Energy is used in a variety of forms in modern industry. Whereas previously we may have only considered our overall energy usage as being a sufficient level of granularity, it is now important to consider each of these as an area for optimisation. The starting point is to minimise wastage.

ELECTRICITY + CONTROL
E+C Spot On

Measure to manage

By C Gimson

In any form of energy efficiency strategy, it is important to have clear and concise data as to the status of the process from an energy perspective before embarking on any savings initiatives. It is also critical to have continuous data on the process once initiatives are put into place to continue to save energy. The simple reasoning behind this was expressed by Lord Kelvin many years ago, when he said: 'If you cannot measure it, you cannot manage it'. In simple terms, if you do not know where you are starting from, you will not be able to select the correct areas of the process to target where the greatest gains can be made, nor will you be able to verify whether or not your initiatives are successful.

Much has been written about monitoring and targeting strategies for energy efficiency, and I will expand on this in relation to the food and beverage industry. Energy management must be viewed as a continuous cycle, as depicted in Figure 1. Step 1 is to collect data, ie measure, Step 2 is to analyse the data and Step 3 is to report on the data you have analysed. This in itself will not save you anything, but the 4th and most important step is the actions you take based on the data you have in hand. Without this initial data you have no clear point of departure for your initiatives, no guide to direct you to the best areas to start with and no proof of success on the action you take. It is critical from the start to know where the areas are to target.

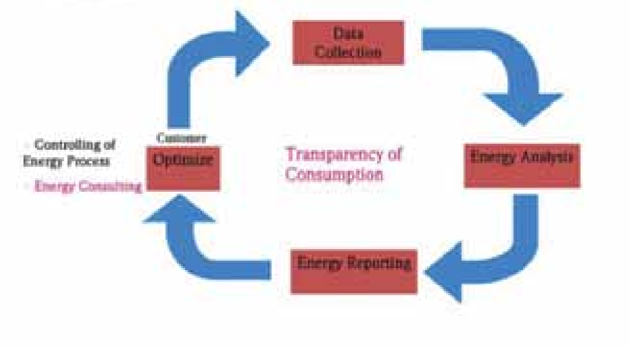

Figure 1: Energy management as a cycle.

Typically, the focus will be on pure electrical users, but there are in fact many target areas to look into. We use the term 'WAGES' for these energy consumers, ie water, air, gas, electricity and steam. Each in itself is a source or user of energy, and as such must be included in the energy balance. When developing an energy strategy, we must also consider the important issues of accuracy versus reproducibility, selection of technology and installation criteria. Also to be considered is what savings strategy to implement based on the data provided by the system and scenario planning using the data to predict savings and actions.

Typical areas of and methods to reduce consumption

Food and beverage (F+B) processes lend themselves particularly well to the WAGES approach, as they are typically large users of all forms of energy in this group. Let us discuss each one in turn.

Steam

This is generally one of the larger energy dependent users in the F+B process, and large savings can be made with little effort by application of some simple methods and actions. Steam usage is wide in an F+B process, and includes applications such as heating, steam in place (SIP) cleaning and boiling in the process. Within these processes losses can be frequent and extensive, and can come in the form of steam leakage, lack of insulation, condensate losses as well as inefficient boilers themselves. According to a guide book produced by the University of Cape Town, leakage losses can be as much as 160 kg/hr from an 8 mm hole, and lack of insulation can result in up to 550 W/m on a 100 mm pipe [1]. These are just two examples of where energy is lost on steam applications.

Implementation of monitoring systems on steam should begin at the boiler houses themselves. As a starting point, each boiler should be monitored at the following points: Fuel supply, incoming feedwater, outgoing steam and condensate return as well as incoming and outgoing temperatures. From these metering points the system can then derive the boiler efficiency and specific consumption of the boiler and determine the condensate losses. With this information, the user will then have a clear picture of his consumption, losses and efficiencies, and will be able to profile the boiler against production. The user will already be able to quantify the usage and cost of losses in energy and financial terms. Some strategies to improve the energy profile could include boiler optimisation using air/fuel ratios (up to 20% savings in energy [2]), pipework insulation (up to 4% savings in energy [2]), and elimination of leaks and losses on steam and hot water systems (up to 50% savings in energy [2]). Once this is done the system will be able to quantify the value of the improvement in energy terms, and provide a clear payback time for the initiative.

When the boiler house has been addressed, the user should consider the distribution network of the complete steam system. All major users and departments on the process should be metered. Once again a consumption profile of each department and user can be developed against production. The performance of the area, department or item of plant can then be compared against the profile, and any deviation quickly addressed. Initiatives can once again be put into place based on the data collected. By referring to the data, the biggest users/loss areas can be targeted up front, followed by the smaller areas. At this point it is critical to mention that departmental measurement is one of the most successful methodologies for improving on wastage and leakage. By putting the costs of the steam used into departmental costs and KPIs (key performance indicators), energy savings initiatives become sustainable. It is well accepted that simply by making the consumption visible to the users and raising their awareness using the data, savings of up to 15% can be achieved. By addressing the unnecessary operation of equipment, plant energy on steam can be increased by up to 200% [2]. Reduction of waste and losses can be achieved by steam leak detection and elimination as well as pipework insulation with similar reductions in energy usage. Other items to look at are steam trap leakage (up to 20% savings in energy [2]) and flue losses. All these areas can result in large improvement in energy usage, but without data to guide the user, there is little chance of achieving and sustaining energy savings on steam systems. At each step after completing a savings initiative, savings can be quantified and payback period determined. A new profile is produced by the metering system after each initiative is completed, and this becomes the target to work towards.

Compressed air

As with steam, compressed air is another big user of energy in an F+B plant, with electricity as the direct energy source. It is also one of the most abused sources and users of energy, as plant personnel generally are not aware of the costs, in energy terms, of producing compressed air. Usage of compressed air is common as instrument air, plant air and in large items of machinery such as blow moulders and filling machines in particular. Major areas of loss are due to leakage, pressure drop and misuse. It is estimated that on a typical compressed air line at a free air delivery of 22 cfm, a 3 mm hole in the line results in the continuous equivalent power loss of 3,5 kW [3]. If you work this back to energy terms it equates to 84 kWh per day (24 hours).

This is around 1 680 kWh per month based on 20 days usage per month. At an assumed tariff of 80c per kWh, the line is losing R1 344 per month on one leak. Now consider 50 leaks of 3 mm each, which is fairly conservative, and you get a loss of R67 200 per month, just on leaks. If you have 200 leaks, this jumps to R268 800 in losses just on air. Now we have to bring pressure drop into the mix. According to the University of Cape Town research, at a free air delivery of 471 cfm at 7 bar(g), a 50 mm nominal bore pipe will have a pressure drop of 2,6 bar per 100 m [3]. This results in a power loss of 18 kW continuously. Again, a monthly energy cost to drive the air in this line using the same figures as in the leakage example is R6 912. It is well accepted that for each one bar of pressure loss in a line, the energy cost at the compressor is around 6 - 8%.

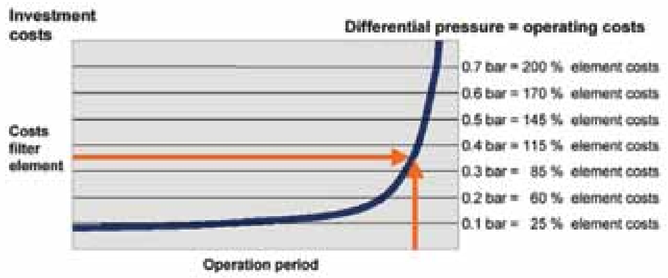

Figure 2: Ratio of energy costs to filter element costs for compressed air efficiency.

In many older processes, these pressure losses are substantial, mainly due to the fact that the consumption on the process well exceeds the design of the plant as there have often been additions to the line without consideration for upgrading the line size accordingly. Another big area of pressure loss is in filters, a largely ignored area of energy loss. According to a study done by the Fraunhofer institute, it is financially viable to replace a filter element at around a pressure drop of 0,35 bar, as beyond this the loss in energy far outweighs the cost of the element [4], as depicted in the graph on Figure 2.

Once again the strategy to improve the situation is the same as described for steam applications, ie measure, profile, target and act according to the data, and repeat the process continuously. Improvement initiatives include leakage detection and elimination, reduction of wastage by raising awareness using the data, reducing pressure losses on wrongly sized pipework and replacement of blocked filter elements. Substantial savings can be made by using a fairly simple approach to the problem, but the key element is to have the data at hand to ensure the success of any initiatives.

Energy sources (fuel and power)

It is important to include all energy sources into the energy balance, and typically in a F+B process these would be in the form of electricity (of course) and fossil fuels. Fossil fuels would include fuel oils (heavy and light), coal, diesel and natural gas. For compressors the energy source would obviously be electrical supply, while diesel is generally used for back-up power generation purposes and the other fuels for boilers. Including these in the measurement is important from two aspects, primarily to measure consumption, but also to be able to produce specific energy per producer. By way of example, compressors' delivery could then be measured in kg air per kWh of power, while steam would more than likely be kg fuel (or kWh in the case of electrode boilers) per kg of steam produced. This is an important measure as it gives a clear picture of the specific consumption of the item of plant related to power, and can be related back to costs by introducing the fuel price into the equation.

Being able to view the consumption in financial terms makes the costs of producing the air or steam transparent to all. Using the specific consumption figures, the data can then be used to highlight the actual costs of usage down to departmental and plant levels. This will raise in users an awareness of the consumption costs as well as the costs related to failures, losses and inefficiencies in the department. It will also highlight the successes made through savings initiatives in financial terms.

Water

Our final measurement target in the WAGES scenario is of course water. This is often ignored in the energy balance as it is not seen as an energy source or user. Apart from the costs of the water itself, costs from an energy perspective are incurred by the pumping of water (directly in pump power costs).

If the water is heated, it again becomes a direct energy user, and should be included in the balance. Measurement of consumption and heating can then be used to calculate the heat losses and heat efficiency in the water cycle. Exactly the same strategy as with steam and air can be followed to generate a clear and transparent view of the water cycle from an energy perspective.

Technology selection, sizing and installation to ensure accuracy and reproducibility

Each of the above items must be carefully considered when looking at measurement of energy parameters. Much can be written on this subject, but it is worth briefly mentioning the issues to be looked at.

Technology selection is the first and most critical step in ensuring that the metering point is giving reliable and accurate data to the system. Most users make the mistake of purchasing the most cost effective measurement technology, which saves costs up front, but in the long term through the lifecycle of the instrument, will cost the process more in inaccurate measurement.

'Fit for purpose' is the critical phrase here. In selecting meter technology, careful attention must be paid to the process parameters. Issues such as actual flow rates, temperatures, pressures, quality of the process medium and many other physical parameters must be considered. Also to be looked at are the requirements for accuracy and reproducibility in line with the technology's capabilities. Only then can the correct technology be selected. Once the technology has been selected, the second and also very important step is to ensure correct installation. Many expensive metering points are worthless to the process as the installation criteria have not been met, and the data being transmitted by the instrument is useless or misleading. Simple issues such as upstream and downstream straight runs and upstream disturbances can cause great effects on the flow profile across the instrument, resulting in inaccurate readings. Gas entrainment, pressure drops, temperature requirements and a multitude of other process conditions must be looked at to ensure a good measurement with the selected technology.

Each technology will have its own requirements, and must be looked at independently for each measurement point. In some cases, accuracy can be substituted with good reproducibility, as long as the data requirement allows this and the users are fully aware of the consequences of the reduced accuracy. If a more inaccurate reading is being produced, but the reproducibility is good, allowances can be made for increased inaccuracies in the system receiving the data. In many cases the inaccuracies will be known and can be compensated for.

Using the data

Once the correct data is arriving into the system, what do we do with this information? A structured process of measurement, data handling, reporting and action should be followed (see Figure 1). The data will not save the energy, but point the user in the correct direction to make the initial savings and sustain these savings. The process should follow the following steps:

- Collect the data and input into a suitable historian or data management device.
- In analysis, create initial benchmarks of the process. This can be split into baseline (consumption under non-productive conditions) and production profiles (consumption versus production).
- Produce relevant reports for the users.
- Determine actions and initiatives based on the data information.

Initiatives may include such actions as leak detection programmes, user awareness campaigns, replacement of defective or inefficient items of plant, installation of energy efficient equipment and energy recovery equipment, and optimisation of the process based on energy profiles. Each of these initiatives should be justified by the data and savings and paybacks confirmed by the system.

Conclusion

In the F+B industry, most processes are extremely energy intensive. Energy savings can be fairly easily achieved in most of these processes, but often the users are looking in the wrong places to make the savings. The availability of data is a key element in achieving up front energy savings, and once the savings are made the data is critical to sustain these savings. Energy management must be seen as a continuous cycle, not a single point activity, with savings made being sustained by the use of accurate and clear data.

Areas to look at when addressing energy savings in a typical process are termed WAGES. The methodology to make these savings in the WAGES areas is easy to follow. The critical item to ensure savings are being targeted in the correct areas, and proof of the success and sustainability of the initiatives, is the availability of data. The selection, application and installation of technologies are critical in ensuring that the data being produced by the measurement point is reliable and usable by the energy users. In the final step, the use of the data is the most important point in the process, as whatever the data is telling you, if you do not act on the information, the savings will not be realised. Each step in the above methodology is important, and missing any of these steps is likely to result in a failed energy efficiency initiative. To sum it up, get reliable data and, have a plan!

References

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Energy & enviroFiciency

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