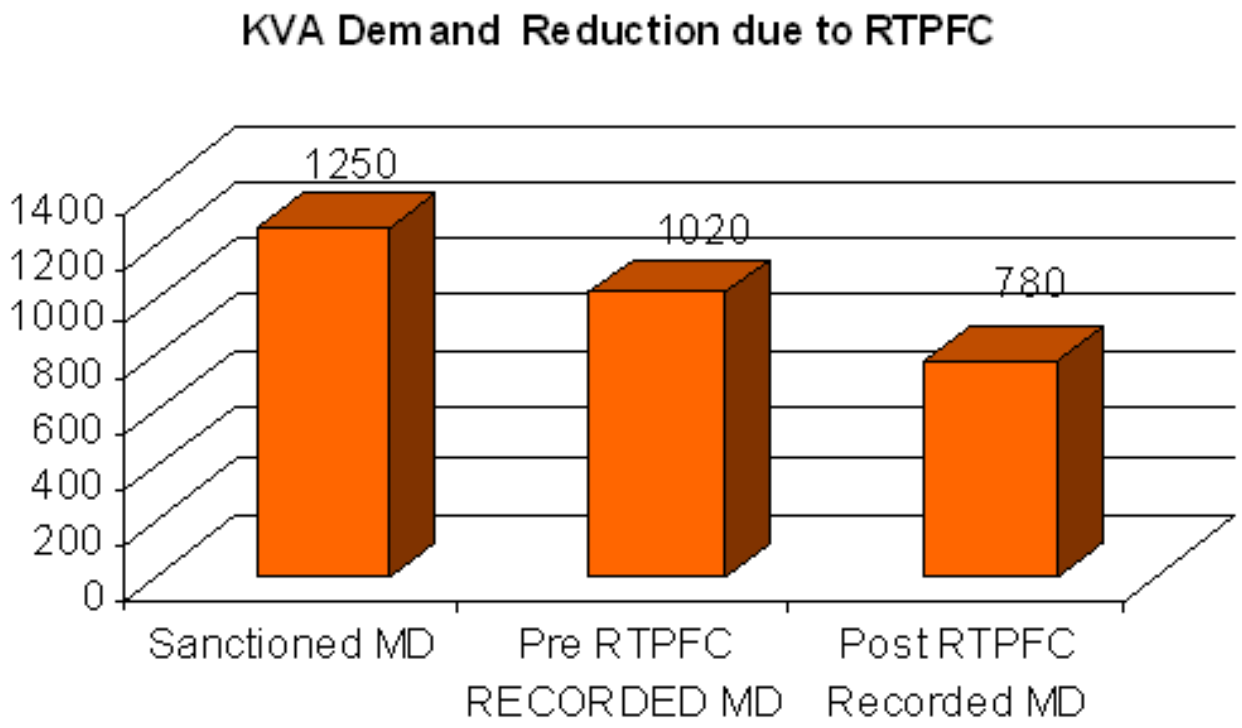
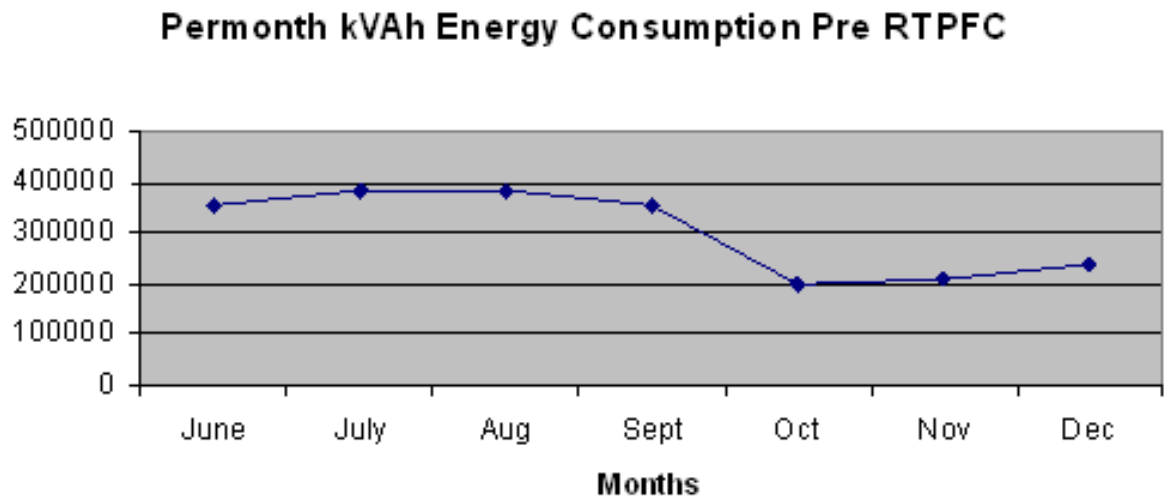
Reduction in Energy Consumption (kVAh) - Hongo



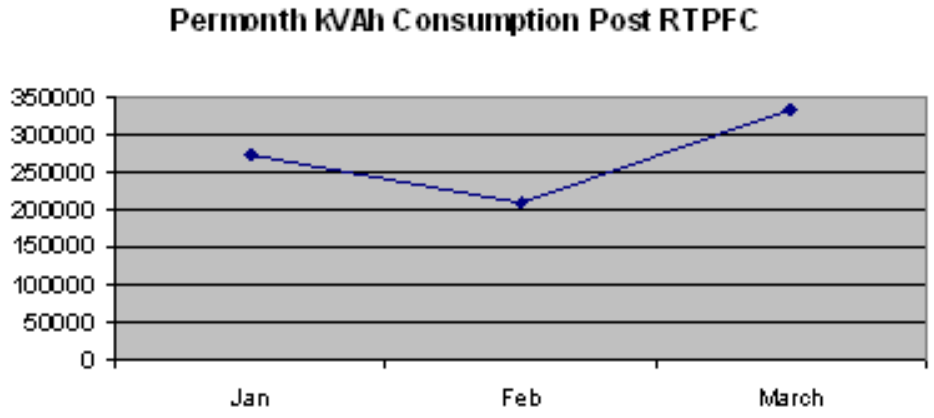
Saving Rs 45000 per month on account of Reduction in kVA demand. Hongo has used this Reduction in demand to meet our expansion load

Reduction in Energy Consumption (kVAh) - Hongo



45% of total Energy post use of RTPFC

Average kVAh Reduction of 31310 units per month.
10.3 % Energy Cost Reduction .



SOURCE AND LOAD SHOULD WORK IN HARMONY….

Load

EB/DG

EB/DG

Load

….POWER QUALITY ASSESSMENT AND CORRECTION ENSURES THIS OBJECTIVE.

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Our Esteemed Customers

Power Generation

Our Esteemed Customers

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Thank you

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