Energy and Sustainability Topics – Energy management in ceramics processing

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Part 1: Reducing energy costs – the first steps

Industry generally treats the cost of energy as 'somebody else's problem' (to be ignored) and regards the cost of energy as an overhead and a fixed cost. In reality, the cost of energy is everybody's problem and it is a variable and a controllable cost.

Most ceramics processors could easily reduce energy costs (without major investment) and increase profits through good energy management practice. This document aims to show how to reduce energy use and increase profits in ceramics processing.

Energy is a variable and a controllable cost

1. The vital questions

Before starting to reduce energy costs it is necessary to understand where, when, why and how much energy is being used. This information provides the benchmarks and signposts for improvement.

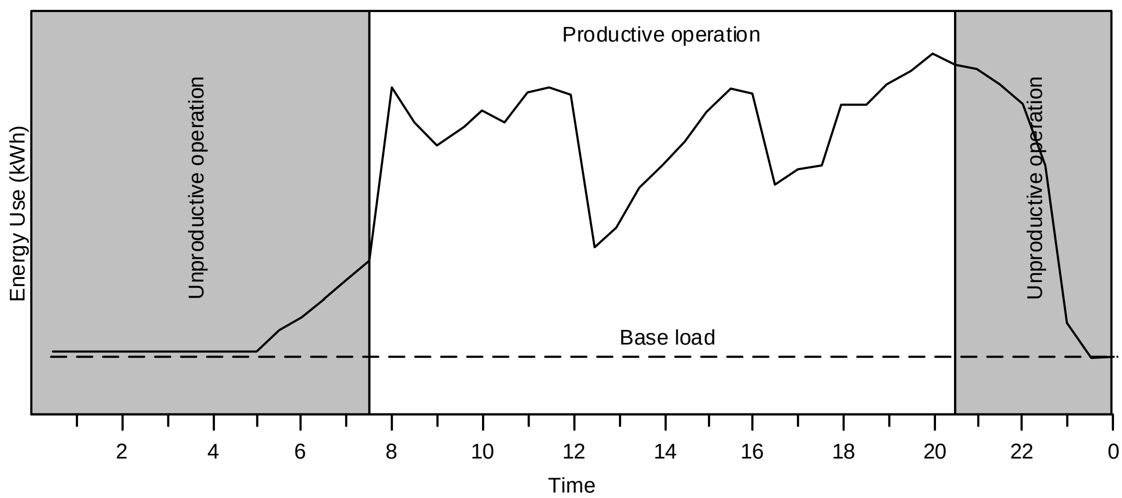
2. Where are you using energy?

The main electrical energy users in ceramics processing are heaters, motors and drives, cooling systems and lighting systems. A simple site energy distribution map will reveal where energy is being used. If only a single meter is being used for the whole site, then it can be cost-effective to install sub-meters to obtain further information on the areas of high energy use. Sub-metering allows calculation of the cost of energy for each operation and the identification of areas of high energy use – key factors in reducing energy costs.

A first step to reducing costs is to produce an energy map of the site to locate areas for monitoring and improvement targeting.

3. When are you using energy?

The time of day when energy is used is also important and total demand plotted versus time gives invaluable information on how to reduce energy costs. Data for demand versus time plots are normally available free from your electricity supply company. Look for unusual peak variations and energy use when there is no production.



Typical site energy use over time

A demand graph also helps to find the 'base load' – the load used for heating, lighting, compressors and pumps when there is no production at all. The base load is a prime target for energy saving.

- **Tip:** Another way to find the base load is to record the meter readings (in kWh) and production volumes (in tonnes) at the end of each shift. Plot the amount of material processed against the energy consumed. From the graph, the energy use at zero production gives an idea of the base load.
- **Tip:** Reducing the base load is a sure way to make savings.

4. Why are you using energy?

Finding out why you are using energy can reveal a wide range of possible steps for reducing energy use. Ideally, energy should be used only to produce good product and the most important energy benchmark is the energy used to process good product (in kWh/tonne). This is the specific energy consumption (SEC) and is found from the slope of the graph produced to find the base load. Your company's SEC can be compared with industry averages to provide targets for energy reduction.

Simple questions will provide a range of ideas for cost savings:

- Is energy being used to keep machines idling when they could be turned off?
- Are heaters running that are not being used?
- Are compressors running just to pump air out of leaks?

5. How much energy are you using?

Electricity charges are based on a combination of factors (see Key Tips) and an initial survey will reveal areas for potential savings. Sometimes actions as simple as changing the tariff can reduce costs at no cost!

Key tips for reducing the cost of electricity
Maximum Power Requirement (MPR) is the maximum current a site can draw at the supply voltage. Reduce the cost by: • Staggering start-ups. • Matching the MPR to the requirements. • Getting the MPR right for new premises to avoid costly charges. • Negotiating an annually based MD instead of an MPR charge. **Maximum Demand (MD)** is the current drawn at the supply voltage averaged over half an hour. Reduce the cost by: • Staggering start-ups. • Giving machinery time to stabilise before starting up new processes. **Power Factor (PF)** is a measure of the phase shift created by machinery. Lightly loaded machinery tends to have a high phase shift, and a low power factor. Improve the power factor by running electric motors efficiently to get power factors close to 1. **Load Factor** is a measure of the hours per day that the user draws from the supply. Reduce the cost by: • Running for greater than a single shift. • Carrying out some operations outside the main shift pattern e.g., regrinding.

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Part 2: The rewards

Energy efficiency measures can improve your profits significantly for minimum effort and costs. For a ceramics company with an annual turnover of £10 million and a net profit of £1 million, the average electricity bill will be approximately £200,000 (between 1% and 3% of turnover). Simple no-cost or low-cost energy efficiency practices can reduce this by up to 20% and increase profits by up to 4%. This is the equivalent of adding sales of £400,000 to turnover and is a worthwhile investment by any standards.

Low-cost energy efficiency measures can improve profits significantly

1. Raising energy awareness

The cost savings possible from energy efficiency will only be achieved if there is management commitment to actually carry out the work necessary. This is best ensured by having an energy policy that is as much a part of overall company operations as its quality policy. The energy policy should ideally be part of a broader company environmental policy and, at the very least, should be formally adopted with top-level management commitment. The policy should be the responsibility of a designated energy manager who has clear responsibility for energy matters. There needs to be regular communication with major users who are held accountable for their energy use, which should be monitored and targeted. The quantified savings from the implemented energy policy should be promoted within the company and used to create a favourable climate for investment treatment of other energy saving programmes.

Energy efficiency is a competitive advantage in any market and an initial site survey is the start of gaining the advantage for your company. This document explains how to carry out an initial site energy survey – the starting point for all improvement plans.

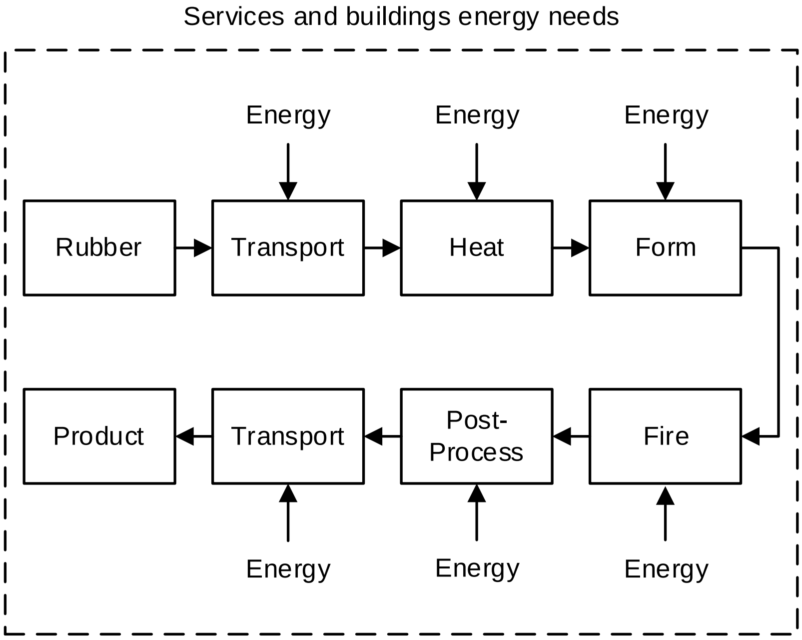
An initial site survey is a key starting point for energy saving

2. The initial site energy survey

The objective of the initial energy survey is to gain an overview of the general site energy use. It is a walk around the site with ‘an energy manager’s hat on’. This will identify some rapid no-cost or low-cost improvements that can be made to save money.

The survey should be carried out as soon as possible – if energy is being wasted now, it is costing money now.

Use the diagram below as a guide during your walk-around to look for areas of high or unnecessary energy use.



The main areas of energy use in ceramics processing

3. How do you carry out a site survey?

Take an unannounced walk around the site at around mid-shift. If there is no night shift it can also be worthwhile to take a walk around the factory when there is no production to look for base load energy uses such as compressors and other services plant.

The questions to ask (and answer)

- Which areas have the largest electrical load? Look for the largest machines – they are most likely to have the largest heating demand and motors, and to create the largest load when they are used.
- Is the thermal insulation on all the machines in good condition? If there is inadequate or no insulation, then why not?
- Are there any good reasons why machines need to be kept idling to be ready for the next production run or when not in production? These include conveyors, water pumps, vacuum pumps, motors, granulators, fans, machine heaters, etc.
- Why are the motors the size they are and would a smaller motor be more efficient?
- Is the airflow from fans being throttled back with dampers and could variable speed drives be used instead?
- Are there leaks in water, air or steam lines?
- Where can you hear steam and compressed air leaks? The hissing noise you hear from leaks is costing real money. If no production is being carried out, then why is the compressed air system still running?
- Is compressed air being used for applications where other cheaper methods can be used, e.g., cleaning or drying?
- Does the compressed air pressure need to be so high or the vacuum so low?
- Is the lighting dirty or broken?
- What simple maintenance measures could be adopted to reduce energy use?
- Are ‘accepted’ practices wasting energy? Can they be modified at no cost at all?

- Are there clear setting instructions for all machines and are they implemented when a machine is set up?

4. Turning a survey into savings

A site energy survey is only worthwhile if action is taken as a result of the findings. Use the survey to estimate the site's excess energy use. Arrange for an electrician to measure the factory's electrical load and then calculate the costs involved. Use the survey to identify operating practices that cost money and need to be changed.

The results of the survey should be distributed with full recommendations for improvements and costs for carrying them out.

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Part 3: Raw materials

Ceramics processors often overlook the treatment of raw materials when considering energy efficiency. The increased use of mechanisation in processing means that energy use in this area is increasing and there are opportunities for cost savings.

The preparation and transport of raw materials uses significant quantities of energy but is often overlooked in energy efficiency efforts

1. Purchasing and storage

Purchasing should always be made to a comprehensive purchase specification that gives details of the acceptable limits of possible contaminants and the size range of the material feedstock (to avoid problems with bridging or blockages in transport systems).

- **Tip:** Purchasing the right materials can reduce costs and energy use by getting the right materials delivered rather than having to treat them in the factory.

Storing any material costs money and uses energy in some way. Even bulk outside storage costs money in terms of the inventory cost; it is estimated that inventory costs in the ceramics industry are approximately 30% of the total value of the materials held per year.

2. Materials transport

Materials are inevitably transported from storage areas to processing areas, generally using conveyors. It is common to see conveyors operating when no materials are being transported. This is clearly a waste of energy; machines should operate only when doing useful work.

- **Tip:** Fit interlocks or sensors to conveyors or link them to machine start-up/shutdown switches so that they only operate when the machines are operating.

3. Size reduction

Particle size is an important factor in all ceramics processing and it is sometimes necessary to grind or mill raw materials to achieve both the correct absolute particle size and particle size distribution. Size reduction of any type uses large motors and heavy equipment. Even if the machine is not processing materials, the energy load will be high.

- **Tip:** Fit time delay switches to all grinding and milling machines to turn them off if no material is being processed.
- **Tip:** If processing small amounts of raw materials, it can often be profitable to save grinding until the night shift to take advantage of lower electricity tariffs and to reduce daytime maximum demand charges. But be aware of possible noise restrictions.
- **Tip:** Large motors with high use on grinders and mills will benefit from being replaced by high efficiency motors.

4. Mixing

Mixing of raw materials is carried out by a variety of methods, e.g., in ball mills or slurries, and wet compounds normally need to be dewatered in a filter press before forming and firing. These processes all use energy for motors and drives, and care needs to be taken in motor selection and use.

- **Tip:** It is always better to change the structure of the operation than to try to change the habits of the staff. Fit cut-outs and interlocks rather than trying to change behaviour.

5. Forming

The basic forming process also uses energy and should be reviewed to reduce costs. The extrusion of ceramics products uses electricity to run the extruder and this can use large amounts of energy.

- **Tip:** Set the extruder to run at its most efficient speed (usually the maximum design speed) and control the screw speed to give an extrusion rate as close to the maximum as possible while still producing good product.
- Motors run most efficiently close to their design output – a large motor at part load is less efficient than a small one at full load.
- **Tip:** Size and control the electric motor to match the torque needed by the screw
- **Tip:** Other forming processes also use significant amounts of energy and need to be considered.

6. Material recipes

Material recipes are largely fixed in the ceramics industry by product and process needs. Despite this, there are some areas, e.g., brick manufacture, where bulk additives are added to the mix. These fall into two categories:

- Those that have no combustible material, but can act as fillers and may contain fluxes to reduce the firing temperature, e.g., pulverised flue ash (PFA) and glass cullet
- Those that are combustible and can act as a source of energy in the firing process, e.g., carbonaceous additives.

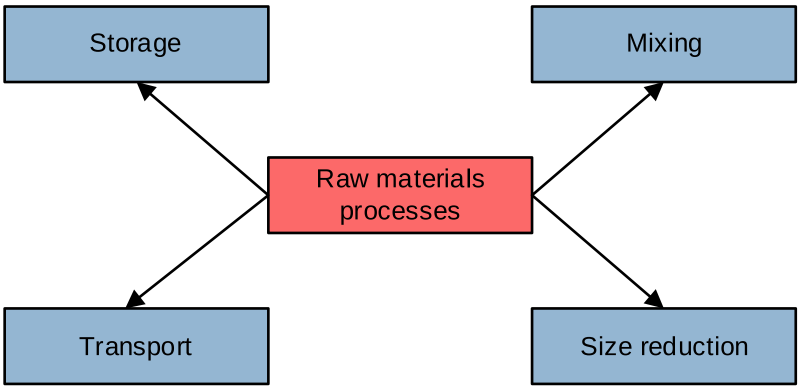
Processors should examine their material recipes closely to see if there are opportunities for material changes to reduce both the costs of the raw materials and their processing.

- **Tip:** Changing materials may be extremely cost effective and reduce not only raw material costs but also processing costs.

7. Reducing materials content

Reducing the amount of material used in any product leads to both cost and energy benefits (processors neither pay for the raw material nor do they pay to process it). It can lead to cost reductions at all stages of production, e.g., increasing the perforation content of bricks can produce bricks with no discernible performance reduction but with cost reductions at all stages of processing.

- **Tip:** Reducing materials content should be an ongoing process. Define the product in terms of a performance specification and adjust the materials content to meet the specification.



Raw material energy use

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Part 4: Drying

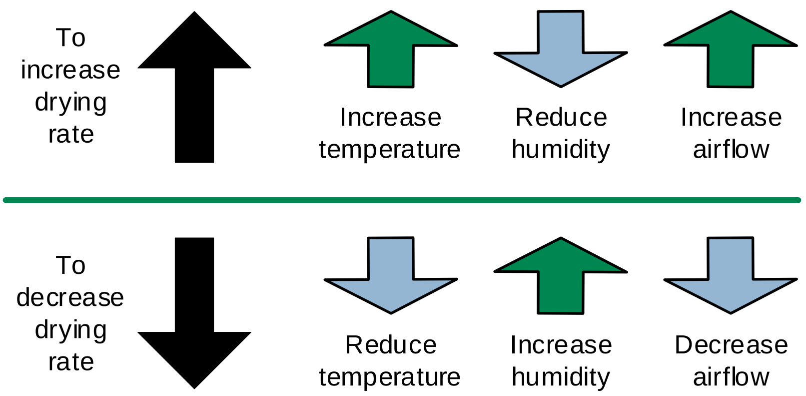
Nearly 30% of the 10,700TJ consumed by the UK ceramics industry is used for drying. However, energy for drying is often used inefficiently and companies could typically save 10% of these costs through improved process management and good housekeeping.

Energy efficient dryers dry the product from the inside, not from the outside

The rate of drying is controlled by:

- Temperature – the higher the temperature, the faster the drying.
- Relative humidity – the lower the humidity, the faster the drying.
- Airflow – the higher the airflow, the faster the drying.
- Product design features – surface area and thickness both affect drying.

These parameters largely determine the size of the dryer and technology used. The high latent heat of water means that large amounts of energy are sometimes used inefficiently in drying. Energy efficiency involves process optimisation, monitoring and maintenance.



The effect of various parameters on drying rate and energy use

1. Process optimisation

Less than 50% of the energy used in a conventional dryer is used to heat the product and evaporate water. The rest is used by the dryer structure, ware supports and exhausted air. Optimisation will improve the process and reduce costs.

Optimisation aims to find the best heating rate to reach maximum shrinkage in sufficient time to allow adequate materials compaction while minimising energy consumption and maximising process yield.

Important considerations for energy efficiency in drying are:

- Temperature and pressure levels.
- Heating method and medium.
- Method of moving the product into and through the dryer.
- Mechanical aids to improve drying.
- Method of air circulation.
- Ware support method.

Energy consumption can also be reduced by minimising the sensible heat load of the structure and optimising the insulation to reduce heat loss from the dryer.

Optimisation is an on-going process

Loading

Loading density is crucial to optimisation; if it is too low, then it may reduce humidity and make it necessary to add moisture.

- **Tip:** Match the production schedule to the dryer cycle to improve loading densities.
- **Tip:** Slowing the dryer and filling the shelves can significantly reduce the SEC.

Airflow control

A major factor in energy consumption is the volume of air used. If there is too much airflow, then energy can be wasted. However, dryers do not function without adequate air and, if the airflow is too low, then temperature and humidity will not be distributed evenly.

A consistent airflow pattern can often lead to inconsistent drying – intermittent airflow is preferred.

- **Tip:** Redirecting airflows can improve consistency and reduce drying time.
- **Tip:** Intermittent airflow patterns can reduce drying time and improve yield.

Kiln effects

Optimisation of the dryer should consider the overall production flow and ensure that drying does not interrupt firing. Firing is the most energy intensive process and adds the most value. The kiln should always be kept working at peak efficiency and drying should support the kiln firing schedule.

- **Tip:** The dryer and the kiln should be scheduled together to give the best production output and energy efficiency.

Using waste heat

Waste heat from other areas can used as a heat source for drying. Possible methods include:

- Heat pumps.
- Recuperators.
- Hot air from the kiln cooling zone (optimum operation is not to let any heat escape from the kiln but use it all in the kiln).

2. Questions to ask:

- Does the kiln waste heat or do gases contain any contaminants that might affect the dryer?
- Is the kiln heat source always available?
- Does the payback justify the additional cost of moving the heat from the kiln to the dryer?

Exhaust air from a dryer will not be fully saturated, i.e., less water will be removed than is possible and more energy will be used than necessary. Many dryers can operate at a higher exhaust humidity without affecting the drying rate, and mixing some of the exhaust gas with the freshly heated drying air can recycle this heat. The capital cost of this measure is low and it can be applied to all types of dryers.

3. Monitoring

Key performance parameters must be monitored regularly to control dryers. These include temperature, humidity, airflow, final moisture content, production throughput and yield, cycle time and energy consumption.

Improved measurement and controls can result in energy savings of 5–10%.

- **Tip:** Install a monitoring and targeting (M&T) system.
- **Tip:** Even the most expensive control system is useless if a sensor is not operating or reading incorrectly.

Temperature and relative humidity are key control measurements. Initial work to optimise a dryer may necessitate measurements at several locations, but routine control may use a single measurement as a control point. The key step is using the measurements to control the product.

- **Tip:** Water should not be allowed to condense in the dryer because some clays can reabsorb water and condensation can cause corrosion of pallets and internal metal supports.

4. Routine maintenance

Operators should carry out routine maintenance but not change the process settings.

- **Tip:** Operators should carry out 'routine maintenance' but be instructed not to change settings. One ceramics manufacturer found out that operators had changed the dryer settings and, after the machine had been reset to the original conditions, waste was reduced by 3%. However, the problem was only spotted after five years of inefficient operation and extra cost!

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Part 5: Firing

Over 60% of the 10,700TJ consumed by the UK ceramics industry is used for firing. Energy costs account for up to 30% of the costs of producing ceramics products and improving the energy efficiency of kilns is essential to reducing production costs.

The greatest inefficiency of all is to fire a product that cannot be sold

Firing can be optimised by:

- Minimising non-payload throughput.
- Maximising firing speed and therefore throughput.
- Maximising heat recovery.

It is possible to improve yields, quality and efficiency by:

- Setting combustion systems correctly.
- Optimising kiln temperature control, atmosphere and pressure.
- Good routine monitoring and maintenance.

New materials

The development of low thermal mass (LTM) materials and ceramic fibres has improved kiln efficiency. These materials have reduced heat up times and can reduce energy use by more than 20% as well as increasing kiln efficiency and reducing labour costs. LTM materials require less heat to reach temperature and can be heated and cooled quickly. They allow the rapid use of intermittent kilns and the development of tunnel kilns that can be operated on a five-day week.

Ceramic fibre veneers can also be applied to the hot face to give faster firing, lower energy consumption and protection to the brick structure.

1. Minimising non-payload throughput

Reducing the non-payload throughput gives better heat transfer and faster firing.

The non-payload throughput of the kiln is crucial to efficiency and refractory to ware ratios of up to 7:1 are found in some companies. Redesigning setters and using LTM materials can reduce this to 3:1 to give a substantial improvement in product throughout and energy efficiency.

- **Tip:** Minimise non-payload throughput by using LTM materials to improve kiln efficiency and energy efficiency.

2. Maximising firing speed

Kilns should be operated to fire the most difficult product. Significant savings can be made by rationalising the product range or operating a second kiln for special products (thus allowing the prime kiln to operate at peak speed and efficiency). Different products should, where possible, be fired separately to allow firing cycle optimisation, constant load patterns and easier control.

Intermittent kilns offer a method of balancing production schedules. They are only half as efficient as continuous kilns for a comparable product, but the production throughput can be much greater and allow continuous kilns to be operated more efficiently.

Faster firing speeds have also been made possible by improved kiln control (particularly atmosphere and pressure control) and by better heat distribution within the kiln.

Adequate insulation is essential if a kiln is required to retain heat to raise the product to the firing temperature.

- **Tip:** Use LTM materials to improve firing speeds and reduce the SEC.
- **Tip:** Energy efficiency in heavy clay kilns should take into account any 'body fuel' in the raw materials that can contribute to the firing thermal input.
- **Tip:** If refiring is required, then it should always be done separately from once-fired products to allow the correct parameters to be set.

3. Maximising heat recovery

Heat recovery should be considered only after the kiln has been optimised. This minimises the heat available for recovery, but is the most energy efficient route.

- **Tip:** Kiln operation should never be compromised to supply a heat recovery system.

Continuous kilns should use most of the heat from the cooling product to pre-heat the product before the main firing. A minimum amount of heat should be available for recovery when they are operated at their design capacity.

It can be difficult to recover heat from intermittent kilns due to the continuous changes in the amount available.

- **Tip:** The first priority should be to re-use waste heat in the same kiln.

After the recovery options at the kiln have been exhausted, then waste heat should be used for drying. However, this should never dictate kiln operation.

- **Tip:** The best opportunities for maximising heat recovery are in kiln design, hot air supply to the burners and using self-recuperative and regenerative burners.

4. Kiln control

Successful firing requires good control to ensure that the product time–temperature profile is correct and that the firing chamber temperature is uniform at each stage.

Control may nominally be very accurate, but the actual kiln temperature depends on:

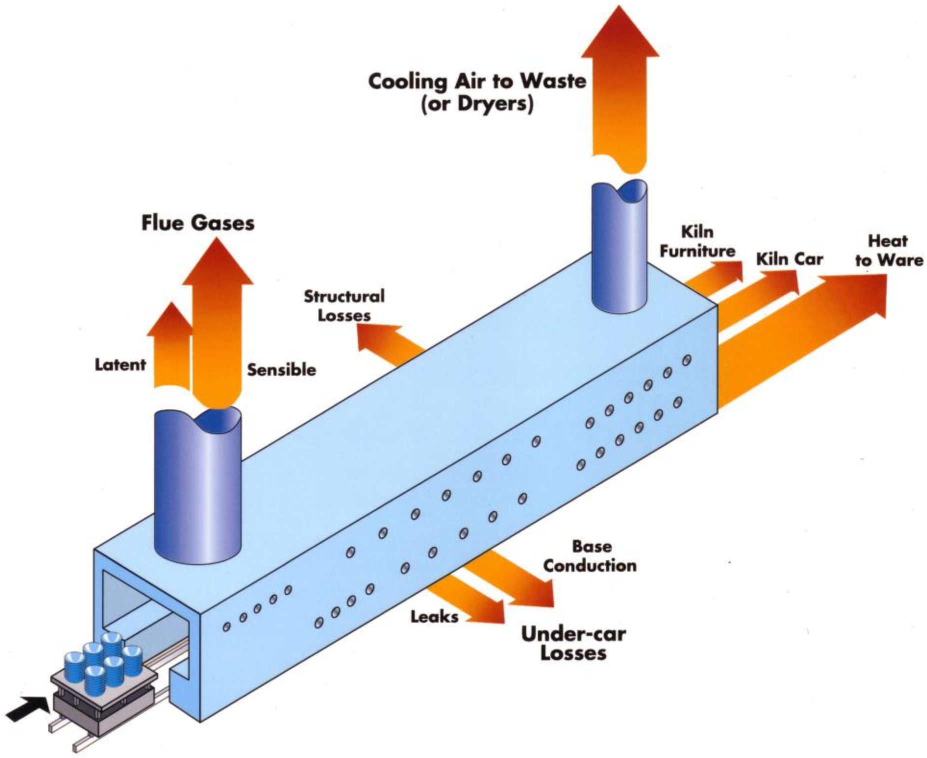
- The position of the ware.
- The relation of the control system to the output of the heating system.
- The condition and position of the thermocouples.

Setting up a kiln is difficult because of the range of variables and settings should only be altered if there are significant changes in throughput, materials or kiln equipment.

- **Tip:** Check, set up the kiln correctly and leave it alone!

5. Kiln energy balance

A kiln energy balance is a useful tool to identify kiln heat inputs and outputs. It can quantify the amount of waste heat available and assess opportunities for increasing the kiln use and reducing SEC values.



Kiln energy balance

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Part 6: Motors and drives

Approximately one-third of the electricity costs in ceramics processing are the result of electric motor use. Yet motors are often overlooked when considering energy use. The motors in the main processing equipment such as material mixers and compounders, moulders and extruders are obvious but the majority of motors are 'hidden' in other equipment such as compressors, pumps and fans. Given that the energy cost of running a motor for 1,000 hours can exceed the purchase cost and that the 'whole life' costs are often over 100 times the purchase cost, then failing to take action with all the motors in a factory is expensive!

The energy cost of a motor can exceed the purchase cost in just 1,000 hours of use

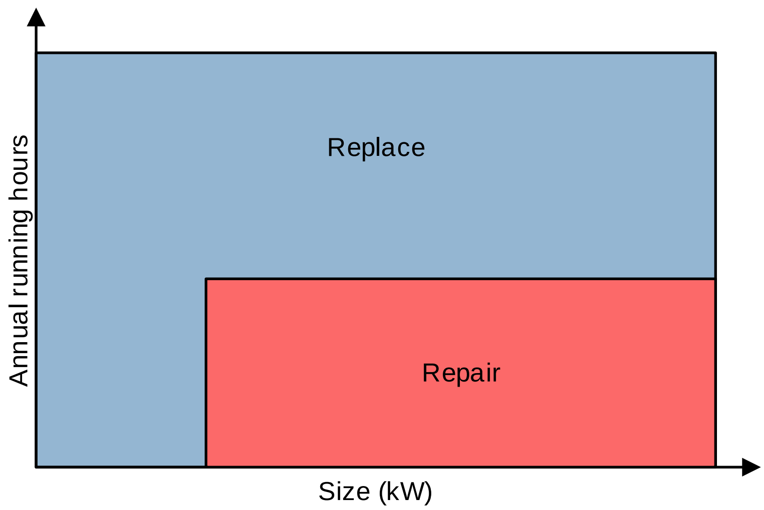
1. The motor management policy

The greater importance of running costs than the initial purchase cost means that companies need to change the way they look at motors. Decisions need to be made on the 'whole life' cost where all purchase, maintenance, repair and operating costs are considered.

The energy efficiency improvements available with the development of variable speed drive (VSD) and high efficiency motors (HEMs) means that, to reduce costs, companies must develop and implement a motor management policy for the purchase and operation of motors. This policy should include guidelines on:

- Repair and replacement based on lifetime costing
- Specification of HEMs for all new purchases.

When new motors are required, the benefits of opting for HEM are obvious. However, the failure of an existing motor raises the question of whether the motor should be repaired or replaced. Repairing a failed motor may appear to be cost-effective, but repair can reduce energy efficiency by up to 1% (and does so every time a motor is rewired) and may not be the most economic long-term action. A motor management policy can provide the framework and rules for making the best financial decision even when urgent answers are required.



A typical motor management policy

2. Motor sizing

Motors are most efficient when their load equals, or is slightly greater than, their rated capacity. Motors can be overloaded for short periods provided that there is a later lower load to allow cooling. If larger than necessary machines are purchased or used, then the motor will not reach the design load and will never run at optimum efficiency. Oversized motors are inefficient; equipment needs to be carefully matched with demand. Even 'steady' loads from fans, compressors and pumps fluctuate slightly and the basic operating load rarely matches that of a standard motor.

- **Tip:** Seek expert advice on motor sizing to reduce costs
- **Tip:** Where motors can be accurately predicted to run at less than 33% of the rated output, it is possible to reconfigure the motor from delta to star connection. This simple low-cost action can produce savings of up to 10%.
- **Tip:** VSDs (see below) will allow motors to run at the required speed to save energy.

The life cost of a motor is often over 100 times the purchase cost

3. High efficiency motors

The cost premium for HEM is now very small and easily offset by the energy cost savings that result from their use. HEM achieve efficiency levels of up to 5% more than conventional motors and have a peak efficiency at 75% of load, thus reducing both energy costs and oversizing problems. A 5% efficiency gain may not sound much, but a £500 motor uses approximately £50,000 in energy over a ten-year life and a 5% saving is £2,500 – this is equivalent to five free motors.

4. Variable speed drives

The speed of an alternating current (ac) motor is fixed by the number of poles and the supply frequency. As a result, the fans used in many processes are designed to be run at a fixed and constant speed but are damped down to provide the correct airflow required by the process. This wastes considerable amounts of energy.

Another way to meet the varying demands is to fit a VSD to the motor. A VSD allows the speed of an ac motor to be varied and the fan output can be matched to the variable demand. This simple application of VSD technology can significantly reduce energy costs.

Other VSD benefits include:

- Reduced noise
- Lower maintenance costs
- Better all-round performance.

VSDs can not only be used for fans, but also for water pumps, air compressors and any other application where the load varies considerably with time. For constant loads, the use of a correctly sized motor is the best option.

Despite this, the varying loads and the difficulty of matching the output to the need will inevitably lead to some energy losses.

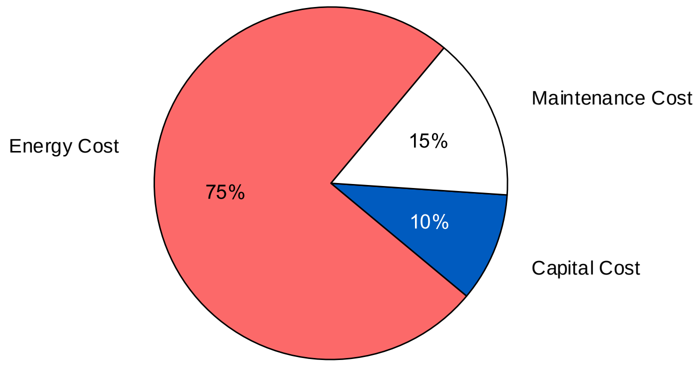
Part 7: Compressed air

1. It is not free

Compressed air is a convenient and often essential utility, but it is very expensive to produce. In fact, most of the energy used to compress air is turned into heat and then lost. At the point of use, compressed air costs more than ten times the equivalent quantity of electrical energy, i.e., an equivalent cost of around £1/kWh. At this price, it should never be wasted and only be used when necessary.

Air also needs to be treated to remove moisture, oil and dirt. The higher the quality required, the greater the energy consumed by the treatment system.

The chart below shows the cost of compressor ownership over ten years. At a site operating 24/7, a 100-kW motor will have an energy cost of ≈ 90,000/year, assuming the cost of electricity to be ≈ 10p/kWh. At these cost levels, an energy-efficient system is highly cost-effective, even if it costs slightly more to install.



Whole life costs for compressors (10-year life cycle)

The cost of compressed air makes it an expensive resource and the way to achieve the best savings is to minimise the demand and then to optimise the supply. Savings up to 30% can be made by inexpensive good housekeeping measures such as making end users aware of the cost of generating compressed air and enlisting their help in reporting leaks.

Compressed air is an expensive resource. Minimise the demand and then optimise the supply.

2. Minimise demand

Reduce leakage

A significant amount of energy is wasted through leakage. Typically, leak rates are up to 40%, i.e., 40% of the generating power is wasted in feeding leaks. A 3 mm diameter hole in a system at 7-bar will leak about 11 litres/sec and cost around £2,000 per year. In a system with numerous leaks, this cost will multiply rapidly!

Simple leak surveys and maintenance can produce dramatic cost reductions, and in some cases, leak reporting and repair have enabled companies to shut down some compressors for all or most of their operating time.

- **Tip:** Simple and repeated walk-around surveys, with leaks tagged and repaired as soon as possible, will significantly reduce leakage rates.
- **Tip:** Isolate redundant pipework, this is often a source of leakage.
- **Tip:** Measure losses due to leakage and target reductions.

Reduce use

Compressed air is often misused because everyone assumes it's cheap. Check every application to see whether it is essential or simply convenient.

- **Tip:** Stop the use of compressed air for ventilation or cooling – fans are cheaper and more effective.
- **Tip:** Fit high efficiency air nozzles – payback can be as short as four months.
- **Tip:** Consider the use of electric tools instead of compressed air tools.
- **Tip:** Do not use compressed air for conveying granules or products.

3. Optimise the supply

Reduce generation costs

The higher the compressed air pressure, the more expensive it is to provide the air. Twice the pressure means four times the energy cost. The real needs may be lower than you are supplying. In some cases, the machine rating is for a 7-bar supply but pressure reducers are fitted inside the machine.

- **Tip:** Check that compressed air is not being generated at a higher pressure than required.
- **Tip:** Switch off compressors during non-productive hours. They are often only feeding leaks or creating them.
- **Tip:** Check that compressors are not idling when not needed – they can draw up to 40% of full power when idling.
- **Tip:** Position air inlets outside if possible – it is easier to compress cold air.
- **Tip:** If there is a machine or area that requires compressed air longer than the rest, consider zoning or a dedicated compressor so that others can be switched off.
- **Tip:** Investigate electronic sequencing to minimise compressors going on and off-load.
- **Tip:** Maintain the system – missing a maintenance check increases costs.

Improve distribution

The longer the compressed air pipeline, the higher the pressure loss over the pipeline and the greater the cost of the system.

- **Tip:** Make sure that pipework is not undersized, this causes resistance to airflow and pressure drops.
- **Tip:** Use a ring main arrangement in each building – air can converge from two directions. This reduces the pressure drop and makes changes to the system easier.
- **Tip:** Avoid sharp corners and elbows in pipework, these cause turbulence and hence pressure drops.

Reduce treatment costs

- **Tip:** Treat the bulk of air to the minimum quality necessary, e.g., 40-micron filters are usually sufficient. Specifying 5 micron will increase filter purchase cost, replacement frequency and pressure drop.
- **Tip:** Test filters regularly to make sure pressure drop does not exceed 0.4 bar – if the pressure drop is higher than 0.4 bar, replace the filters, since the cost of power to overcome this drop is usually greater than the cost of a filter.
- **Tip:** Manual condensate traps are often left open and act as leaks. Consider fitting electronic traps to replace these.

4. Next steps

Compressed air is not free and you can save at least 30% of the costs of compressed air by simple management systems and maintenance.

Energy and Sustainability Topics – Energy management in ceramics processing

Part 8: Buildings

Buildings-related energy use is often seen as secondary but it actually represents an average of 17% of the total energy costs. Buildings-related energy is an easy area in which to make energy savings because any changes do not impact on production. In most, cases a simple site survey can reduce costs considerably.

Building energy costs are a significant percentage of the total energy costs.

For the rubber processing industry, recent years have seen vast improvements in factory buildings and working conditions. This upgrading of conditions has produced significant improvements in all-round site efficiency, and has resulted in a general reduction in the usage of energy. However, large opportunities still remain for energy savings in areas such as lighting, space heating and general hot water supplies.

Many processes generate excess heat and it is worth investigating if this can be used for other purposes, such as space heating on colder days.

Building energy costs

ECG018 ‘Energy Efficiency in Industrial Buildings and Sites’ presents the results of a survey conducted across all UK industry. The figures below give the average annual delivered energy use and cost. The main figures represent an average working day of 2.3 eight hour shifts and the figures in brackets give the values per eight-hour shift worked.

	kWh/m^2	Ł/m^2	% total kWh	% total cost
Process	532 (231)	26.60 (11.56)	61.0	82.9
Buildings	340 (148)	5.48 (2.38)	39.0	17.1

Of the building’s energy use, the space heating element was over 50%:

Space Heating	288 (125)	2.88 (1.25)	33.0	9.0

The buildings energy use values from the sample ranged from 300 (130) to 550 (239) kWh/m^2. Calculate your annual buildings energy use per m^2 per shift, and compare it to the sample range above.

- **Tip:** Processes that involve any vaporising solvents will require ‘local exhaust ventilation’. Processes that only generate heat have options for general or local ventilation or preferably energy recycling through a heat exchanger.

1. Building audit tips

The starting point to reduce building energy use is an audit of the buildings and systems. The following tips can serve as a basis for the initial audit.

Existing buildings

Improving the energy efficiency of existing buildings can be very cost-effective and easy to do.

- **Tip:** Reducing heating load is the top priority, so prevent unnecessary heat loss by making buildings as airtight as possible. Draught-proofing doors and windows is cheap but effective.

- **Tip:** Automatic fast-acting roller shutters save energy on external access doors used for forklifts and other mechanised access.
- **Tip:** High ceilings increase your heating costs. Investigate the use of false ceilings, or destratification fans to blow hot air from the roof space down to the working area.
- **Tip:** Restrict the areas to be heated by using partitions or local systems to control the key areas. Don’t ventilate or heat the whole building space for a few small areas.
- **Tip:** Do not heat areas where you have windows or outside doors open.
- **Tip:** Do not heat lightly occupied stores or warehouses when you are only trying to prevent excessive dampness.
- **Tip:** Insulate supply pipes to radiators.
- **Tip:** Install tamper-proof thermostats and controllers to stop staff changing them. For larger sites, Building Energy Management Systems control energy costs without relying on staff.

Improving building energy efficiency also improves staff comfort and work output

New buildings/refurbishment

New or refurbished buildings are an ideal opportunity to reduce long-term costs. Low energy buildings are not only cheaper to operate but are more comfortable for staff.

- **Tip:** Ensure building insulation and fabric meet the current best practice.
- **Tip:** Double glazing can both reduce heat loss and improve comfort. Modern low-e glass and systems are even more effective than standard double glazing.
- **Tip:** Condensing boilers are the best option for new or replacement small hot water systems.

2. Lighting

Although they may only be a relatively small part of the overall energy usage, lighting systems offer easily demonstrable opportunities to save energy. Pay attention to areas with:

- High or continuous lighting levels and no or low occupancy. Use occupancy sensors or time switches.
- Fluorescent tubes at high levels without reflectors. The use of reflectors increases light levels and the number of fittings can often be reduced.

In lighting, simple measures can save money easily and a well-designed lighting system can be a permanent energy-saving feature.

- **Tip:** Many major lamp manufacturers also offer advice and contract consultancy on lighting. Use any free help to save energy.
- **Tip:** Replacing old tungsten bulbs with LED lighting saves money in the long-term. Although they cost more, LED bulbs use only 10% of the energy of tungsten bulbs and last much longer. The reduced maintenance costs, especially for lights in high fitments, can easily fund the extra purchase costs.
- **Tip:** LEDs can also be used to replace T12 or T8 tubes in offices and to replace high pressure sodium or tungsten in warehouse/storage areas.
- **Tip:** Use natural daylight where possible and keep skylights clean to reduce the amount of artificial lighting needed.
- **Tip:** Research shows that lighting switched on in the morning will rarely be switched off until the evening – whatever the changes in daylight levels in the intervening period. Carry out a lighting audit to determine if lighting demands can be reduced.