Energy Saving At CFH Docmail Ltd

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Introduction

This white paper, Energy Saving at CFH Docmail Ltd, is the result of a two year partnership between CFH Docmail and the University of the West of England, aiming to make the Somerset headquartered print firm more energy efficient.

Believed to be the first collaboration of its kind within the print industry, CFH Docmail and UWE received a government grant to help implement the programme.

CFH Docmail is based on a 10 acre site at St Peter's Park in Radstock, near Bath. Each year around 350 million critical documents are produced on-site, with additional sites at Slough, Livingston (Scotland), Almere (Netherlands) and with postal delivery depots in Bath, Bristol and Edinburgh. Initial environmental improvements are carried out at the Radstock headquarters, and then rolled out to the satellite sites.

Measures identified by the survey stand to reduce the company's overall energy usage by at least 15%, with practical estimates standing at close to 20% and optimistic targets aiming to cut a third of all energy.

This Partnership received financial support from the Knowledge Transfer Partnerships programme (KTP). KTP aims to help businesses to improve their competitiveness and productivity through the better use of knowledge, technology and skills that reside within the UK Knowledge Base. KTP is funded by the Technology Strategy Board along with the other Government funded organisations.

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This paper has been made available free of charge to other print industry companies to help in their own energy efficiency drives.

Dave Broadway - CEO, CFH Docmail Ltd

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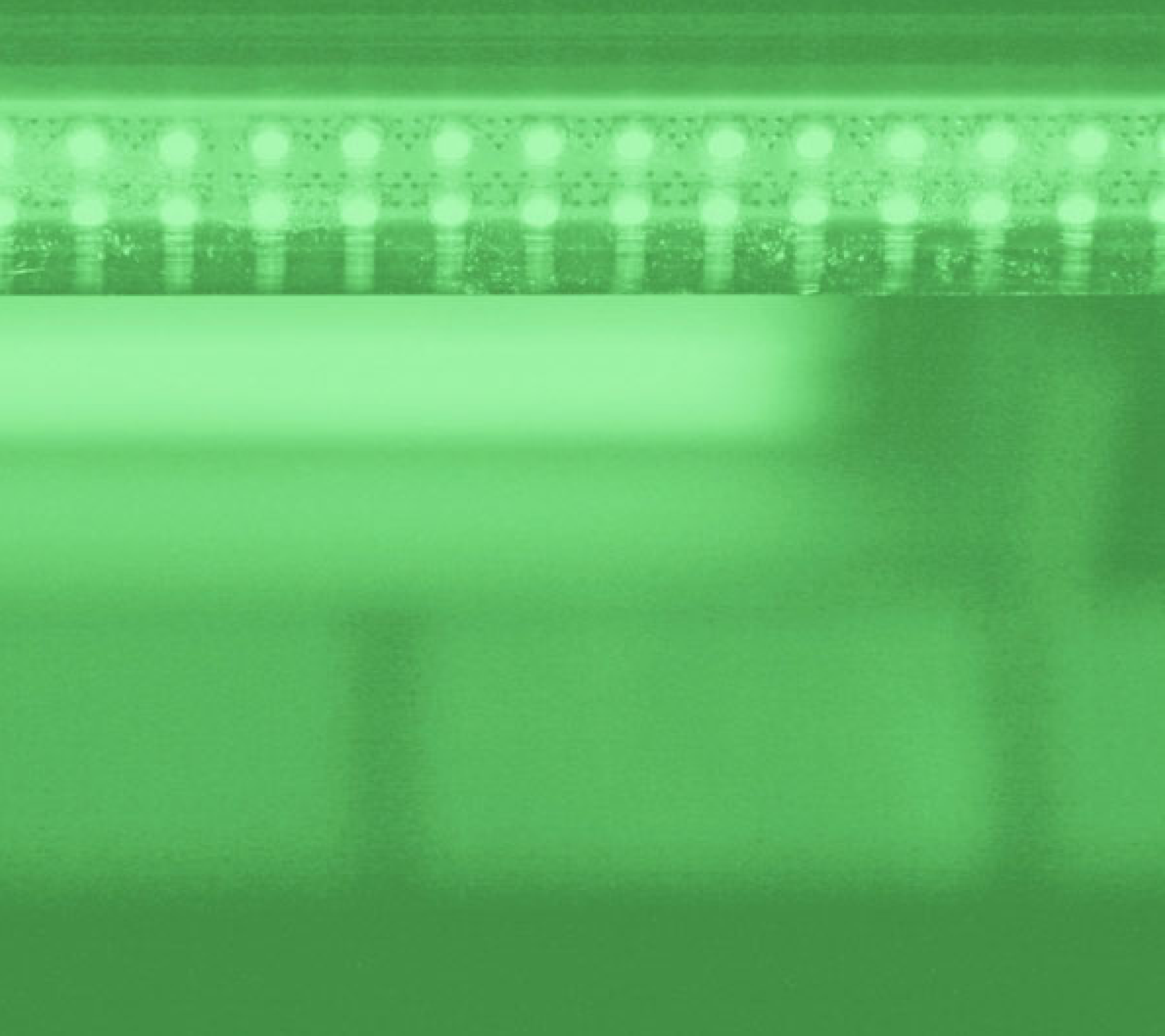
Saving Energy



Chapter 1: How to save energy in printing

Background

Printing is an industry under pressure. In some aspects of life, traditional print is being gradually replaced with its digital equivalent. At the same time, print customers are demanding ever quicker turnaround and delivery of more data with 100% accuracy. Under such circumstances it would be hard for even the most environmentally conscious of businesses to take a step back in order to examine and change its energy usage.

The considerable engineering functions in the print industry mainly centre on maintenance and keeping the presses rolling. Unlike some of the really energy intensive industries, direct energy use in printing is not the biggest cost factor to take into account. However, it is significant - increasingly so as energy prices increase, particularly for electricity.

The industry has placed great emphasis on getting the print through the machines as fast as possible, reducing labour costs. Some of the sophisticated techniques used to increase speed have resulted in (often hidden) higher energy usage. The net result is that, on some machines, energy costs are as much as 50% of operating labour costs.

Process

In our industry, attempts to save energy often founder on the use of expensive consultants who are expected to produce instant results. Engineers or others involved tend to portray the process as rigorously scientific, depending on measurements to lead to an optimum solution. We have found that the most effective process is quite different.

A better way to think of it is like a detective solving a crime, using limited data to guide further investigation and acquiring sufficient evidence, based on scientific process and measurement, to make energy saving decisions. These decisions, although not entirely risk free, will have a high probability of success.

The outcome is likely to propose many different actions, each of which has some impact. When added together they can result in large reductions in energy use.

Measurements

It can be difficult to obtain accurate measurements in a high pressure industrial environment. Nevertheless, attempts have to be made and the use of obtained data, even if it is not wholly accurate, will always result in better decisions than those that are based on guesswork.

Measuring electrical energy consumption in many parts of the factory, including in machines with heavy consumption, can be relatively easy with unobtrusive, easy-to-use and inexpensive probes. Competent site electricians will be capable of setting up and monitoring these. Not all consumers have to be monitored over a long period; some data can be deduced by difference. But the heavy energy users will have to be monitored for a sufficient time to cover a full range of different operating conditions.

The results are often surprising. As well as identifying energy use, your survey will also find previously unknown faults. Publication of the results will raise awareness of energy within the company and the results can also be used to guide future investment decisions.

In the medium term, it is clear that a permanently installed system is likely to be useful and cost-effective.

Results

The following results cover the findings at CFH Docmail, but the resulting advice will also be appropriate to many other organisations.

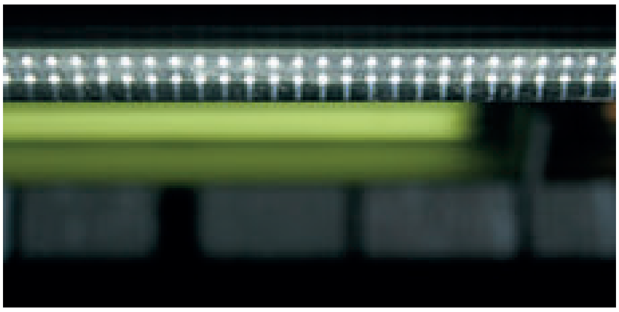
Do not ignore the obvious energy usage which you might take for granted. At CFH Docmail, an average of 20% of our electricity use was in lighting. Approximately 70% of this energy can be saved by using easily installed LED lighting technology. Even without a Government subsidy, this will have a payback time of less than 2 years. This represents an easily achieved 14% saving in our total energy usage.

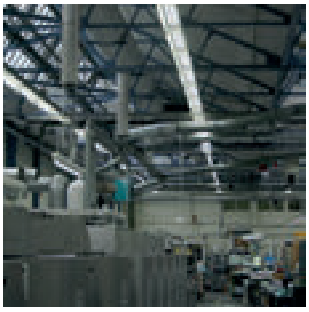
CFH Docmail has now installed, over a 5 year period, LED lighting for almost all site requirements. Savings have met targets, reliability, which was always reasonable, has improved to excellent and the price has decreased. Payback is attractive, even for areas that are only lit for part of the 24 hour cycle.

Many printers use large quantities of compressed air. If you examine all aspects of its supply there are a number of savings available. Some can be rapidly obtained, others require further research.

Buy an efficient compressor. At CFH Docmail, over 16% of our electrical energy was used to supply air at pressure. The cost of the electricity used in one year was almost double the price of a new compressor. Modern variable speed compressors are 15% more efficient than most older on/off controlled systems, even more so when coping with constantly changing demand.

LED lighting is installed throughout the factory, replacing conventional strip lighting.





Put the air intake outside. Pressure is required for most appliances and the consequent high temperature is an unwanted side-effect. Compressing cold air, rather than that at room temperature, can save up to 3% of energy used.

Make sure that the compressed air is not at a higher pressure than required for the operation. Some operations require high pressure, others often need much lower pressure. Reducing the compression for low pressure operations will restrict flow, meaning less air is supplied therefore using less energy. On some print machines, the turnover bars (for printing on both sides) use the air as low friction bearing to ensure smooth and high web speed. This can be particularly high in compressed air usage - up to 50% of the air supplied. But experiments have shown that the pressure can be dramatically reduced with no detrimental effects on print quality.

If a significant amount of your compressed air - say more than 25% - is at low pressure, having two independent compressed air systems can bring further benefits. Let us imagine that there is a requirement for air at 7 bar gauge (above atmospheric pressure) and a similar requirement for air at 2 bar gauge. If it is all supplied by a compressor producing 7 bar then for the proportion that can be at 2 bar all the further compressor energy used between 2 and 7 bars is wasted. This could easily amount to 15-25% of total energy used for compression. The saving has to be balanced against the additional cost of a low pressure compressor, but remember that the high pressure one can also be reduced in size when it is replaced.

Modern compressors, even if more efficient, still produce large quantities of usable heat, which is often exhausted into the atmosphere. By adding a heat exchanger this heat can be recovered and used for space heating, hot water or, better still, any process heat requirements. This can amount to 75% of the input electrical energy. It appears a large proportion, but remember that it is low grade (low temperature) heat which is of far less value than electricity. Nevertheless any fuel savings, normally gas, are still well worth having.

Automated housekeeping can pay dividends. With set-up times forming a significant proportion of the duration of some jobs, machines are often stationary for long periods. But air is still supplied to the turnover bars (for instance) during this time and a system linking the supply to monitored machine speed could produce worthwhile savings. Similarly, monitoring of pressures around the system and comparing them to the normal pattern can give early indication of problems and leaks.

For high-speed printing, drying is a shockingly high energy user. UV drying of photo-initiator based inks is environmentally friendly but uses around two thirds of total print machine energy in many cases. At CFH Docmail, this was typically amounting to 17.5% of our current electricity use. The UV lamps required are of sufficient power that the surrounding air produces ozone, which has to be vacuum pumped into the atmosphere through charcoal filters. Additional water-cooling is also needed together with associated refrigerant-based cooling. For machines in intermittent use, the problem is compounded by the low turndown ratio of the lamps which, to maintain a sufficiently fast response when machines are re-started, must operate at 50% full power, even when the web is not moving. This can be a significant percentage of the time.

There are now new generation UV systems, which have lower consumption due to better reflective systems and greater turndown when the web is stationary. However, the gains in energy consumption are limited and the cost of replacing UV systems is high. The case for investment is not as good as in (i) and (ii), with a payback of 5 years at best.

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A better long-term option may involve the use of LED-based UV lamps, as are already used in some low speed applications. These lamps are even more expensive but could save up to 75% of energy use compared to typical UV systems. Lifetime is longer than for conventional UV, therefore the economic case is compelling. In addition, they avoid the need for removing the ozone with vacuum pumps and they reduce the water-cooling requirement. However, this technology needs further development at high speed (it is currently limited to 75m/min), as the lamps are slightly underpowered and current ink photo-initiators are not well tuned to the wavelength of the light. Nevertheless, there is sufficient interest and support from LED UV lamp and ink manufacturers to support a development program. The possible benefits are large and savings could amount to approximately 12.5% of current electricity use at CFH Docmail.

Air conditioning has many applications within a modern printing operation, notably temperature and humidity control of IT and other printing equipment, space cooling and water chilling for dryers. The total consumption is around 10% of average electricity use, although requirement is biased towards summer.

Conventional air conditioning uses AC motors to compress refrigerant vapour. This process is the prime energy user. They often operate at part-load and are considerably less efficient in these conditions. A 10% reduction in energy use for air conditioning is obtainable by conditioning the electricity supply to the motor at relatively low cost, typically £70 per small machine. Air conditioning involves several components, which need to be synchronised to achieve efficient operation. This can only be done by simultaneously measuring the operation of the components. There are companies that specialise in this, which often results in a further 10% energy saving. These combined effects are quite small, of the order of 2% of total energy use, but are inexpensive to implement.

More radical savings can be made by investing in systems using different principles. For temperature control, but not humidity, free cooling uses ambient air for the 90% of the year when it is cold enough. For the rest of the time, conventional air conditioning has to be used. Free cooling savings can be around 25% compared to conventional systems, but this needs to be balanced against capital cost.

Perhaps a more attractive option is evaporative cooling, where a water soaked pad cools the air by evaporation. The manufacturer claims that this meets the cooling needs for computer servers in Britain at any time, although in theory it could struggle on a very humid 35C day (very unlikely with our climate).
Savings are similar to free cooling but if a backup conventional system is not used, it is cheaper to install. Water use is very low, almost negligible. CFH Docmail has installed evaporative cooling for new office space, which has proved reliable and efficient, with energy savings of 50% compared to conventional systems. This method is even more cost effective for cooling server rooms, where there is a year round cooling demand and humidity requirements are less important than temperature. At CFH Docmail, there is the intention to expand evaporative cooling to server rooms, subject to satisfactory reliability from the office trial.

A further possibility which seems attractive is absorption chilling, which runs on heat rather than electricity. However, it needs a high heat rate of high temperature fluid that is unlikely to be available without an in- house electricity generating plant. It is also complex and expensive, and is only effective for large centralised cooling requirements.

Waste system design is another area that requires attention. Waste, mainly edge trim, but also some shredded material has been a significant labour cost for many operations. Use of automated trim extraction using vacuum based air extraction for each machine has saved labour, but increased energy consumption. At CFH Docmail, there are 20 print machines which are attached by pipe-work to 3 chopping fans, a separator and compactor. The electricity consumption of the fans alone amounts to some 40kW or roughly 10% of the now reduced total site consumption. The need to keep the fans running continuously at constant high speed is governed by the need to maintain a minimum conveying air velocity of 15-25 m/s in all parts of the system to avoid conglomeration of material and blockages. Nevertheless, blockages are regular, pipe-work difficult to reach and dismantle, with significant Engineer input to solve the problem. Meanwhile, valuable production time can be lost.

Investigation has shown only a small proportion of machines are trimming at any one time, often none at all for 1 particular fan. Clearly, on/off control of the 3 fans can save electricity, probably in the region of 25%.(10kW). Careful design of individual pipe-work and a more complex control system together with fan speed control can increase the saving to 40%. However, the highest savings could be achieved by reducing the required 20m/s conveying velocity and using the optimum solids loading in the air flow. Hence, a joint venture with a waste system supply company, possibly grant supported, has been initiated, with the aim of studying the detailed design of system components and operation. This should achieve even further savings.

CFH Docmail also uses considerable quantities of gas for space heating, up to 400kW peak load in winter, with an annual average which was originally around 130kW. This represents a significant cost although as gas is significantly cheaper than electricity, the cost is much less than that for electricity.

Reductions of roughly 25% in gas consumption have been made through 2 measures :

(i) Use of an intelligent control system to reduce the time boilers are fired, with very accurate temperature measurements for key zones being an important factor. Gas air heaters, which are used in cold periods, are high consumers, for which large savings can be made by switching them off well before demand temperatures are reached. The point is that these heaters retain large quantities of residual heat in their heat exchangers which can be utilised after their burners are switched off.

(ii) Use of waste heat channeled from the cooling systems of print machines in winter, the heat being rejected to atmosphere in summer.

The assessment of improvements is complex in that one winter can be quite different from another, but local weather data for “degree days” enables an accurate before and after comparison to be made.

Conclusions

No single factor is likely to dominate energy use in the printing industry. Reductions can only be obtained by looking at all the factors, and choosing the most suitable targets. At the CFH Docmail plant, the measures discussed here target 80% of our current electricity use, from which savings of at least 25% of total electricity use could be made. In practice, to date our savings are nearer 20% of total energy use, but, if research is successful, they could be as much as 40% - half of our energy use in the targeted areas. Some was achieved with small-scale investment, with rapid paybacks of 2 years or less. More recently, larger investments have had to be made with paybacks of 4/5 years. To achieve the higher figure of 40%, there has to be research, development and test work in specific areas, which has a significant lead time and level of risk.

Savings in gas use can also be made, although these are more dependent upon the characteristics and age of particular sites. A figure of 25% is probably typical for sites built in the 1950-1980 era.

It is notable that the savings have been obtained at a time of increasing turnover. The figures quoted take no account of carbon free generation, covered in the next section.

If this could be repeated across the industry and in other industries, the implications for national energy supply would be massive.

Efficient variable speed compressor with heat exchanger, which also saves on space heating bills.

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Energy Generation

Chapter 2: Energy generation at CFH Docmail

Introduction

CFH Docmail uses electrical energy at a roughly constant rate of 460kW and uses gas at an average rate of 150kW, although this is greatly biased towards the colder months of the year. Much of the workload is time sensitive with a quick turnaround required, so the power supply must be secure and guaranteed. Diesel generators that cover full site requirements in the event of the grid electricity supply being interrupted are available, although currently seldom used.

The company and its customers are sensitive to environmental issues. CFH Docmail has previously sought to offset its carbon footprint through planting trees. The requirement for a secure supply, coupled with electricity price increases and future doubts about the integrity of the grid, has led the company to investigate the generation of its electricity in-house. The following is a summary of the results of the feasibility study, as they apply to CFH Docmail. For other companies, circumstances may vary.

A number of possibilities were examined, some in more detail than others, depending upon how promising the initial results were. CFH Docmail has a large site with significant space to accommodate further development of this nature.

Wind Energy

The wind profile for the area was investigated. It was established that the average wind velocity was low, at 3.2 m/s. Space requirements, the urban environment and the intermittent nature of supply ruled this option out.

Photo-voltaic cells

When we reviewed the position in 2012, well-publicised reductions in the cost of PV cells together with increasing efficiency (W/m2 output) worked in their favour. However, despite a high area of south facing inclined roof, an average load of no more than 60kW with a highly intermittent nature means that the grid independence requirement is compromised. Cost is extremely high and despite the 43p per kW/hr feed in tariff subsidy (since reduced to 21.5p), payback was rather longer than suppliers indicated. Independent calculations suggested payback could not be achieved in less than 12 years, even with a higher rate.

By 2014, the position had radically changed. The result has been that the use of photo-voltaic cells (PV) has been chosen as the most suitable technology, with good available roof space and the lack of difficult waste streams important factors. Furthermore, although subsidies from feed-in tariffs have decreased, prices of PV panels have decreased at an equally rapid pace, and better reliability and inverter electronics have increased utilisation factors to virtually 100%.

An initial batch of solar panels with 250kW peak output has been installed for 6 months, with a projected annual average output of 25kW, investment of £1000 per kW peak and a payback of 6-7 years. After this period, the generation becomes highly profitable with a guaranteed lifetime of at least 10 years for all equipment, and a likely lifetime of 25 years, during 20 of which current inflation proofed levels of subsidy through the feed-in tariff will be maintained. So far, performance has exceeded target by 5-10% and a further 150kW has been ordered. Following this, about 10% of CFH Docmail average electricity use will be supplied from PV. At peak generation, the whole factory requirement may be supplied.

CFH Docmail has a fairly constant electrical load profile, so that all of the output will be able to be utilised internally. However, the local grid is not currently able to take export of any excess generation which should occur, so that further expansion of PV is difficult. The site is, however, capable of supporting a 1000kW peak installation, which would meet 25% of total requirements on average. To utilise this and provide seamless production if the grid fails, the use of energy storage is being considered. Battery technology, with car manufacturers TESLA arguably the world leaders, is being consistently improved. A feasibility study, which considers the variation of PV energy from the sun, indicates that 26,000kWhr of storage would be sufficient to utilise all of the 1000kW peak PV output at all times. TESLA is currently proposing industrial storage units of 1000kW, so that 26 of these would be sufficient. Lifetime is a guaranteed 10 years, with an extension to 20 years if a further fee is paid. The technical feasibility is sound, with the 10 year guarantee improving on current lifetimes for other battery technology. However, economic feasibility remains challenging, with a 12 year payback using estimated costs for the storage. This is principally because the cost of storage increases the total package costs (of PV and storage) by 75% above that for PV alone. Costs for storage are expected to decrease in the future. If electricity costs become higher at peak times, as many feel is likely, the economics may become more compelling.

Anaerobic digestion

This produces gas that can be burnt in a gas engine or turbine, which is used to drive an alternator and produce electricity. Various waste materials, especially food waste and sewage, can be broken down using suitable bio-organisms. Gas, mainly methane, is then produced. This is essentially a batch process, with somewhat variable and unpredictable gas production rates meaning that a large volume is needed for gas and fuel storage. The resulting gas contains some corrosive impurities, which have to be removed before combustion. Waste material, which has

The initial array of panels on the roof of one of the factory buildings capable of delivering 250kW. Space exists to grow this to 1000kW.

the advantage that it can be used as fertiliser at suitable times of the year, is as much as 33% of the input material.

This method was rejected because of the unpleasant nature of the input waste, storage space requirements and volume of the output waste stream.

In addition, very little plants of suitable size are available. Most are municipal in scale in the range above 5MW, while there are also a few micro-size schemes less than 50kW. This was a factor that affected almost all of the possible methods. The capital cost is also very high, of the order of £1500-£3000 per kW installed capacity.

Pyrolysis

There are several variants of this theme in which the fuel is burnt slowly at high temperature and with considerably less than the air requirement for complete combustion. The result is the production of a gas, mainly hydrogen and carbon monoxide, which can be burnt in a gas (large diesel) engine. A solid char is also produced, which can also be burnt in a suitable combustor. However, most systems have no such combustor so the char must be treated as waste. In any case, it contains some incombustible ash, the amount of which depends upon the fuel used, typically 10-20% of the fuel. Some waste heavy tars are also generated. The possible fuels are many, although woodchips are a favourite.

These plants are somewhat more compact than those of anaerobic digestion, with reduced fuel, waste streams and storage requirements. However, the high temperatures and pressures involved do lead to a similarly high capital cost. Another important factor is the availability and cost of a dependable fuel stream. If woodchips are to be the fuel, then costs that are high, variable and subject to future volatility (dependent upon future demand) need to be taken into account. These solid fuels require conveyors, screw feeders or other maintenance-heavy equipment. They are notoriously unreliable. A combination of these factors led to the rejection of this option.

Conventional combustion with a steam turbine

This is the most conventional way of electricity generation, with a wide choice of fuels. The study centred on alleged sustainable fuels such as woodchips and other bio-crops.

Steam turbines of sufficiently small-scale for this application are rare and inefficient, typically cycling thermal efficiencies of 15-20% for electricity generation. Even with subsidy, this is a marginal operation, and is highly sensitive to fuel price fluctuations. With a significant payback period because of high capital cost comparable to that of anaerobic digestion and pyrolysis, fuel cost risk is high.

Combined Heat and Power (CHP)

The economics of electricity generation for all combustion-based processes can be considerably improved if the waste heat from the process can be effectively utilised. This is dependent on having a sufficient local heat load.

Heat is usually needed for space heating, but this suffers from the disadvantage that it is seasonal and, in summer months, cannot be used. A local process requiring heat can change this outlook, such as brewing. Other constant heat loads include swimming pools. Refrigeration is another possible load, through the absorption chilling process where heat is used instead of a compressor to drive the refrigeration circuit. This is conveniently often required in summer months. Nevertheless the process is complex, adds significant capital cost and is dependent on concentrated cooling loads close to the plant. If the cooling loads are distributed, costs of moving chilled air around the site can be prohibitive.

If the waste heat can be utilised for a sufficient proportion of the time, the installation becomes due a subsidy from the renewable heat obligation (RHI), which further improves the economics. However, the RHI requirements are quite stringent. For many installations, it is necessary to dry the fuel before processing. If this is part of the local system, then the chances of receiving RHI is considerably increased, as is the space requirement and capital cost of plant.

Indirect gas turbine technology

Conventional gas turbine technology relies on a compressor, followed by a combustor, where gaseous or kerosene fuel is burnt before the flue gas passes through a turbine where the net power output is extracted. Use of solid fuels is not possible because of damage to the turbine blades from high velocity ash and un- burnt fuel particles. Gas turbine efficiencies are quite low for small-scale devices, with resultant high quantities of waste heat. The efficiency is highly dependent on achieving the highest possible temperature at the turbine inlet.

For indirect systems, heat is passed across the solid walls of a heat exchanger to clean air which, having previously passed through the compressor, passes through the turbine. The heat exchanger has to be made from expensive, resistant material and be of high surface area to transfer sufficient heat. As a result, the turbine inlet temperature is low because the exchange surface cannot be cooled independently by cold air. This restricts efficiency to low levels. Also, the high surface area leads to large frictional pressure losses as the clean air passes through the heat exchanger, which increases the energy that has to be supplied by the compressor and further reduces efficiency. Nevertheless, the separation of the clean air stream from the flue gas is a major advantage in that it allows the use of solid fuels including biomass. The scale of electricity generation is small, such that cheap proprietary car or lorry fitted turbochargers can be used as compressor and turbine. One typical installation has an output of 25kW net, which is clearly far too small for CFH Docmail requirements. There is, however, the possibility of increasing output from larger systems based around marine diesel turbochargers in the future.

Paper as a fuel

CFH Docmail has a large waste paper stream: some is currently recycled and has some value; some, due to print contamination, is of little value. Extensive research was conducted into the use of this as a fuel. It was concluded that the waste stream was sufficient to fuel some 20% of the required power output. As there were plentiful similar sources in the locality, this was thought to be a viable proposition.

Paper is not suitable as the major feedstock for anaerobic digestion, a small wetted proportion being possible but organic material being preferred. For pyrolysis, it is a possible feedstock, but would probably have to be pelleted to be effective. Direct combustion is possible, with possible low residence time in the furnace and incomplete combustion being one drawback for lightweight shredded paper. Also, the use of chlorine in the bleaching process for paper production results in significant hydrochloric acid in the flue gas. This is expensive to scrub clean before emission to atmosphere. Nevertheless, it is clearly technically possible to burn paper to generate steam subsequently passed through a turbo-alternator.

The ultimate reason for rejecting this technology at CFH Docmail, aside from high cost, was the attitude of environmental lobby to burning paper. They feel a more effective use for waste paper is to recycle it. This is debatable, given the transport of large volumes of waste paper over long distances to the mills and the very restricted proportion of recycled material that can be used due to problems with reduced fibre length. The truth is that most recycled material goes into corrugated cardboard which is then composted after single use, with the same greenhouse emissions as if it had been burnt.

Gas fired CHP

Although gas only partly meets the need of energy supply security, there being a reliance on the gas grid rather than the electricity grid, it has tremendous advantages as a fuel. It is comparatively easy to burn, has low emissions and requires no handling or storage equipment. The net result is a low capital cost of less than £500 per kW capacity, less than one third of the lowest cost rivals.

It can be burnt in a purpose-adapted diesel engine with an electricity generation efficiency of 37%. This compares with that at a combined gas turbine/steam cycle at a modern power station of around 50%. Transmission losses bring the delivered grid efficiency down to 42-45%, dependent on location. However, taking the grid as a whole, the delivered efficiency is very much lower, around 30-35% due to the use of old coal-fired or nuclear power stations. When the use of the waste heat from the cycle is considered, the advantage of local gas fired generation increases considerably, a further 35% of the heat released from the fuel being available, with a resulting overall energy efficiency of around 70%. Often, it is quite difficult to find a use for all of the available waste heat, CFH Docmail being no exception.

With the above efficiency advantages, it is not surprising that significant subsidies were available from the last Government for gas-fired CHP. These resulted in a payback period of less than two years at CFH Docmail. An order was to be placed at the time of last election, following which the new Government eliminated subsidies for gas-fired CHP. This increased the payback considerably, the current economics becoming close to cost neutral. If electricity price rises outpace gas, then the plant becomes profit generating. This is a likely outcome, given Government enforced user subsidy to increasing proportions of high cost renewable electricity. However, it is possible to argue the gas price will outpace electricity due to factors such as lower indigenous gas production,

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high gas prices on world markets due to increased requirements of Japan and Germany (following the recent nuclear disaster) and other emerging nations. On the other hand, it is equally possible to argue that new sources will outpace increased demand. Note the low US gas prices resulting from gas in shale (fracking) developments and the increasing recovery of wasted gas in oil production, the scale of which is immense. Unfortunately, the economics of the plant is highly sensitive to the electricity/gas price differential. A small change can make a large difference.

Despite this uncertainty, the environmental benefits of high overall efficiency, the increased power supply security and the fact that PV cannot meet all of site requirements mean that it is possible that CFH Docmail might invest in a gas-fired CHP plant in the medium term.

Conclusions

Electrical power generation, for those with interests in security of supply and/or renewable energy, is also site dependent. With urban sites, such as those of CFH Docmail, photo-voltaic solar panels are likely to be the most acceptable and convenient option. There are issues with the intermittent nature of supply, which, although it is fairly predictable, mean that supply of the total power requirement is unlikely to be possible. The fraction of the requirement that can be met from this source can be considerably increased through the use of energy storage, which is technically feasible. The cost of and long payback from storage are, however, a challenge. If the grid is able to accept energy in excess of site demand, this increases the maximum capacity that can usefully be installed, provided the space is available.

For some companies, the combination of the environmental benefit of high energy efficiency, low capital cost, low roof space requirements and convenience means that gas-fired CHP is a practical choice for energy generation. In some locations, where there is sufficient space and a consistent local source of cheap biomass fuel, the considerable additional investment in more complex technology may be justified by the even greater environmental benefits.

For most technologies, the market is supplied with some micro-scale plant of 50kW or less electricity generation capacity and there is large-scale plant of 2MW or greater available. For the medium scale market, between these two limits, choice is very limited.

Government driven subsidies are available and vary according to the type of plant. They are also subject to variation due to rapid policy changes, which tend to respond inversely to the level of demand for subsidy. However, once installed, subsidies are guaranteed and inflation indexed for 20 years.

Processes for obtaining subsidy can be lengthy and costly, both in time and additional instrumentation needed to prove that required subsidy conditions have been met.

List of useful companies

Energy generation

ENER-G . . . . . www.energ.co.uk
Talbotts . . . . . www.talbotts.co.uk

Energy monitoring

ELCOMPONENT . . . . . www.elcomponent.co.uk
Electrocorder . . . . . www.electrocorder.com
Airius (Destratification systems) . . . . . www.airius.co.uk

LED lighting

N E Technology, Cambridge . . . . . www.netledlighting.co.uk

Compressed air

Kaeser Compressors . . . . . www.kaeser.com
Atlas-Copco . . . . . www.atlascopco.co.uk
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Reassessing

Addendum: Reassessment of compressed air savings

Tony May 17/2/2012

1. Introduction

There are a number of proposed ways in which energy and cost savings from changing the way compressed air is used and supplied. Whilst the possible savings from each measure have been individually assessed, there is an interaction between the different measures, so that when they are consecutively applied, the overall savings are not as high as when they are individually assessed and added together.
This paper suggests an order of applying the savings measures based on ease of achieving each measure, with the easiest first. An overall assessment of consecutive savings is then made.
The base energy consumption of the new compressor is now taken as 56kW, which has been measured over a suitable time period with the supply pressure set to 6.8 bar gauge (7.8 bar abs). This is a considerable reduction below the 72kW measured in summer, 2011, although there is some anecdotal evidence that this figure may have already been reduced in the period before the new compressor was installed (early January). If the reduction from 72kW to 56kW is truly representative, then the more efficient new compressor is already producing savings of 16kW (£14000pa), from reduction of electricity consumption alone.

2. Further savings measures

These are listed in suggested order:-

(i) Reductions of supply pressure

(ii) Automatic turning off of compressed air supply to air bars when print machine is not in operation eg. during make ready procedures. This is an idea suggested by the both the previous and current Engineering Manager

(iii) Reduction in air bar supply pressure progressively from 6.8 bar gauge to 1 bar gauge. This affects mainly the Drent. Some other machines are already fed at low pressure

(iv) Air supply to the compressor to be taken from outside the factory at lower temperature. This reduces the energy to compress the same mass flow of air.

(v) Supply of air to the turning bars from an inexpensive centrifugal blower at a pressure of 1 bar gauge. This saves the further energy, subsequently wasted by pressure regulation, which the current compressor uses to reach 6. 8 bar gauge

Each of the measures discussed individually

2.1 Reductions of supply pressure

This saves energy in two ways. Firstly, the air is not compressed as much and, secondly, all loads, including leakage, take less flow because the supply pressure is lower. With a variable speed compressor, fluctuations in supply pressure are reduced so that the minimum pressure becomes closer to the average during a control cycle. Furthermore, the compressor installation included a new air storage vessel place close to the Drent, which should further reduce fluctuations in that area. The net result is that it should be possible to operate with lower set or average pressure without compromising operations due to an unacceptably low minimum pressure.

Each 0.1 bar pressure reduction results in a 2%, roughly 1kW, energy saving. So a reduction to 5.8 bar gauge from 6.8 bar gauge would save 20% of compressor energy or 11.2kW (£9800p.a.).

2.2 Automated air bar supply control

This involves shutting off the supply to the air bars (turning bars) when the machines are stationary. According to data collected in summer, 2011, machines are often stationary for 1/3 - 1/2 of the time with the air bars on. This would achieve a saving of 6kW out of the 45kW consumption (after reducing pressure) for all machines or roughly 3kW for Drent alone. Cost savings are £5250 for all machines or £2625p.a. for the Drent alone. The cost of the valve permachine is £200, this being the only cost if the control circuits can easily be linked to the valve.

2.3 Reduction of air bar pressure supply to 1bar gauge for the Drent

This would save 70% of the energy used to supply the Drent air bars, which can be estimated, after previous savings, as 5kW (£4380p.a.). Reduced savings may also be available for press 2. The cost of doing this may be minimal if the valve used for the previous measure can be modulated. Reduced savings, perhaps around 2kW, may be available for press 2.

2.4 Inlet air for compressor to be taken externally to building

When external air temperatures are low (in the winter) this can result in considerable savings. If the inlet air temperature drops from 270C to 70C, there is a 6.7% energy saving when compressing the air to the same pressure. However, in summer, there would be little saving. Assuming an average temperature difference of 100C during the year, the saving amounts to 1kW (£876p.a.).

2.5 Use of centrifugal blower to supply air bars

Through the previous measures, air bar supply consumption has already been reduced from 18kW to 5kW. This could be further reduced by the use of a centrifugal blower by 3kW (to 2kW). However, if the other proposed measures are successful, then the saving (£2500p.a.) is quite low. It is probably still worth implementing, although the cost of a blower could be £2000 and it would require some additional maintenance expenditure.

Conclusions

1. Table of savings

Measure	Saving (kW)	Saving (£pa)	Cost (£)	New consumption (kW)
Supply pressure reduction	11	9800	0	45
Automated air bar control	6	5250	1000	39
Air bar pressure	5	4380	0	34
External inlet air	1	875	500	33
Low pressure blower	3	2500	2000	30

2. Basis of calculations

Some of the savings are based on purely theoretical calculations, notably those concerned with air bar consumption. It might, at a suitable time (weekend), be wise to check them by switching various air bar supplies on and off and observing the compressor response. The response should be fairly rapid so test time need not be lengthy.

3. Compressor operation at low loads

The maximum load on the compressor is 75kW. It can be turned down over a limited range, but it may not be possible for continuous operation at 30kW. In this case, it may be sensible to maintain some flows or pressures slightly higher than the bare minimum, which the above savings are based upon. As the operational efficiency declines with the load reduction, it may not be worth implementing measures 2.4 and 2.5, although they are achievable at fairly low cost.


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