R070631-01PT
Jaguar Cars
(Whitley)

Preface

The following report details the compressed air audit conducted at Jaguar, site from 16:44:41 on the 7th of January through to 15:58:11 on the 22nd of January 2004 (a total audit of 359.2 continuous hours), and compares the original results to the existing installation after the recommended changes of new compressors in conjunction with an intelligent control and monitoring system were installed. The current audit data was downloaded from the embedded memory contained within the control and monitoring system and contains information from 00:00:00 on the 18th of July through to 08:56:00 on the 25th of July 2006 (a continuous audit of 176.9 hours).

The electrical tariff has been adjusted on the original data to today's rate of £0.075/KW/HR for direct comparison.

The original audit was carried out with the installation of calibrated auditing equipment to facilitate data logging via an industrial PC at a log rate of 5 seconds per channel (System note: LB34/LEM500AMP x 3, – current sensors/CMC 0-16bar, 4-20mAmp – pressure sensors) provided raw data to an analysis software package. Within this software package, the raw data was configured against the measured power and output performance for each air compressor and the cost of energy on site over a 24-hour cycle.

Through this audit we were able to establish existing system performance, identifying opportunities where significant improvements into system efficiency can be effected. The subsequent audit enables us to show by comparison the effectiveness of the changes implemented

Site Data

Company: Jaguar Cars
Address: Coventry

Contact: Mr Mick Satchwell

Original equipment audited: Compressor 1 – Bellis & Morcom VH28N
Compressor 2 - Bellis & Morcom VH28N
Compressor 3 – Bellis & Morcom VH28N

Current equipment audited: Compressor 1 – CompAir L37-7.5bar
Compressor 2 - CompAir L37-7.5bar
Compressor 3 – CompAir L45SR

Original compressor reference data:

Bellis & Morcom VH28N
Output 1000cfm (28.32m³/min)
Pressure 7.0 bar g
T.P.I.P. 172kW (fully loaded)

Current compressor reference data:

CompAir L37-7.5bar
Output 203cfm (5.75m³/min)
Pressure 7.5 bar g
T.P.I.P. 37kW (fully loaded)

CompAir L37-7.5bar
Output 56cfm t0 280cfm (1.59 to 7.93m³/min)
Pressure 7.5 bar g
T.P.I.P. 9kW (min speed) to 45kW (fully loaded)

Site electrical cost data:

£0.075/KW/HR

Original site statistical review

Topic	Running	Loaded	Unloaded
Compressor 1 (3)	99.91%	39.05%	60.95%
Compressor 2	0.00%	0.00%	0.00%

In order to satisfy demand on the original audit, only one compressor has been utilised during the period of the audit. (see Figure 1 – Capacity total).

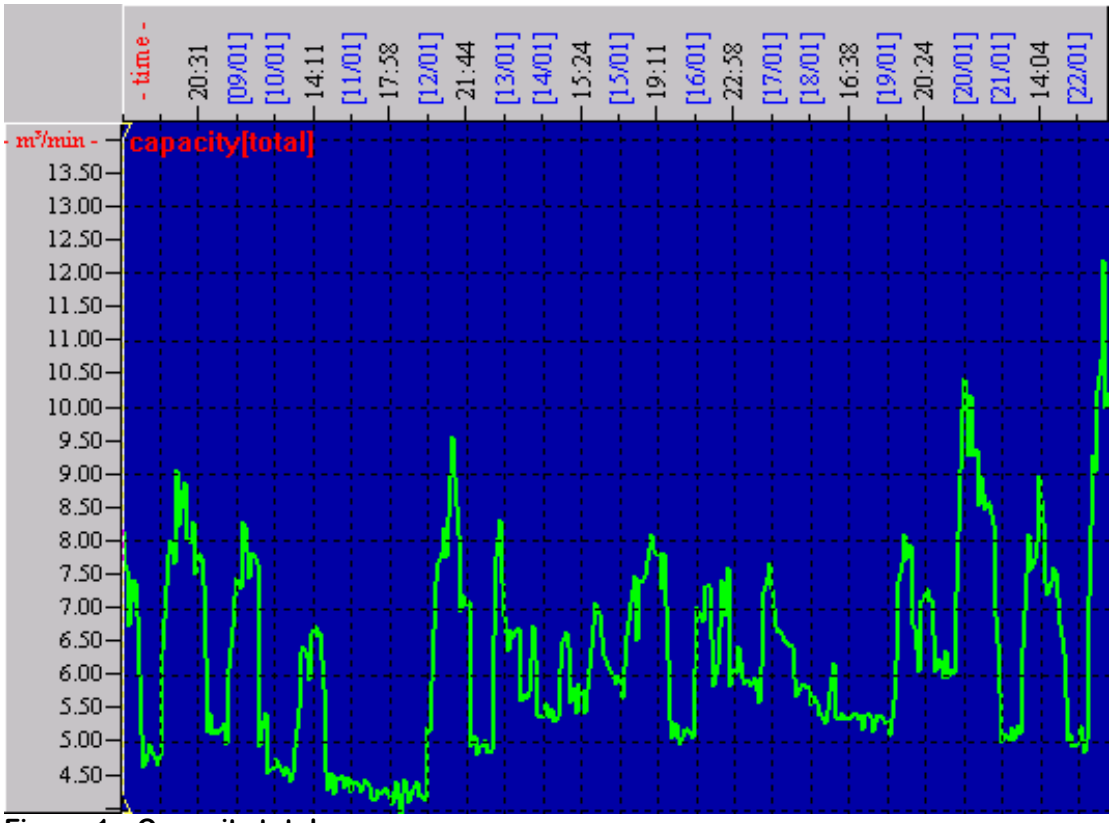


Figure 1 – Capacity total

Current site statistical review

Topic	Running	Loaded	Unloaded
Compressor 1	15.30%	99.00%	1.00%
Compressor 2	28.67%	99.25%	0.75%
Compressor 3	100.00%	99.90%	0.10%

In order to satisfy demand on the current audit, all three compressors have been utilised during the period of the audit. (see Figure 2 – Capacity total).

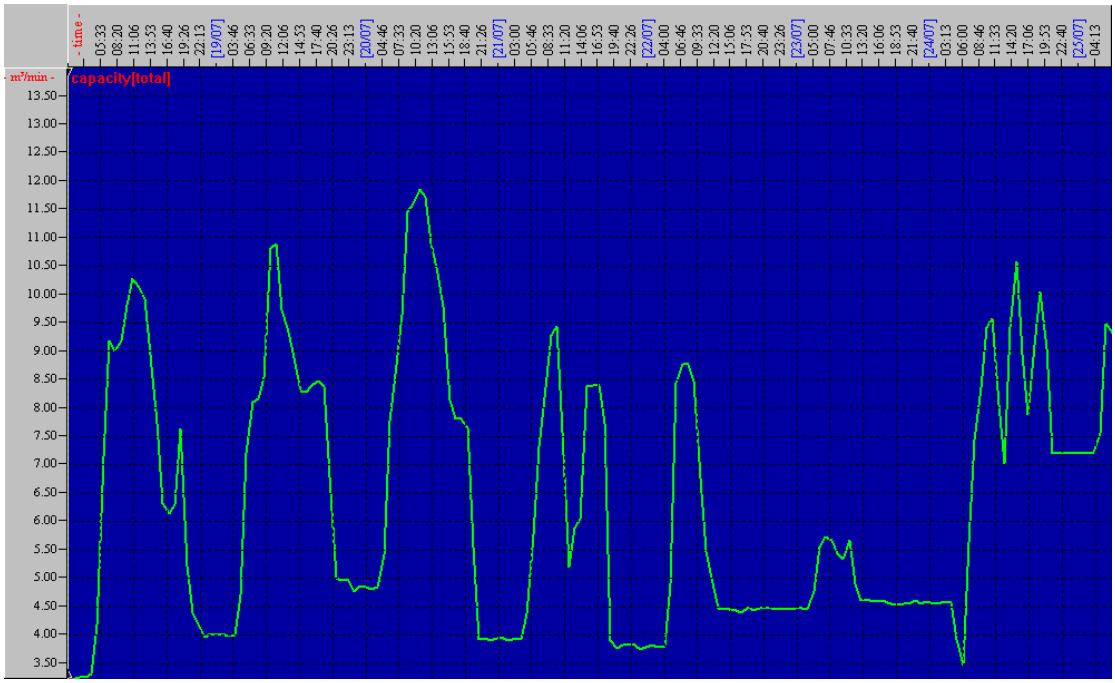


Figure 2 – Capacity total

In summary on the original audit compressor 3 (Jaguar compressor number) which due to the audit measurement configuration shows as compressor 1 has ½ loaded using the central cascade three step pressure switches to match factory demand. In the current audit all three compressors have been used to match the factory demand, which from comparison of the two capacity graphs is largely unchanged from the original audit. The compressors are now controlled and loaded by the intelligent control system installed with the new compressors.

Original Audit

Topic	**Total**
Input	**36602.40kW hours**
Output	**135510.06m³**
Operational time	**359.2 hours**
Productive input (energy)	**52.42%**
Non-productive input (energy)	**47.58%**
Efficiency	**16.21kW/m³/min**
Cost efficiency	**£0.0166/m³**
Total cost of energy (logged period)	**£2745.17**

Original Audit

Topic	**Total**
Input	**7584.99kW hours**
Output	**67389.22m³**
Operational time	**176.9 hours**
Productive input (energy)	**99.93%**
Non-productive input (energy)	**0.07%**
Efficiency	**6.75kW/m³/min**
Cost efficiency	**£0.0084/m³**
Total cost of energy (logged period)	**£568.87**

System performance review

Original compressor utilisation

Of the total energy consumed by each compressor, 47.58% of this energy was 'non-productive'. That is, compressors were rotating but not compressing air.

An extract from a current data file (in this case, Compressor 1) (Figure 3 – measured current data) shows the effect of compressors rotating but not compressing air. Here as with all compressors in the system audit carried out at Jaguar, the compressor ½ loads as a result of decay in pressure. Loading at the beginning of the green (productive) area on the current graph, building up to pressure at the green area peak and off loading where current begins to fall (yellow – non productive energy).

When decay in pressure is detected once more, the compressor loads again.

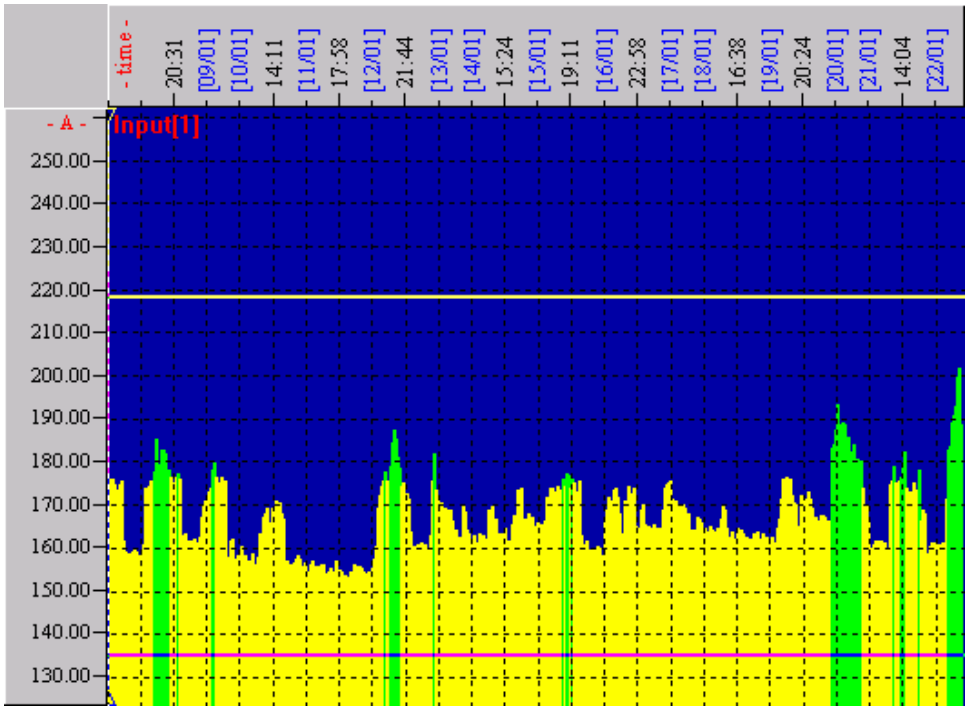
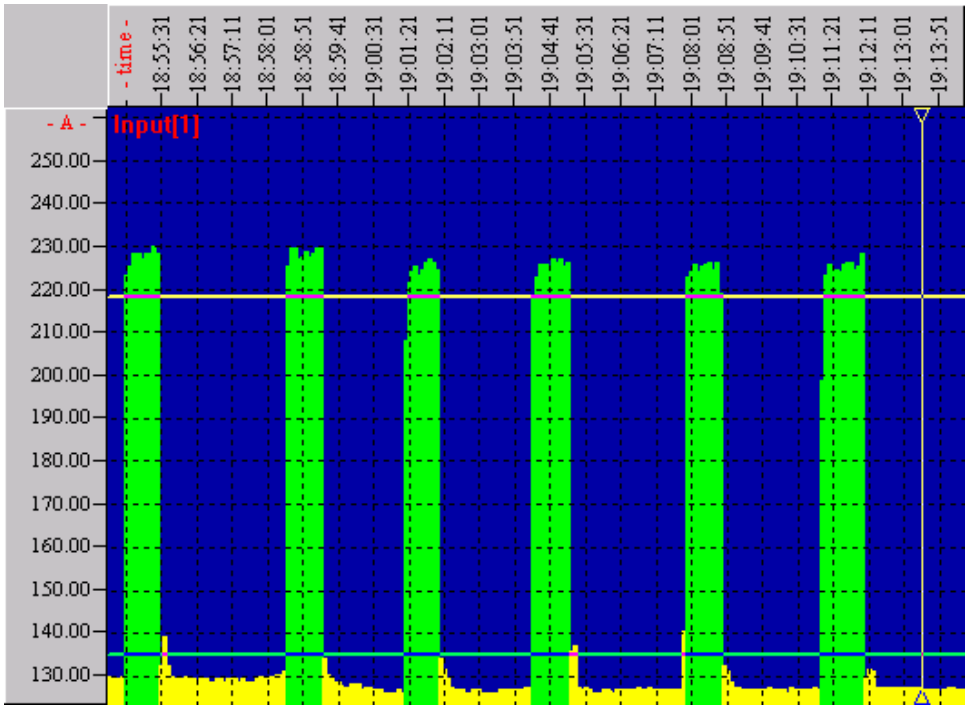


Figure 3 – Current - Macro view (359.2 hours)

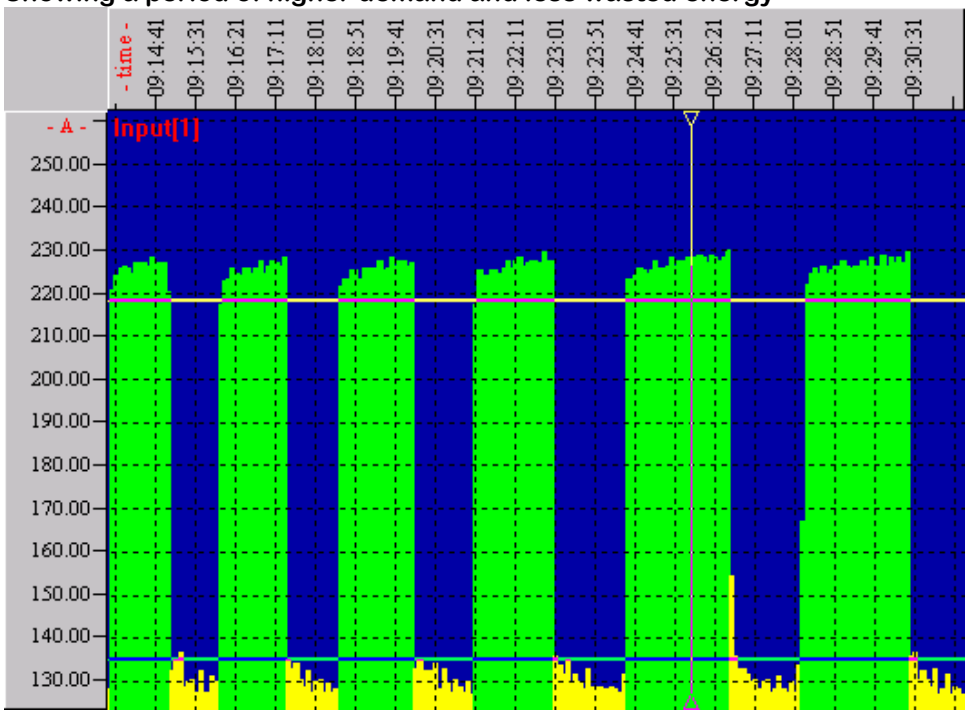
Zoom 1:

Showing a drill down during a time of a high off load percentage

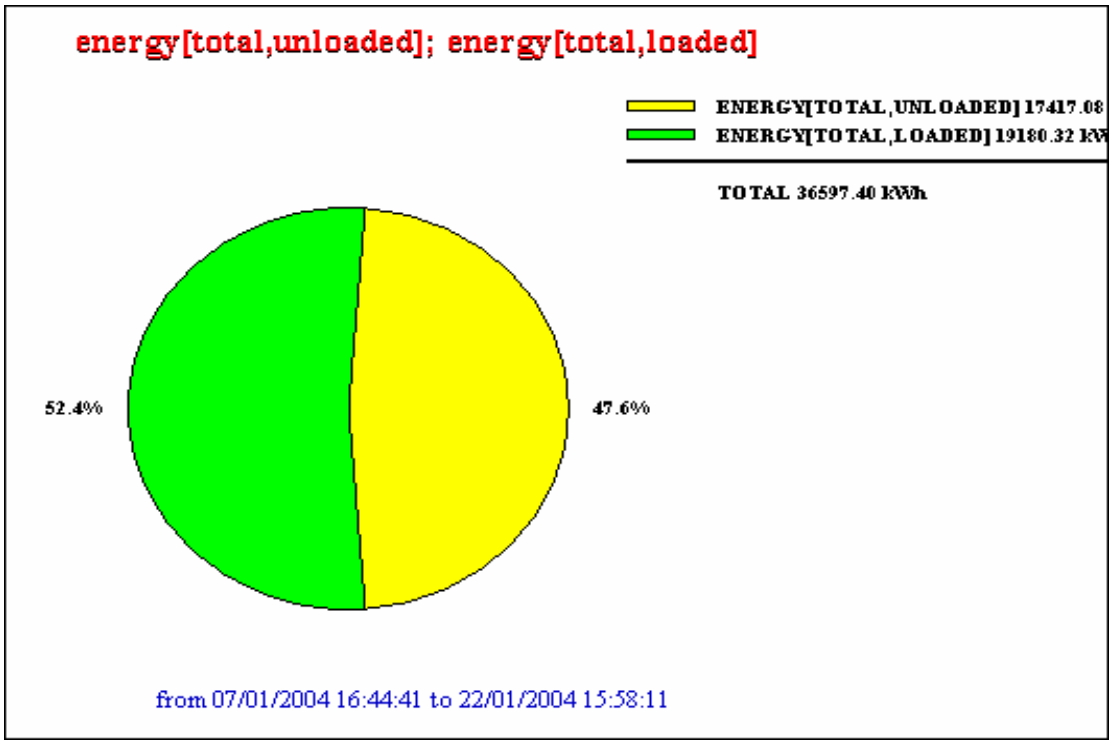


Zoom 2:

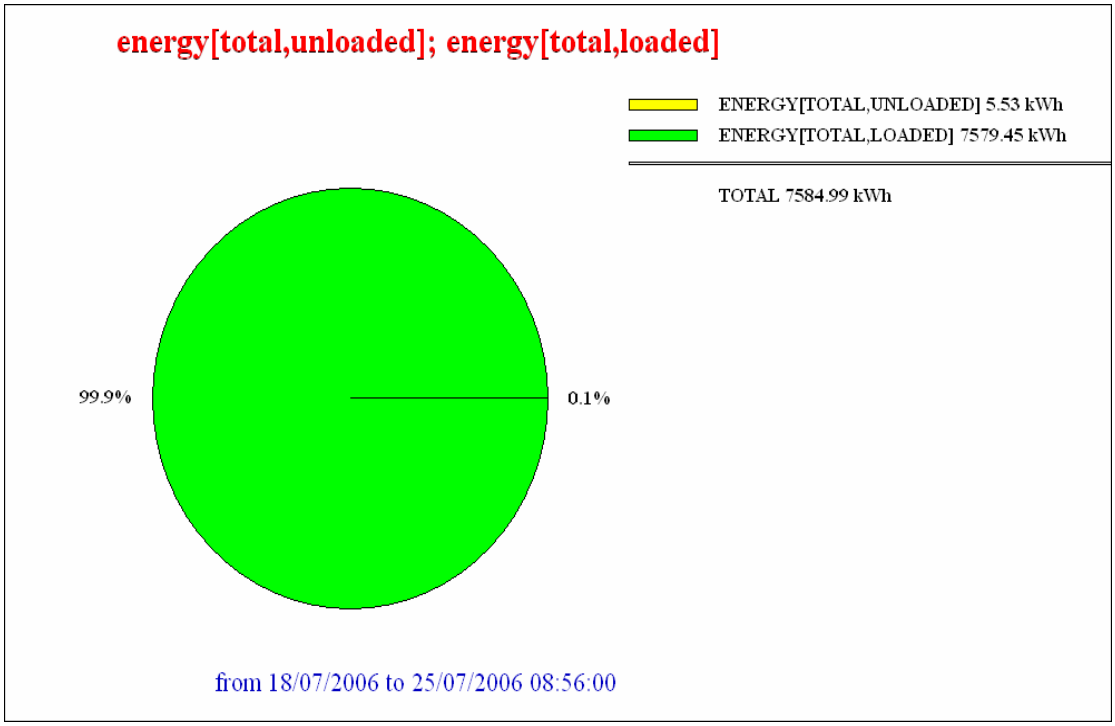
Showing a period of higher demand and less wasted energy



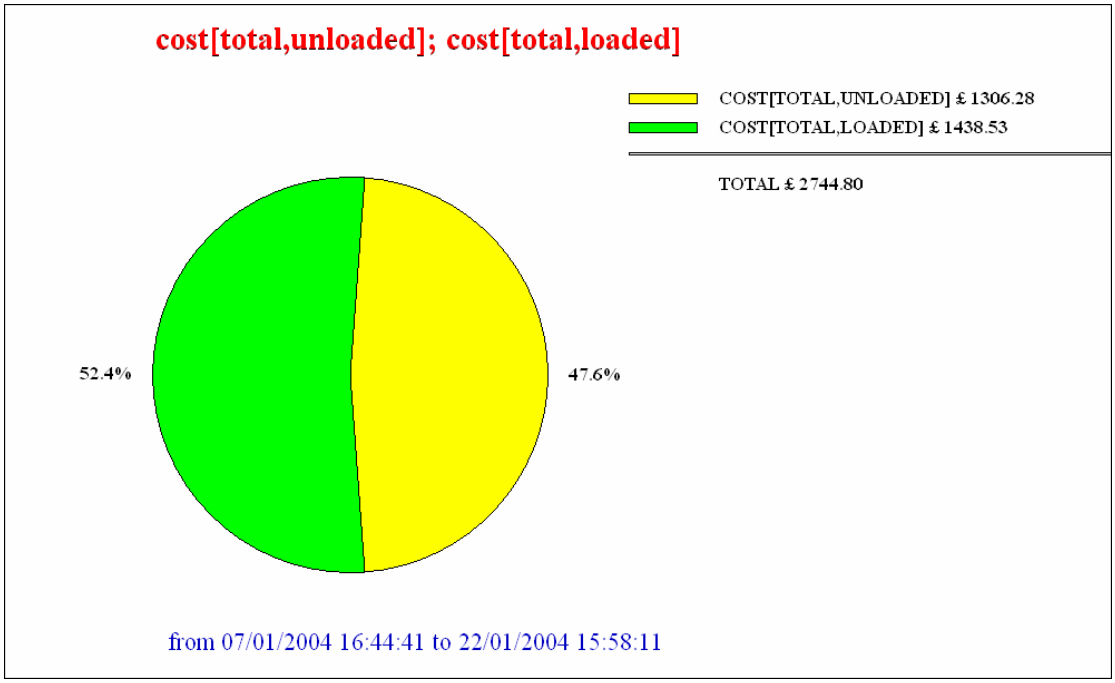
By isolating loaded or productive energy from energy that is unloaded or non-productive, the original audit data can be compared to the current audit data and charted as follows:



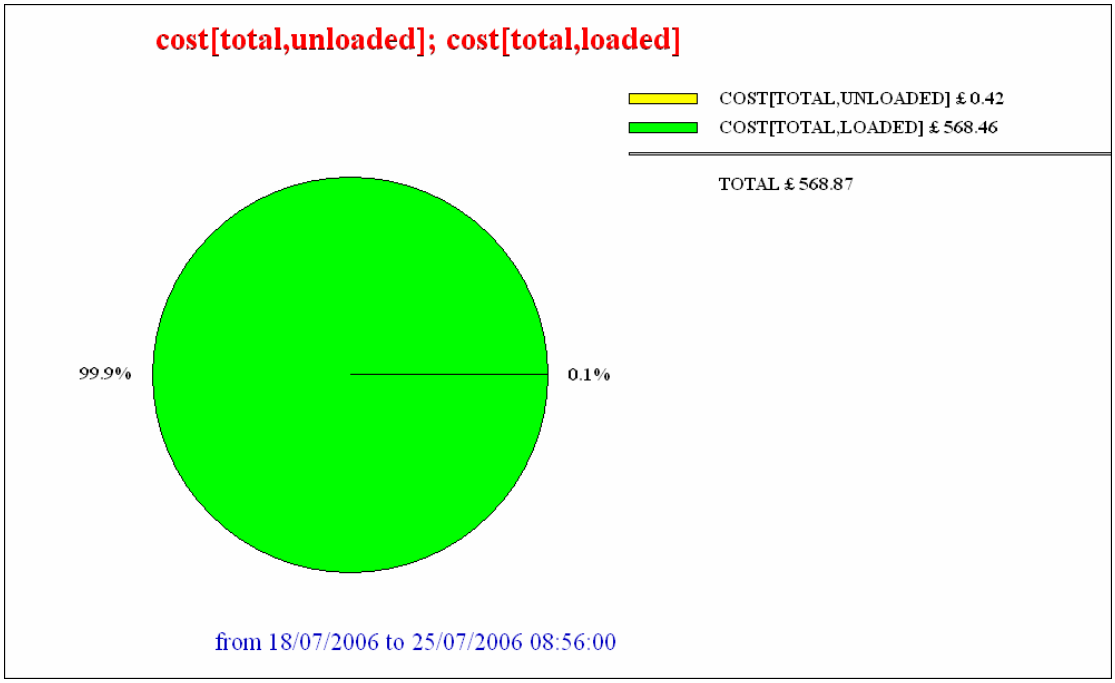
On the original audit non-productive energy represents 47.58% of all energy used.



On the current audit on-productive energy represents 0.07% of all energy used.



On the Original audit non-productive energy represents 47.58% of energy costs.



On the current audit non-productive energy represents 0.07% of energy costs.

Annualised data

If we take the total cost of energy over the original audit (359.2 hours) which was £2745.17 and annualise this :

Based on 48 weeks per Year

Cost of energy	**£2745.17 in 359.2 hours or £61,628.87 per annum**

Of which productive & non-productive energy represents:

Productive	**£1,439.02 in 359.2 hours or £32,305.85 per annum**
Non-productive	**£1306.15 in 359.2 hours or £29,323.02 per annum**

If we take the total cost of energy over the current audit (176.9 hours) which was £568.87 and annualise this :

Based on 48 weeks per Year

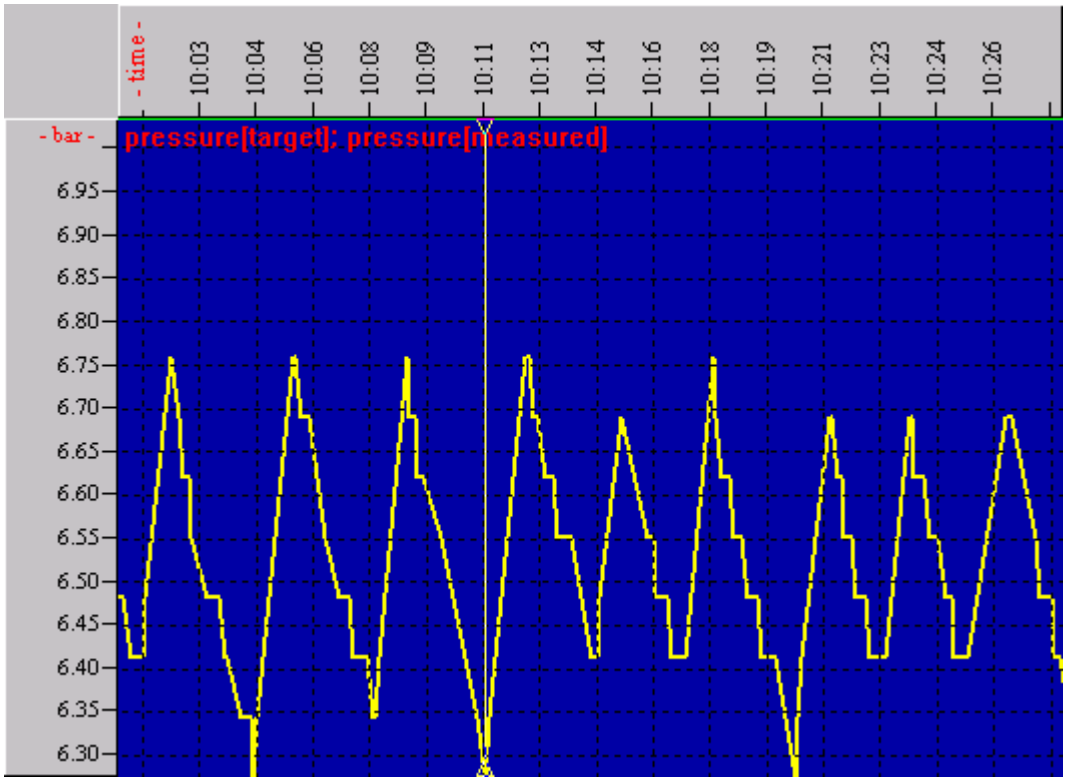
Cost of energy	**£568.07 in 176.9 hours or £26,014.63 per annum**

Of which productive & non-productive energy represents:

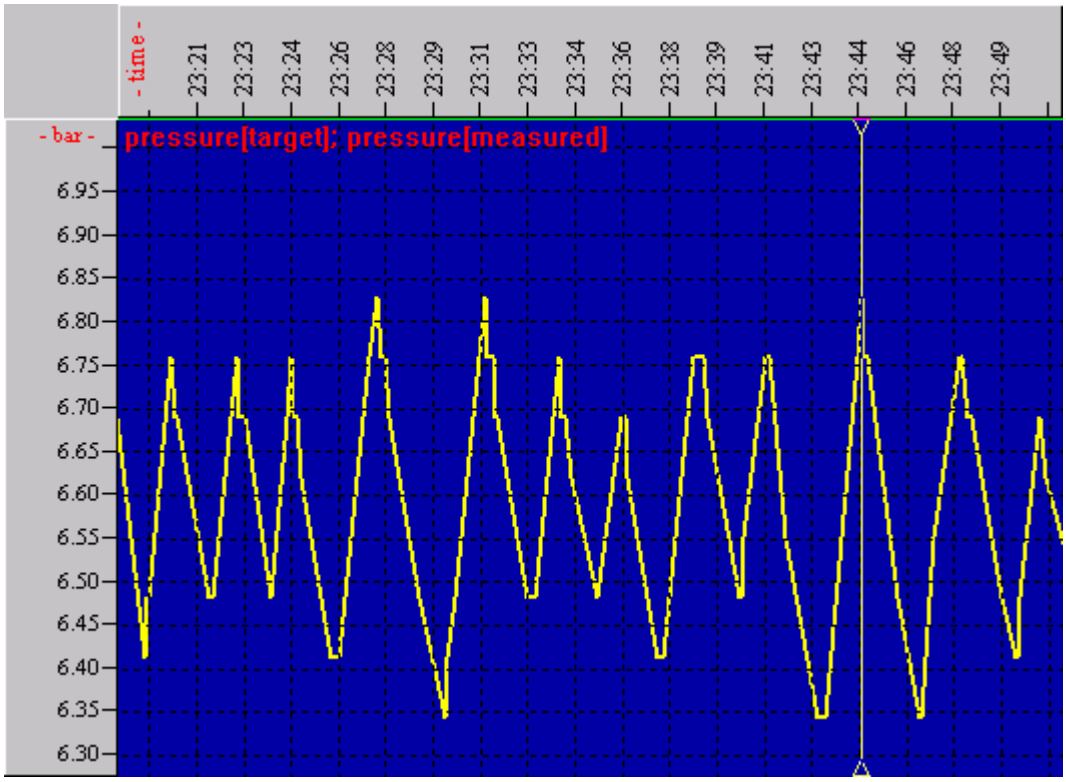
Productive	**£1,439.02 in 176.9 hours or £25,996.42 per annum**
Non-productive	**£1.01 in 176.9 hours or £18.21 per annum**

Original audit system pressure (measured)

Minimum = 6.28bar

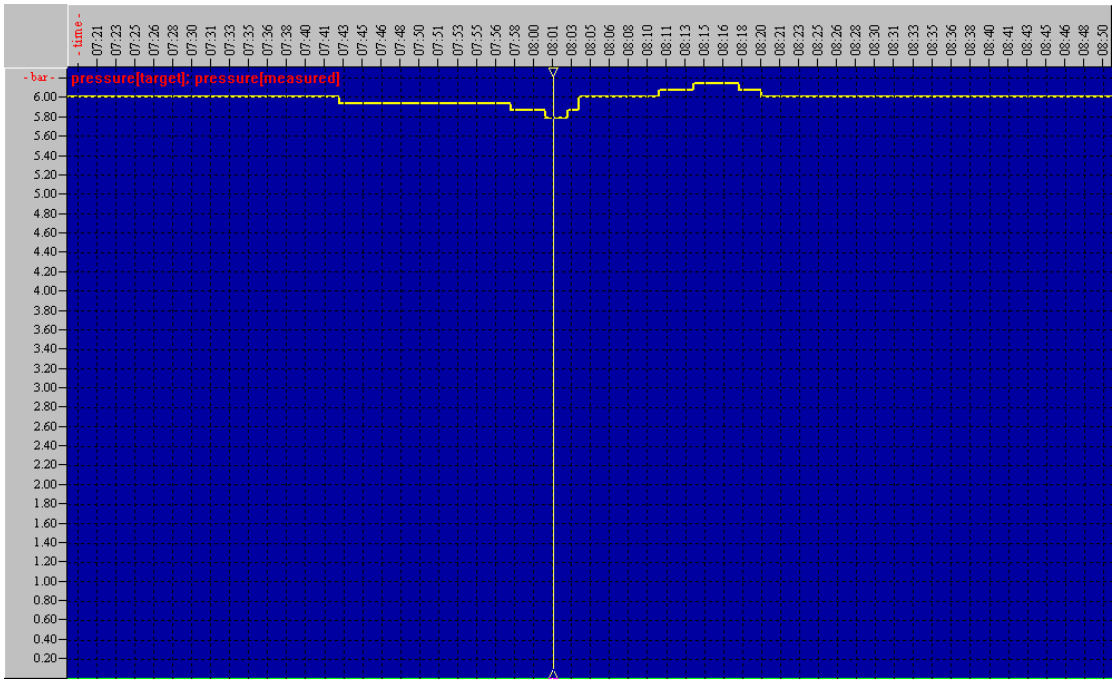


Maximum = 6.83bar

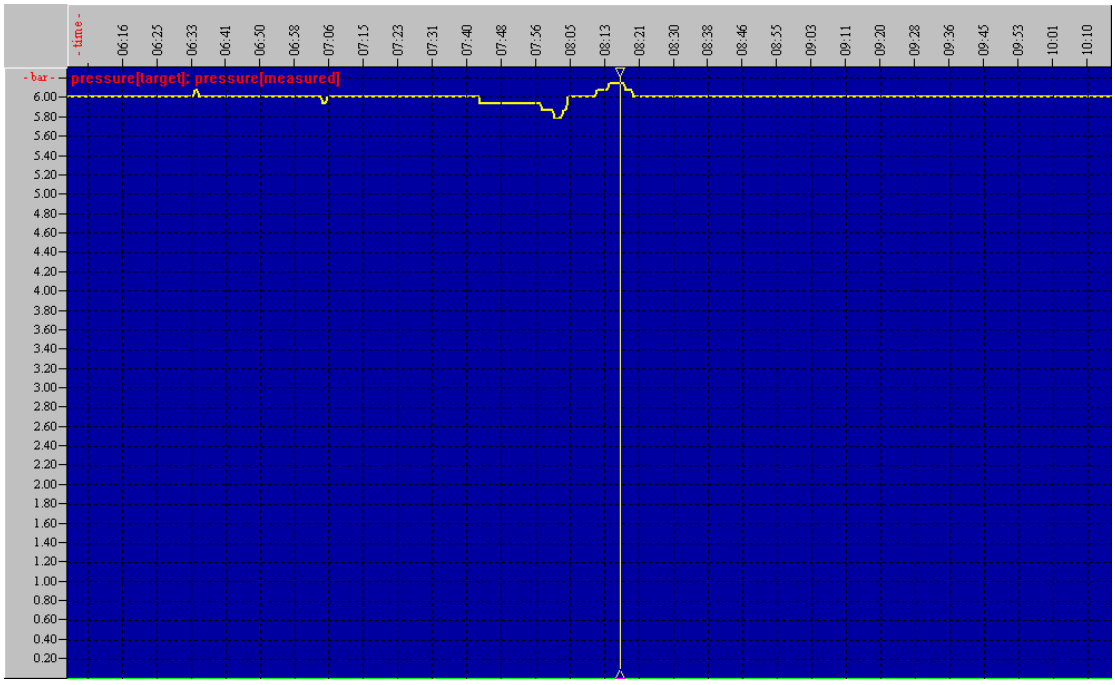


Current audit system pressure (measured)

Minimum = 5.79bar



Maximum = 6.14bar



Conclusions & Recommendations

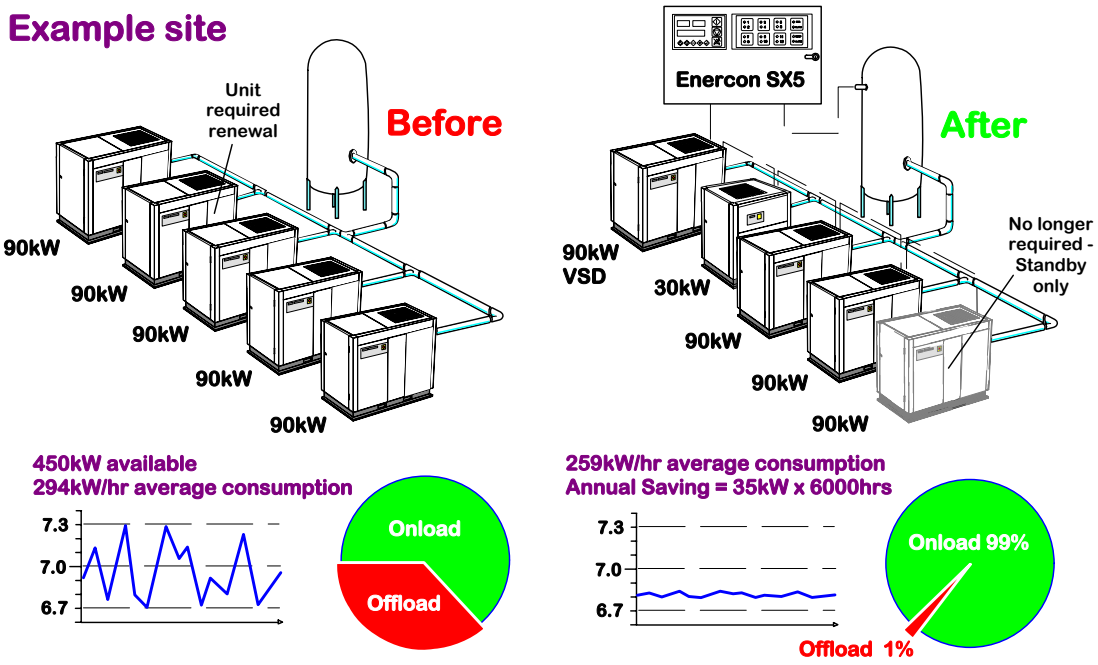
From the original audit conducted, it can be seen that one Compressor (Bellis & Morcom VH28N) was used to satisfy demand for compressed air over the audit period.

The original compressors were loaded & unloaded by the central control pressure switches on a rigid cascade basis.

In order to more closely match compressed air generated to that of the air demand profile audited, the original compressors were changed to smaller units with two fixed speed and one variable speed drive unit.

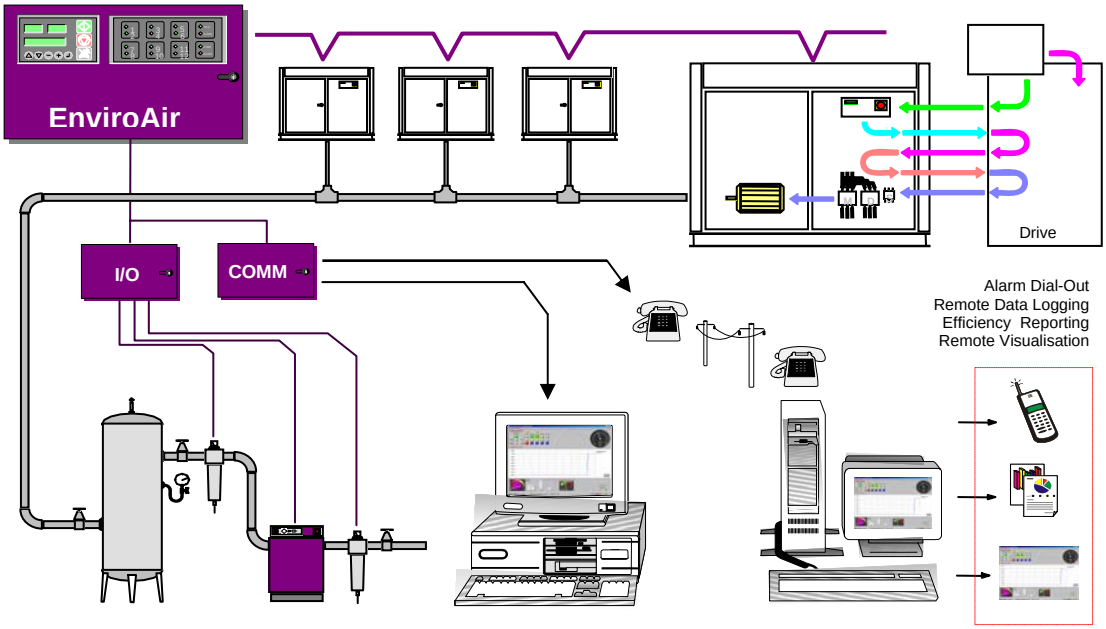
By utilising one variable speed drive compressor in a coherent way with fixed speed compressors, a major reduction in off load energy has resulted.

The variable speed compressor is used to efficiently modulate between the air demands of less than one full compressor. Managed along with fixed speed compressors, this has reduced off load energy consumption (originally 47.58% of all energy consumed).



In order to manage the compressed air system in an efficient way, inclusive of a variable speed drive air compressor, a new management control system has been installed.

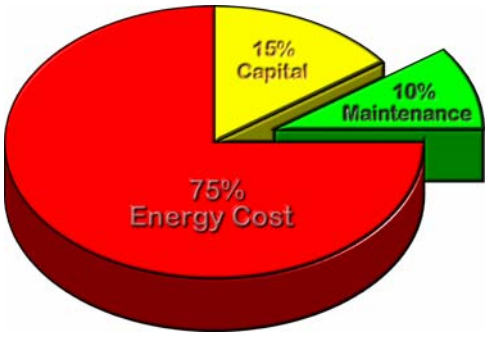
In addition to having the capability to manage both fixed speed and variable speed air compressors in an efficient and coherent way, the management control system is capable of monitoring the entire compressed air system.



The result is an efficiently managed compressed air system with condition monitoring of compressors and their associated air treatment and ancillary equipment within the compressor house. Output to existing factory BMS is available should this be required.

Additionally, an important feature of the Management system is an embedded datalogger, which will continuously monitor system efficiency. The data logger has provided logged data for efficiency reporting using the software package used to generate the original report.

The data logging and efficiency reporting is recommended against a backdrop of compressed air 'life costs'.



With energy representing typically 75% of life cycle costs and a cost of energy calculated for the original system annually at £61,628.87 per annum, an efficiency-reporting package to ensure that system efficiency is maintained at the current level of £25,996.42 is required.

Trending of report data will identify how effective improvements have been and also what compressed air strategy should be employed into the future.

Efficiency reporting can be done remotely via an industrial modem, which forms part of the system. Additionally, key data such as service due conditions and alarms can be routed directly to your service provider for enhancements to your subcontractor services.

Energy Savings Projected From The Original Audit

Two principle areas were identified for energy savings and our original recommendations address them.

Item 1: Reduction in off-load 'non-productive' energy & its cost

By replacing the existing compressors using one variable speed drive compressor and two fixed speed compressors as recommended previously we would expect to reduce off-load or non-productive energy consumption by up to 95%.

95% of off load or non-productive energy cost is equal to £27,856.87 per annum.

Item 2: Reduction in overall system pressure

The original system was operating between 6.83 & 6.28bar whilst site pressure requirements are for a continuous supply of air at a pressure were known to be 6.0bar or less.

By using advanced control software embedded within our management system, we are able to reduce pressure at the compressor to more closely match site demand. Reducing overall compressor pressure by at least 0.5bar equal to 5.25% of the total energy cost.

As a result, the elimination of 'over pressurisation' in the system will save up to £3,235.52 per annum. Additionally, by driving system pressure down further (as site characteristics permit) additional savings can be made.

Summary

From a Yearly running cost of £61,628.87

Total potential energy savings on this site amount to £ 31,092.39 per annum

This equates to : 50.45%

Actual Energy Savings From The Current System Against The Original Audit

The actual energy savings achieved in the two principle areas identified for energy savings and our original report.

Item 1: Reduction in off-load 'non-productive' energy & its cost

By replacing the existing compressors using one variable speed drive compressor and two fixed speed compressors as recommended previously we have achieved a reduction of off-load or non-productive energy consumption by 99%.

99% of off load or non-productive energy cost is equal to £29,304.81 per annum.

Item 2: Reduction in overall system pressure

The existing system is operating between 6.14 & 5.79bar whilst site pressure requirements are for a continuous supply of air at a pressure known to be 5.79bar or less.

By using advanced control software embedded within our management system, we have been able to reduce pressure at the compressor to more closely match site demand.
Reducing overall compressor pressure by at least 1.0bar equal to 10.24% of the total energy cost.

As a result, the elimination of 'over pressurisation' in the system has saved up to £6309.43 per annum. Additionally, by driving system pressure down further (as site characteristics permit) additional savings can be made.

Summary Of Actual Savings Achieved

From a Yearly running cost of £61,628.87

The current yearly running cost is £26,014.63

Total energy savings achieved on this site amount to £ 35,614.24 per annum

This equates to : 57.79%

Note:

All calculations above do not take into account the additional cost of the Climate Change Levy, which comes into force in April of 2001. Any additional costs as a result of the Climate Change Levy should be added to your total energy costs associated with compressed air. Resulting energy cost savings are equally proportional.