The Brockmoor Foundry Co Ltd

Energy

The company is participating in the UK Target 2010 Climate Change Agreement, and is therefore committed to a program of continuous improvement. This will be achieved via the implementation of an Energy management system.

A breakdown of the energy consumption at the company is shown in Table 1 below.

Table 1 Energy Consumption 2002

Energy Source	Delivered kwh	Primary Kwh	% Primary
Electricity	15,549,233	40,428,006	91%
Gas	3,468,785	3,468,785	8%
Oil	586,560	586,560	1%
Total	19,604,578	44,483,351	100%

The Specific Energy Consumption (SEC) for the site as a whole has been calculated as shown below in Table 2 for the years to September 2001 to September 2002. It is not currently possible to provide SECs for specific parts of the process.

Table 2 Specific Energy Consumption for the site

Year	SEC	CCL TARGET
2001	5,774	5,810
2002	5,389	5,810

It is not considered appropriate to compare the site SEC against any sector benchmarks, as the nature of the operations and the product mix is specialized. However, under the Climate Change Levy agreement, performance will be monitored and evaluated against the historic baseline to assess improvements.

The proposed measures for improving energy efficiency at the site are broken down into four aspects, as listed below and detailed in Table 3:-

- Operating and maintenance procedures
- Basic physical measures
- Building services
- Appraisal of all applicable measures in an energy efficiency plan

CastingsTechnology*International*
www.castingstechnology.com

Registered Office
7 East Bank Road, Sheffield, S2 3PT, UK
Tel: +44 (0)114 272 8647 Fax: +44 (0)114 273 0852

Regional Office
Alvechurch, Birmingham, B48 7QB, UK
Tel: +44 (0)1527 66414 Fax: +44 (0)1527 585070

Email: info@castingstechnology.com

ENERGY AUDIT REPORT
IN CONNECTION WITH THE CLIMATE CHANGE LEVY

Prepared for:

The Brockmoor Foundry Company Ltd
Leys Road
Brockmoor
BRIERLEY HILL
West Midlands DY5 3UJ

Ref: MJF/RES/CD/Alvechurch

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M J FALLON

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R E SHERWOOD

April 2000

CastingsTechnology*International*
www.castingstechnology.com

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ENERGY AUDIT REPORT
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EXECUTIVE SUMMARY

Introduction

The Brockmoor Foundry Company Ltd is an iron foundry with a typical output of around 6,500 tonnes of ductile iron castings annually.

The following table provides data on the output of castings in 1999, together with the energy usage, to provide an average specific energy consumption for the year.

Specific Energy Consumption

OUTPUT OF GOOD CASTINGS	ELECTRICITY USAGE	GAS USAGE	FUEL OIL USAGE	TOTAL ENERGY USAGE	SEC
tonnes	kWh	kWh	kWh	kWh	KWh/tonne
6685.1	16364219	3666069	28032	20058320	3000

A typical SEC for this type of foundry is 2,650 kWh per tonne.

Energy Saving Opportunities

Changes to operating practice within the foundry will result in energy savings along the lines given below.

Process/System Change	% Reduction in Energy
Installation of new furnaces	13.3% based on 1999 mains frequency figures
Modification to heat treatment cycles	0.22%
Modification of charge make-up	0.50%
Drawing air from outside the building	0.02%
Leak reduction programme	0.04%
Improvements in yield (2%)	0.73%
Changes to motors and drives	0.56%
Lighting changes	0.06%

TOTAL ENERGY REDUCTION BY 2010	**15.43%**

In summary, the following opportunities are available for energy saving.

1. Low Cost/No Cost Opportunities

- Reductions in melting energy consumption by more efficient working
- Modification of heat treatment cycles and associated reduction through metal charge make-up
- Compressed air leak reduction and installation of ducting to draw air from outside the building
- Improvements to yield
- Introduction of a formal Energy Management Scheme

2. Medium Term Opportunities Within ACE

- Provision of appropriate sub-metering
- Appropriate changes to motors and drives
- Reductions in gas consumption through improved ladle and space heating

3. Long Term Opportunities Involving Changes to Plant and Process

- Extension to the Disaforma cooling track, as proposed in the Business Plan
- Replacement pipework and air dryers to improve compressor efficiency

1. INTRODUCTION

The Brockmoor Foundry Company Ltd is a producer of ductile iron castings for the engineering and allied industries. Production is based around a medium/high volume Disaforma greensand moulding machine and a low volume chemically bonded sand section.

All melting is via electric furnaces and molten metal is nodularised using a George Fischer converter. Treated iron is manually poured on the semi-automatic casting loop of the air-set section using conventional ladles, while the Disaforma machine is fed from an electrically heated autopour unit.

Some castings are heat treated to achieve the desired specification and this is carried out in electrically heated ovens. Melting, pouring and heat treatment together constitute the largest electrical energy usage. The remainder is distributed among the other production processes, heating and lighting. Gas is used on site for some coremaking processes, pre-heating and maintenance of the George Fischer converter body temperature, ladle pre-heating and other minor process needs. A small amount of fuel oil is used for fork lift truck internal transport.

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2. ANALYSIS OF ENERGY USAGE

2.1 Total Energy Usage & Calculated Specific Energy Consumption (SEC), January - December 1999

The Company has supplied details of purchased energy and consumption for 1999. For convenience all consumptions have been converted into equivalent kWh values as shown below:

Total energy consumption	**20,058,320 kWh**
Total electricity consumption	**16,364,219 kWh (81.6%)**
Total gas consumption	**3,666,069 kWh (18.3%)**
Total fuel oil consumption	**28,032 kWh (0.1%)**

These data show that electricity is by far the largest energy source.

Based on the above the overall SEC related to a good castings output of 6685.1 tonnes can be calculated as follows:

$$\frac{20{,}058{,}320}{6685.1} = \mathbf{3000\ kWh/t}$$

2.2 Distribution and Use of Energy

2.2.1 Electricity

During 1999 the recorded energy consumption at the Company was 16,364,219 kWh the largest proportion of which was metered. Meters were available and read for both the mains and medium frequency coreless furnaces, the auto-pour unit, and the Excel top hat and Salem heat treatment furnaces. The meter readings provided energy consumption data which appeared to be consistent with usual practice.

The breakdown of electrical energy consumption is shown below:

PROCESS	**METERED ENERGY**	
	kWh	**% of Total Electrical Energy**
Melting Furnaces	8,913,356	54.5
Auto-pour Furnace	1,032,389	6.3
Heat Treatment Furnaces		
- Excel Top Hat Furnace	414,780	2.5
- Salem Batch Furnaces	236,005	1.4
Total	**10,596,530**	**64.8**
	ESTIMATED ENERGY	
	kWh	**% of Total Electrical Energy**
Compressed Air	628,789	3.8
Lighting	263,952	1.6
Total	**892,731**	
Grand Total	**11,489,271**	**70.2**
Total Electrical Energy Usage	**16,364,219**	

From the above table about 30% of the electrical energy is unaccounted for. This energy will be consumed largely in a variety of motors and drives across the site.

2.2.2 Gas Consumption

Gas consumption has been measured at 3,666,069 kWh (18.3% of total energy consumption). There are 5 gas meters on site but these are insufficient to give precise detail regarding individual consumptions on all major items of gas consuming plant. It would be advisable therefore to install sub-metering, in order to clearly identify gas consumption in specific areas of the foundry.

Obvious heavy users are the thermal reclamation plant that operates at 197 kWh/t, which is normal for the industry (200 - 210 kWh/t average), and the George Fischer converter-ladle heater, where it is possible to assess consumption by subtraction. The indications are that a small gas saving is possible with regard to this heater, but an evaluation of the most appropriate burner configuration and control equipment would be required to establish the precise saving that could be achieved.

Other areas of the foundry consuming gas are the hot coremaking processes, the air-set moulding ladle and the various space heaters, particularly in the dressing shop/heat treatment area. Based upon the Company's expertise in cold box coremaking technology there seems to be no clear reason to continue with hot-process coremaking and its elimination would save gas. Changing to inverted ladle heating technology for the air-set ladle and reducing unnecessary pre-heat time would similarly achieve a saving. This would typically be about 70 kW but without sub-metering it is difficult to judge the magnitude.

2.2.3 Fuel Oil

Fuel oil is used solely for the internal fork lift truck operation. It is a very low proportion of the total energy consumption - 0.1%.

3. ENERGY SAVINGS OPPORTUNITIES

3.1 Melting and Holding

By far the largest electrical energy usage (60.8%) is associated with melting and with holding in the autopour. The Company has mains frequency furnaces which are in the process of being replaced and during the time of the audit both the mains and medium frequency furnaces were in operation. The higher efficiency of the medium frequency furnaces is expected to result in a reduction in specific electrical consumption for melting and holding and this has been confirmed by analysis of the small number of data presently available, as follows:

Historical average for mains frequency melting furnaces	887 kWh/tonne
Measured average for medium frequency melting furnaces (Dec/Jan)	717 kWh/tonne
Minimum likely savings accruing from the change	170 kWh/tonne

Savings on the gross metal melted of 11,319 tonnes
for Jan - Dec 1999 - 1,918,571 kWh = **9.6% of total energy consumption**

Based on a typical energy efficient medium frequency process of 650 kWh/tonne, in the longer term, savings should be 236 kWh/tonne, or **13.3% of total energy consumption.**

For a melt throughput of 11,319 gross tonnes the autopour power consumption was 1,034,389 kWh, equating to 91.38 kWh/tonne, which is typical of an energy efficient operation.

3.2 Heat Treatment

Heat treatment is carried out in two Salem batch furnaces and an Exel Top Hat furnace to achieve certain material specification requirements. Measured energy consumption for the calendar year commencing 1 January 1999 indicates a consumption of 650,785 kWh, comprising 4% of the Company's total electricity usage (3.2% of total energy usage).

Examination of the heat treatment cycles shows that the chosen operating temperatures are too high and can be reduced with safety to provide the desired material properties. The following illustrates the point:

Stress Relieving

Excel furnace - existing temperature 625°C, desired temperature 550°C saving 75°C. At a ramp rate of 50°C/hour this constitutes 1½ hours saving at 80% of full power, equivalent to 19,740 kWh/annum, based on current throughput.

Annealing

(i) Salem Furnaces - existing temperature 930°C, desired temperature 900°C, saving 30°C. At a ramp rate of 100°C/hour this constitutes 0.3

hours saving at 80% power, equivalent to 8,273 kWh/annum, based on current throughput.

(ii) Exel Furnace - existing temperature 930°C, desired temperature 900°C, saving 30°C. At a ramp rate of 100°C/hour this constitutes a 0.3 hours saving at 80% power, equivalent to 15,792 kWh/annum, based on current throughput.

Total annual savings by reducing operating temperature is 43,805 kWh, constituting **0.22% of total energy consumed** (6.7% of heat treatment energy).

More importantly the majority of annealing is carried out to meet specifications in castings which are knocked out hot from the Disaforma strand. Because of residual trace element levels the material is then too pearlitic. Extension of the Disaforma line as outlined in the business plan would help to solve this problem, as would modification of the furnace charges as shown below in Appendix No 2, to increase charge purity without adversely affecting charge cost. The running systems and feeders of copper containing pearlitic grades should be clearly identified by appropriate changes in the design to incorporate a pad marked CU. This will avoid accidental additions of copper containing returns to the ferritic charges. Additional improvements resulting from the use of a bismuth containing inoculant and an extension to the length of the cooling track will further help to ensure the production of an as-cast ferritic structure meeting the relevant material specification.

It is estimated that these modifications to practice should reduce the need to anneal at least half of the existing heat treated product, resulting in a saving of about 100,000 kWh or **0.5%** of total energy consumed.

3.3 Compressed Air Supply

The large compressor (Atlas Copco GA110) operates for 24 hours per day, 7 days per week, 47 weeks per year to service the requirements of the foundry. It is supplemented with a CompAir RA60, which operates 13 hours per day, 5½ days per week and 47 weeks per year. These two compressors provide the majority of the air requirements to the foundry including the moulding machines, core machines and the air requirement of the Fischer Converter gas pre-heater. This latter equipment has a small, dedicated compressor, which is not currently operational.

The main foundry operates from 6.45 a.m. to 6.00 p.m. and the only air requirement outside these hours is for the Laempe and Lorimendi coremaking machines, one of which currently works a 3-shift system commencing with the Sunday nighshift. Savings in compressed air costs can be achieved by modification of current practice, as follows:

Current Position:	GA110:	24 hrs/day, 7 days/week, 47 weeks/year
	RA60:	13 hrs/day, 5½ days/week, 47 weeks/year

Compressor	Rating	Operational hrs/annum	kWh on-load	KWH off-load	Total kWh
GA110 RA60	110 kWh 37.3 kWh	7896 3360	512,450 25,065	71,222 20,052	583,672 45,117
Total energy consumption: 628,789 kWh (3.1% of total energy consumption)					

Revised Position: GA110: 12 hrs/day (6am-6pm), 5½ days/week, 47 weeks/year
RA60: 24 hrs/day, 7 days/week, 47 weeks/year

Compressor	Rating	Operational hrs/annum	kWh on-load	KWH off-load	Total kWh
GA110 RA60	110 kWh 37.3 kWh	3102 7896	99,396 206,164	47,770 17,671	147,166 223,835
Total energy consumption: 371,001 kWh (1.85% of total energy consumption)					

Examination of the system indicates that the revised position shown above should theoretically be capable of providing the majority of the air supply to the foundry, however attempts to operate in this manner have failed because of pressure drops along the line. These cannot be related to air leaks, although there are some present. It is possible that this pressure drop is associated with an insufficient diameter of supply pipe and possibly also the air dryers in use. It would need to be established, therefore, whether increasing the diameter of the pipework and replacing dryers would solve this problem and also whether such a change would fall within ACE. On the presumption that this was the case, there is an estimated saving of 257,778 kWh 1.28% of total energy consumption.

It would also be beneficial to install ducting to allow the compressors to draw air from outside the building. A 4°C reduction in the air intake temperature provides a **1%** reduction in energy consumed - **0.2% of total energy used.** This is typically the difference between the inside and outside temperatures in most foundries.

Compressed air leaks are a common cause of excess energy consumption. Auditing the Company's system during a non-production period indicated that some leakage is occurring and the adoption of a leak reduction programme should enable some improvement to be effected. A saving of 2% of compressor energy should be achievable - **0.04% of total energy usage.**

3.4 Motors and Drives

About 70% of the electrical energy consumed at Brockmoor Foundry is associated with melting, pouring and heat treatment. The remaining 30% is associated with a variety of other process requirements involving the use of motors and drives.

The plant electric motor list indicates an installed capacity of 2,793 kW, of which 1,883 kWh (67.5%) is represented by 38 motors of 20 kW rating or more.

If it is assumed that 4,500,000 kWh is associated with motors and drives, a 2.5% saving in such consumption over 10 years is equivalent to 225,000 kWh, or **0.56%** of total energy consumed. Such a reduction would be expected from the gradual

introduction, as and where appropriate, of new and improved technology such as high efficiency motors, variable speed drives, timers etc.

3.5 Factory Lighting

The most significant issue with regard to lighting is the 100 or so mercury vapour lamps operating at 0.4 kWh. This constitutes a total annual electricity consumption of 263,952 kWh, or 1.3% of total energy consumption. (In a typical large foundry lighting constitutes about 3% of total energy consumption).

Savings on power for lighting need to be viewed with caution because of the health and safety implications. The use, for example, of passive infra-red to switch lighting on and off automatically provides an energy saving but the time to full illumination is such that dangerous occurrences could occur.

As all of the lighting in the foundry is either on or off, savings would be achieved without safety implications by zoning. It is however difficult to assess the energy reduction achievable by this change. A 5% saving on lighting by zoning would result in a reduction in the total energy consumed of **0.065%.**

Regular cleaning of the clear panels allowing natural light through the roof into the building may well result in further savings in lighting energy.

3.6 Other Major Electrical Energy Consumers

Other major pieces of energy consuming plant are the moulding machines, sand conditioning plant, shotblasts, fettling and cleaning operations, dust extractors and machining stations. There is no evidence of energy wastage in these areas, however there is no sub-metering to determine actual energy usage compared with typical figures. As the prime energy users on this equipment are the motors and drives the comments made in that section apply.

3.7 Yield

The 1999 calendar year figures of 11,319 tonnes melted against 6,685 tonnes of net good castings provide the overall figure of 59% yield, which must be considered good. A typical yield figure for medium-sized ductile iron production is quoted as being between 50 and 60%. The last yield specific survey involving 71% of all ductile iron output returned an average figure of 55.7%.

Examination of the running and feeding systems in the pattern stores shows them to be generally well designed with some anomalies where over-large feeders are still in use. Further improvement in yield and thus SEC based on running and feeding system design could be obtained by the adoption of cruciform shaped feeders and the cost-effective implementation of exothermic/insulating feeders, where appropriate.

From the 1999/2000 figures, internal scrap averages 3.27% with a further 0.55% of customer returns, making the total scrap figure 3.82% (this is equivalent to a 765,157

kWh energy consumption). The figure is not unreasonable for a ductile iron foundry such as Brockmoor.

Based upon the examination of yield, there are no major initiatives which would provide an immediate substantial improvement and a 2% improvement in yield over the next 10 years would be considered a reasonable target. This equates to a **0.73%** saving in total energy consumption.

3.8 Air Set Moulding

The air set moulding operation produces 34 moulds/day equivalent to about 3.5 tonnes of metal poured, or 882 tonnes/annum. At an average of 60% yield the tonnage of saleable castings is 530 tonnes/annum. If the foundry could double production, then this would have a positive effect in reducing specific energy consumption.

An additional 530 tonnes/annum of good castings has the following effects:

- At an average of 717 kWh/tonne it raises the total energy consumed to 20,410,289 kWh.
- The additional 530 tonnes raises the total production of good castings to 7,215 tonnes.
- The net result is a specific energy consumption of 2,829 kWh/tonne.
- The reduction in specific energy consumption over present figures is 171 kWh/tonne.

4. ENERGY MANAGEMENT

4.1 Energy Monitoring

Energy Monitoring procedures are in place with regard to electricity and gas usage, but these are confined to a limited number of plant items, which are separately metered, and the "big picture" via energy bills. There are a number of areas where monitoring cannot be carried out, thus making it difficult or impossible to effect improvements.

It is recommended that sub-metering is installed in the following areas to ascertain power consumption, or clip-on meters are used to obtain a snapshot of performance.

- Electricity consumption on shotblast machines, ideally separately, or combined with the dressing shop
- Electricity consumption of the extraction plants
- Electricity consumption of the sand plant and Disaforma moulding machine

This assumes that all of the associated plant within one area is on the same supply, enabling metering to be installed. If this is not the case then concentration on the main power consuming plant would be appropriate.

4.2 Assessment of Energy Awareness

Although there is a high level of "energy awareness" by some members of senior staff the Company has no Energy Management System and no formal energy policy. Staff have not been specifically designated with energy responsibility, particularly at foreman and line management level.

4.3 Energy Management System

It is a requirement of DETR that IPPC foundries should introduce a formal Energy Management System and this should be a major consideration for the Company in the near future.

Development of an embryonic energy management system (EMS) will include a formal written policy, this being:

- A public expression a the Company's commitment to energy conservation (and environmental protection)
- A working document to guide energy management practices and provide continuity

The EMS itself contains:

- A declaration of top management commitment to, and senior/middle management involvement in, energy management
- A statement of policy
- A statement of objectives/targets (short/long term)
- An action plan with defined accountabilities/responsibilities and timescales
- The nomination of an energy 'champion' and team (or working group)
- A programme of training in energy awareness
- The development of a communication system
- The introduction of review procedures

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APPENDIX 1

PROPOSED CHARGE MODIFICATIONS TO ELIMINATE HEAT TREATMENT

420/12 Present Charge

Current position based on a charge comprising:

Tinfos Pig Iron	400 Kgs @ £95/tonne
Steel scrap	4400 Kgs @ £75/tonne
Returns	3200 Kgs @ £80/tonne (average cost)
Graphite	175 Kgs @ £375/tonne
FeSi 75%	130 Kgs @ £395/tonne

Actual charge weight 8305 Kgs.

Material	Addition, %	C	Si	Mn
Tinfos Pig Iron 4%C 1.1%Si 0.04%Mn	4.8	0.19	0.053	0.002
Steel 0.2%C 0.2% Si 0.3% Mn	53	0.11	0.11	0.16
Returns 3.5%C 2.5%Si 0.24%Mn	38.3	1.34	0.96	0.092
Graphite 99%C	2.1	2.08		
FeSi 75%	1.6		1.20	
Theoretical Composition		3.72	2.32	0.25
Typical Composition at Autopour		3.60	2.35	0.26

Material	Kgs Charged	£/tonne	£ Charge Cost/tonne
Tinfos Pig Iron	400	95	4.56
Steel	4400	75	39.75
Returns	3200	80	30.64
Graphite	175	375	7.87
FeSi 75	130	395	6.32
			89.14

420/12 Revised Charge for Increased Purity

Tinfos Pig Iron	2400 Kgs @ £95/tonne
Steel scrap	2400 Kgs @ £75/tonne
Returns	3200 Kgs @ £80/tonne
Graphite	86 Kgs @ £375/tonne
FeSi 75%	110 Kgs @ £395/tonne

Actual charge weight 8196 Kgs.

Material	Addition, %	C	Si	Mn
Tinfos Pig Iron 4%C 1.1%Si 0.04%Mn	29	1.16	0.32	0.01
Steel 0.2%C 0.2% Si 0.3% Mn	29	0.06	0.06	0.09
Returns 3.5%C 2.5%Si 0.24%Mn	39	1.37	0.98	0.09
Graphite 99%	1.07	1.06		
FeSi 75%	1.37		1.02	
Theoretical Composition		3.65	2.38	0.19 *

* Mn will reduce as returns are consumed to 0.16% after 5 charges.

Material	Kgs Charged	£/tonne	£ Charge Cost/tonne
Tinfos Pig Iron	2400	95	27.55
Steel	2400	75	21.75
Returns	3200	80	31.20
Graphite	86	375	4.01
FeSi 75	110	395	5.41
			89.92

Table 3. IPPC Energy Action Plan

Action	Responsibility
Aspect : Operating & Maintenance Procedures	
1. Ladle and Furnace pre-heating. Develop procedures to minimise the time taken for pre-heating ladles and furnaces	Metal Melting
2. Induction furnace holding times. Examine holding times currently to determine feasibility of reduction.	Metal Melting
3. Compressed Air Develop planned maintenance scheme for the compressed air system.	All Areas
4. Switching off equipment. Communicate to employees the requirements to switch off equipment when not in use and include in procedures where possible.	All Areas
5. Operation and maintenance of motors and drives Ensure that regular maintenance and service motors and drives (as detailed in IPPC energy efficiency guidance note appendix 2D) is documented in planned maintenance procedures.	All Areas
6. Optimised cleaning of filtration equipment. Ensure all abatement plants are included in planned maintenance schedules and cleaning carried out at the required intervals.	All Areas
Aspect : Basic Physical Measures	
7. Minimise excessive heating losses Regular inspection of heat treatment furnaces should be included in procedures to highlight refractory failures, door seal failures, etc.	Heat Treatment
Aspect : Building Services	
8. Lighting Document current status regarding replacement of lighting systems and plan for the ongoing improvements defining types to be used	All Areas
9. Evaluate alternative heating equipment and climate control systems.	All Areas
Aspect : Energy Efficiency Plan	
10. The adoption of the proposals documented in [Report on Energy performance - potential savings] prepared by C.T.I. In April 2000 will provide the basis for an ongoing energy efficiency programme. Together with the setting up on Energy Management System this will meet the IPPC requirement for an Energy Efficient Plan.	Management