USER PERCEPTION OF DEMAND SIDE MANAGEMENT

Vincent THORNLEY, Ruth KEMSLEY, Christine BARBIER, Guy NICHOLSON
Econnect Ventures – UK
vincent.thornley@econnect.com

ABSTRACT

Demand Side Management (DSM) is about participation of electricity users in the management of electricity networks. Econnect's experience in demand side management is obtained through the application of Distributed Intelligent Load Controllers (DILCs) to off-grid networks where the benefits are obtained by users through higher system reliability. On grid networks the benefits are increasing efficiency, opportunity for greater renewable energy and (on some grids) improved reliability. If demand side management is to be applied on grid networks users must accept the potential for load disconnection. The reasons for non-acceptance and proposals to increase acceptance are discussed. Comparisons are drawn between off-grid and on-grid scenarios.

INTRODUCTION

Consider yourself in a hospital operating theatre in the middle of Africa. The surgeon is mid-operation at a crucial point, and the lights go out. Whichever role you pictured for yourself the prospects are daunting. Or then you may be the general manager of a diamond mine who has just lost a day's production due to a scheduled rolling blackout to limit load on a struggling network. Both of these events, while on different scales of consequence, and in very different grid situations, are connected by a common cause: insufficient generation to meet demand.

For off-grid networks (alternatively called island networks or mini-grids) the prospect of insufficient power to meet demand is common. For large grid customers blackout events are usually unknown. It is the system operator's job to ensure that sufficient power is available and to carry out balancing on a minute-by-minute basis. However, grid system operators will usually act to prevent grid-wide blackouts by taking pre-emptive action – rolling blackouts is a solution which is becoming more commonplace, and can result in severe financial pain for customers.

The standard response for such problems is to increase the size of generation; however, this is not the only solution. Demand Side Management (DSM) is about participation of electricity users in the management of electricity networks through adjustments to the magnitude and time of energy usage. This can smooth the demand profile for the network, or match it to the available supply profile. The benefits of this include:

- reducing the cost of providing electricity by reducing the peak power requirements, reducing or eliminating the need for spinning reserve and allowing access to more efficient generation;
- ensuring continuity of supply when power demand is close to the maximum power system supply capacity; and
- allowing increased penetration, and increasing use of, renewable energy sources whose supply profile is variable, particularly when it is irregular.

Demand-side management can be applied at very small scale, whereby distributed individual loads are controlled automatically in response to operational requirements; up to large scale, in which major energy consumers agree to adjust their energy consumption profile. Small-scale distributed demand-side management may involve externally-enforced adjustment of usage patterns, and disconnection of appliances at a time when their use is demanded. The extent to which this is considered acceptable is dependent on the extent to which the benefits directly impact on users.

LOAD CONTROLLERS

Econnect's experience in demand side management is obtained through the application of Distributed Intelligent Load Controllers (DILCs). These devices rapidly switch off when the system frequency falls beneath a setpoint and perform a delayed switch-on when the frequency is restored above the setpoint. The switch-on delay is random to ensure a smooth recovery of the system and provide an element of fairness between different disconnected users. The devices are intended to be applied to individual appliances and circuits throughout an off-grid network to give incremental control over the network.

Load Controllers can be deployed for load shedding or load adding purposes, depending on the applied frequency setpoint. When used for load shedding, the Load Controllers fulfil the requirement to ensure continuity of supply by switching off non-essential loads. It is this function that protects against the blackouts described in the introduction to this paper.

With load adding the Load Controllers switch on additional "bonus" loads in response to an excess of power. This is especially applicable with off-grid systems with renewable generation such as wind and PV, where if the power is not

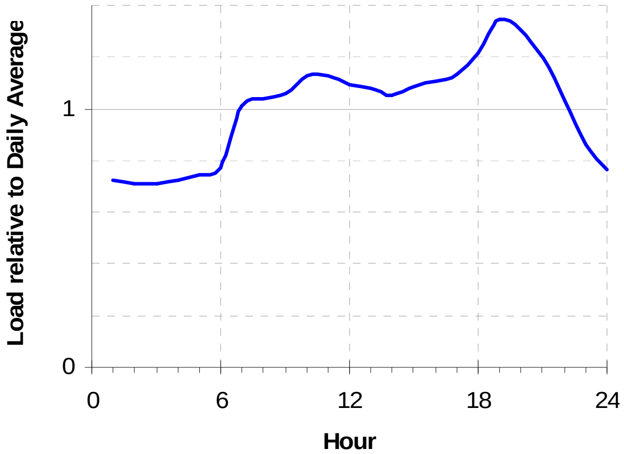

Figure 1 Daily Load Profile in February for St. Helena

Figure 2 Plug-in Load Controller (with Kettle)

used it is lost. Storage devices such as batteries are an essential feature of such systems, and when the batteries are fully charged the load controllers allow surplus renewable energy to be usefully employed.

USE OF LOAD CONTROL

Off-grid Communities

In common with all networks, off-grid networks see a varying load profile over the course of the day - Figure 1 gives an example from the Island of St. Helena. With smaller networks the peaks of load are usually more pronounced through a lack of load diversity. Load Controllers provide the possibility of smoothing the load, removing the peaks and filling in the troughs. If the available generation is peaky, as provided by photovoltaics (PV) or wind, the load can attempt to match the generation profile more closely.

Although Load Controllers can be wired into networks, Econnect has most often employed them in the form of plug-in devices such as pictured in Figure 2. When the frequency falls due to insufficient energy the device will switch off the load – in this case a kettle. The advantages of plug-in devices are that they are easily and rapidly deployed with a low skill level required.

Readers who are used to the secure benefits of a grid network may at this point be exclaiming "but surely users will simply bypass the device" and this response is interesting in the context of grid networks, as discussed later in the paper. However, people who live and work in isolated communities with off-grid supplies, and who have suffered the inconvenience of frequent black-outs understand the benefits that load control can bring. Users are encouraged not to bypass the devices if appropriate loads are selected carefully and fairly, and the need for and use of the load controllers is explained well. Buy-in from the community together with evidence of the improved electricity supply that is provided by demand side management helps to ensure that users do not bypass the devices to avoid the mild inconvenience of a delayed clothes wash or interruption to vacuuming.

Grid Networks with Insufficient Generation

Most grid networks have surplus generation and rarely, if ever, suffer large-scale blackouts as a result of insufficient generation to meet demand. However, there are some, such as the Southern African Power Pool, where developments of industry are occurring faster than the energy supply industry can keep up. South Africa, particularly, has been noticeable in recent months for imposing rolling blackouts to prevent complete collapse of the grid.

This is a situation where widespread deployment of demand side management on "non-essential" loads could act to prevent grid collapse while removing the need for rolling blackouts. However, for this to be a success one of two criteria must be fulfilled: enforcement or buy-in.

For demand side management to be enforced, Load Controllers must be installed in a manner that they cannot be bypassed. This is likely to be impractical on such a large scale. The other possibility is a willingness of the population to accept and embrace the use of demand side management. Users will be well aware of the inconvenience of the rolling blackouts so the potential benefits (a secure grid supply) are clear. However, when compared with the off-grid community it is not likely that users will readily accept interruptions of loads.

The reasons for this are twofold. Firstly, there is much lower correlation between a load being on and grid collapse. For a small off-grid network if a user unplugs the load controller, bypasses it and plugs the kettle straight into the wall, when the load controller has disconnected it, there is a good chance of an immediate grid collapse – i.e. blackout. This is an instant demonstration of the reasons for load control and should act to prevent future violations. Whereas on a large grid network such as that of South Africa it is unlikely that one extra kettle will result in the demise of the grid.

The second reason is community. For an off-grid network the community truly lives together, enjoys successes together and suffers failures together. The benefits of demand side management are clear for all to see so it gains the buy-in of the whole community. The community lives on trust and each person realises that if he or she breaks that trust and misuses a load controller it is the community as a whole that will suffer.

With a large grid network the number of people bound together is in the millions, such that there is not the same sense of community between all the people who benefit or lose from the use or abuse of demand side management. To obtain buy-in for altruistic rather than economic reasons requires the population to be small enough that all members identify with the community. Otherwise it is likely that short-term personal gain will win over longer-term community gain, i.e. the demand side management device will be bypassed to prevent a temporary interruption, at the expense of benefit to the grid. Artificial, probably financial, incentives may need to be provided to encourage users to accept DSM.

Increasing efficiency of grid networks

Demand side management can be used to increase network efficiency by, for example, reducing the need for spinning reserve. However, if the likelihood of buy-in by whole populations to protect their grids is low, then for the purposes of increasing efficiency it is close to impossible. When used to protect networks the inconveniences and benefits of demand side management are suffered and enjoyed by the same people – the users of electrical appliances. However, in the highly developed grid networks such as those of Europe this is not an issue.

Spinning reserve is maintained by system operators to allow balancing of load and generation on a minute-by-minute basis. If there is a shortfall of generation to meet demand the frequency will fall, and the system operator will call on the spinning reserve to fulfil the shortfall. Demand side management can be used in this situation to reduce load and rebalance the load and generation.

But here the benefits and inconveniences are not aligned. For instance, on a Scottish island or remote village in Africa the inconvenience of disconnection from time-to-time is often outweighed by the benefits of having a 24-hour, continuous, lower cost electricity supply. In contrast, for a grid connected user in the UK, the direct benefits are rarely seen by the user, while the inconvenience of disconnection is unlikely to be acceptable.

A proposition is required which users must find acceptable to mitigate the inconvenience of periodic disconnection of appliances. To some, the benefits of enabling low carbon technologies will be sufficient, however, many people will require financial motivation.

In today's market-led grid networks there must be a market need for any action. If the market forces were sufficient it would be possible to persuade users to accept occasional disconnection of loads. This is something that is technically achievable if market regulators and system operators create suitable market opportunities and appropriate market mechanisms.

In the UK there is a market for ancillary services including the provision of spinning reserve. An aggregator could offer demand side management into the market as a form of "negative load", and pay individual users to participate. The payment could be by usage of the facility (i.e. when a load is interrupted) or payment by facility (i.e. a rebate if a demand side management facility is installed regardless of whether it is used). However, what level of financial compensation is sufficient to encourage large numbers of users to accept the possibility of load disconnection? What price do users put on 24 hour power and what price are consumers and generators willing to pay to reduce their overall carbon footprint? It is likely that the price will not be high enough to justify the use of distributed demand side management as a spinning reserve

The above discussion is based on the proposition of customer load disconnection, however, demand side management may also involve switching on loads. Demand side management can also be applied at a local level when there is local generation available. For instance, in the absence of feed-in tariffs, it is financially sensible to use all available renewable generation locally rather than exporting it to the grid. There are also less tangible benefits, such as the ability to reduce consumers' carbon footprint by maximising their use of renewable power. Paper [1] addresses the scheduling of loads to coincide with generation. It looks at the technical and social aspects of

Table 1 Comparison of Inconveniences and Benefits of Demand Side Management

	Off-grid Networks	**Grid Networks with Generation Shortfall**	**Grid Networks with Sufficient Generation**
Principal Benefits	• Ensure continuity of supply • Increased efficiency • Increased opportunity for renewables	• Ensure continuity of supply	• Increased efficiency • Increased opportunity for renewables
Benefits Directly Obtained by	• Energy users • Community energy company	• System operator • Energy users	• System operator
Inconvenience	Intermittent disconnection of appliances		
Inconvenience suffered by	Energy users		

demand side management in this scenario, and initial results suggest that the prospect of automatically switching on loads is more acceptable to users than automatic disconnection. Previous research [2] has also shown that a means of alerting users to the availability of renewable power so that they can voluntarily switch on non-time critical loads is the favoured mode of operation. In the reverse scenario, where no renewable power is available, a key unknown is the price which consumers and generators are willing to pay to reduce their overall carbon footprint.

INCREASING DEMAND SIDE MANAGEMENT

Table 1 compares the benefits of demand side management for different situations. What is clear is that the areas where demand side management are well accepted (i.e. off-grid networks) are those in which the benefit and inconvenience are closely aligned. If it is desired to see greater use of demand side management in grid networks, it is likely that either the benefits must be directed more specifically or some other form of financial motivation or stimulus needs to be introduced.

For grid networks with generation shortfall one solution could be to create local pools which are disconnected in low frequency situations if the load is too high. This then creates community level motivation to embrace demand side management as a means to avoid disconnection. Creation of local backup or standby generation for the local pool would help to reinforce this community.

For the grid networks where the aim is to improve efficiency it is clear that financial motivation is required. Time will tell whether it is possible to create a sufficiently motivating market for small scale users to be willing to participate. However, as energy prices continue to rise the economics will swing more towards disconnection of load as a means of providing spinning reserve, rather than unnecessary wastage of energy resources by turning generator sets at poor efficiency with low power output.

CONCLUSIONS

Demand side management provides tangible benefits in the off-grid scenario and has been in use in relatively limited applications such as island power generation for many years. It is likely that load controllers will see further adoption in other off-grid settings in the coming years, such as industrial islands and with standby diesel generation. A major challenge for the next decade is to create incentives for grid-connected users to co-operate with demand-side management, in order to allow distributed demand-side management to assist with improved overall system operation at a utility scale.

This may be achieved through the artificial creation of community benefits and the encouragement of market aggregators to offer demand side management into the ancillary services market.

REFERENCES

[1] P. Taylor, H. Svendsen, C. Barbier, and C. Welby, 2008, "Demand for Wind, Maximising the Value of Wind Power through Demand Side Management", *presented to CIRED Smartgrids Seminar*, Frankfurt, 23-24 June 2008.

[2] Econnect Ltd, 2005, *Local Load Management System and Intermittent Power on the Grid*, URN05/1275, London, DTI.