Switched-on energy saving

Dr Nigel Smith, Dr Philip Taylor and Tim Matthews describe how the cost-effectiveness of small hydro can be improved through intelligent load management

IN RECENT years a considerable amount of effort has been spent on reducing the capital costs of stand-alone hydro schemes. Savings have been made in a number of areas, including standardising components, replacing mechanical and hydraulic controls with power electronic-based systems, and using labour from project beneficiaries. However, little attention has been given to improving load factors.

Stand-alone hydro schemes are often characterised by high peak and low average demand. This is particularly the case with community electrification schemes in developing countries. Average demand in such schemes may be just 15-20% of the peak demand.

This means that at peak times generators are overloaded, resulting in undervoltage operation when overloads are small, and repeated tripping when overloads are large. The result is customer dissatisfaction and productivity losses where there are income-generating activities. But during times of low demand, the power from the hydro is only partially utilised and, since most stand-alone schemes are run-of-river, available energy is wasted. This reduces the benefits to the recipients and the overall cost-effectiveness of the scheme.

The technologies

Two technologies for demand-side management can be used together to tackle the problems of overloading and low load factors.

The first option is peak demand control by means of current limiters. The use of kWh meters is so widespread that it is usually assumed that direct measurement of electricity consumption is the only acceptable basis for charging for an electricity supply. However, kWh meters do not limit peak demand, and as a result there are many stand-alone electrification projects where demand has risen and exceeded the supply capacity with serious consequence to supply quality and reliability.

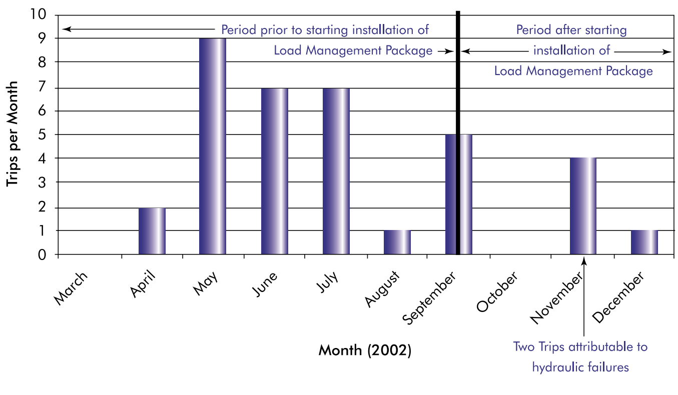
With a current-limited supply, the consumer is allowed to draw a current up to a prescribed limit at all times and pays a fixed monthly service fee according to the rating of the current limiter. If the customer exceeds the limit they are temporarily disconnected. By fitting current limiters to all connections the maximum demand can be controlled to within the capacity of the generator. Demand growth can be managed by upgrading to higher rated current limiters only in the event that there is surplus capacity.

The concept of a fixed or limited current connection is well established, although until now it has suffered from a lack of suitable technology. In Zimbabwe, standard miniature circuit breakers are used as current limiters, replacing metered supplies to more than 100,000 households connected to the main grid.

However, these circuit breakers have a serious drawback – as they have to be readily accessible for resetting, they can be bypassed easily by fraudulent consumers.

A purpose-designed current limiter, called PowerProvider, has recently been introduced which auto-resets after a fixed time delay. These are more convenient to the user: in the event of a trip, they can just reduce their load and wait for the power to come back on. In addi-

Figure 1: Occurrences of Whole Electricity System Trips



Above: View of the turbine house at Kisiizi hospital in south west Uganda

tion, they are more secure against tampering and bypassing as they can be mounted on a service or distribution pole outside the house.

The fixed monthly payments for a PowerProvider supply make budgeting easier for the consumer and reduce the likelihood of defaults on payments. An annual advance payment option can be offered to enable farmers to pay for their supply when income is generated at harvest time.

The second technology is distributed load controllers to improve off-peak energy utilisation.

Most small hydro schemes below 250kW use an electronic load controller to regulate the generated frequency by dissipating any surplus power in a resistive load known as the ballast or 'dump load'. For schemes of this size, such controllers are cheaper and more reliable than flow-control governors. The energy dissipated in the ballast is rarely used productively. There are a number of reasons for this:

- *The ballast heaters* are usually installed in the turbine house to be cooled by running water and this is often remote from the consumers.
- *The uncertain and variable* power dissipation is unsuitable or inconvenient for many applications.
- *The ballast is essential* for correct operation of the hydro system and therefore it should not be used for any application that may compromise its reliability.

The distributed intelligent load controller (DILC) allows productive use to be made of the surplus power available without overloading the system.

A number of DILCs are fitted at convenient points on the distribution system, each controlling a low-priority load – typically water heaters or room heaters. The DILCs sense the generated frequency and switch on their loads when the frequency is normal.

Overloading will cause the frequency to fall and the DILCs sense this and switch out the loads that they control. The DILCs can be set at different frequency thresholds so that their loads can be prioritised. The use of DILCs enables more productive use of the generated power, reducing the amount of energy that is dissipated in the ballast.

The following case study shows how, by using both DILCs and PowerProviders, problems with overloading can be solved and more productive use of energy can be achieved

Kisiizi hospital, Uganda

Kisiizi hospital was founded in 1958 and is situated in south west Uganda. It serves a large rural area. In the mid 1980s, a 60kW hydro system was installed using a turgo turbine, synchronous generator and electronic load controller. This replaced a smaller hydro system and is the only electrical power supply for the hospital.

As well as supplying power to the hospital, the generator supplies accommodation for the management, doctors, nurses and ancillary staff. From the outset the power was supplied free of charge and seen as beneficial for attracting quality staff. Over the years the hospital and staff numbers have grown and by the early nineties the load was exceeding the power generated at peak times. The consequence was that the overload protection system would shut down the turbine and the entire hospital complex would be without power.

A number of attempts have been made to control the peak demand. These have included installing time switches on water heaters so that they operate only at night and confiscating electric cookers and other high-power loads from residences. However, improvements have always been temporary, as demand in the hospital has continued to grow and some staff have failed to obey the restrictions on appliance usage.

By 2001 the extent of the overloading problem was such that it frequently proved very difficult to reduce the load after a trip to a level where an immediate repeat trip would not occur. As a result, an isolation switch was fitted so that the entire residential supply could be disconnected if necessary. This was a drastic measure in view of the effect on the staff and their families.

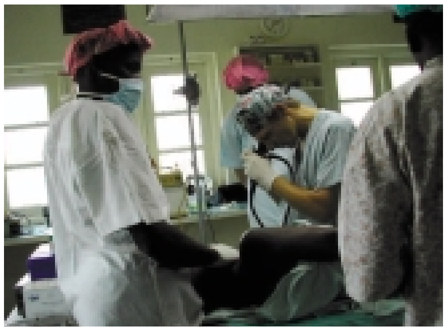
After discussions with management and staff at the hospital, a new load management package was designed to provide the following:

- *A secure supply to the hospital.*
- *Limited secure supplies to the staff houses for essential loads, such as lights and refrigerators.*
- *Additional power to the staff houses at off-peak times, such that water heaters and other high power appliances can be used when sufficient power is available.*

The limited secure supplies used 83 PowerProvider-type current limiters, one fitted to each house. The current ratings are 1A, 2.5A and 5A, which correspond to 230VA, 575VA and 1150VA. The current rating fitted was determined according to the seniority and needs of the particular staff member. If a household tries to exceed the current rating of their supply they are inconvenienced by temporary disconnection, but the supply to the hospital and other residences is safeguarded.

DILCs are used to provide extra power to the staff houses at off-peak times. Senior staff houses and communal buildings such as the nurses' hostels were fitted with 40 DILCs. A dedicated electrical circuit, separate from the circuits limited by the PowerProvider, is supplied for the DILC and provided a bonus supply of up to 13A.

Some DILCs were designed to replace time switches on the water heaters and others were fitted with a standard socket so that other high-power appliances such as cookers, irons and kettles could be



Above, left to right: An incubator at Kisiizi hospital; view of the hospital complex; photograph showing the hospital operating theatre

used. The trip frequencies were set at 47-49Hz for the water heater DILCs and 46-47Hz for the other DILCs. At the rated frequency of 50Hz all the DILCs are switched in. When the hospital load is increased so that the generator output is exceeded, the frequency falls and causes some or all of the water heater DILCs to switch off. At higher hospital loads, some or all of the other DILCs are switched off. The supply to the hospital is secured and the high-power domestic appliances have a higher priority than the water heaters.

The PowerProviders and DILCs were fitted between September and December 2002. Generator performance data, prior to and after fitting of the units, was obtained by a computer-based monitoring system that was installed in March 2002.

There was a clear reduction in the number of trips (see Figure 1 on p27), which indicates that the load management package is producing a marked benefit. Some system trips are due to trashrack blockages or problems with the turbine-generator and not a result of overload and therefore it is possible that none of the trips in November or December were due to overload.

As well as this improvement, in terms of fewer system trips, there has been a noticeable increase in the amount of power consumed in the hospital and residences and hence a reduction in power dissipated in the ballast. Figures 2 and 3 show results for a typical day prior to installation of the load management package and at the end of the installation period. With all the DILCs and PowerProviders installed there is an increase of more than 15% in the power consumed in the hospital and residences and little or no power is dissipated in the ballast between 7.30am and 11.30pm.

There was an initial period of disquiet as people went through a learning process and established a practice of switching off loads when they were not required so as to free up their PowerProvider-controlled supply. Households that did not have a 5A PowerProvider or access to a DILC socket complained that they were unable to iron with their electricity supply. This is being overcome by providing more DILCs in communal areas and offering to modify the power consumption of existing irons so that they can be used with 2.5A PowerProviders.

Overall the feedback has been positive, with praise for the improved reliability of the supply both in the hospital and homes. Also there has been a significant increase in the amount of hot water available and people are pleased once more to be able to use cookers, kettles and other previously banned appliances.

DILCs and PowerProviders are complementary technologies, which are now proven to improve the reliability and productive use of power from small hydro schemes. They can be used to overcome problems with overloading and poor energy utilisation on existing schemes, provided that there is strong management. However, they are best installed at the beginning of hydro projects so that good practice is introduced from the outset. IWP&DC

Figure 2: kW Hours Energy Consumed
12 July 2002

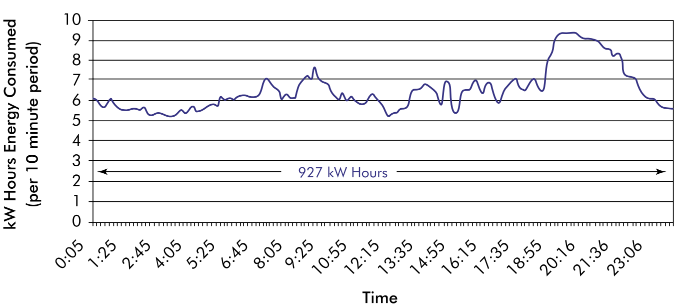
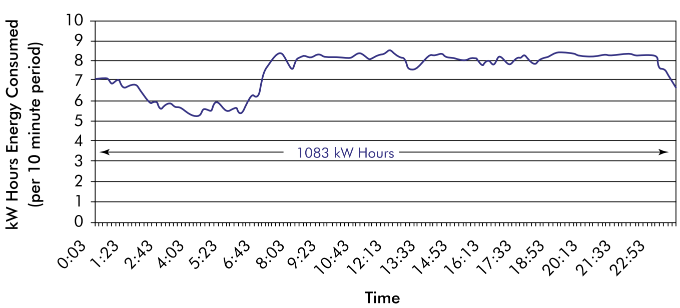


Figure 3: kW Hours Energy Consumed
13 December 2002



The authors are Dr Nigel Smith, Sustainable Control Systems Ltd, 4 Charleston House, Peel Street, Nottingham, UK and Dr Philip Taylor and Tim Matthews, Econnect Ltd, 19 Haugh Lane Industrial Estate, Hexham, UK

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