Issue No. 6 | August 2010

NERA
Economic Consulting

Can Smart Metering Deliver Benefits to Rural and Remote Communities?

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Energy Market Insights

From the Editor

"Smart grids" are one of the hottest topics in electricity, so we focus in this hottest (Northern Hemisphere) season on one aspect of smart grids: remote metering in remote locations. Smart meters are of course only one part of the "Smart Grid" concept, and this month's *EMI* discusses an extensive cost-benefit study performed in Australia. Good cost-benefit work requires careful thought to create relevant categories of costs and benefits, good survey design to select relevant test areas, and the use of appropriate methods to calculate and aggregate the results. The results are a fact-intensive inquiry, which highlights the need for a careful evaluation of local circumstances before generic statements about net benefits can be made.

Jonathan Falk, Editor

Introduction

In the not too distant future and whether you like it or not, electricity businesses are going to have a lot more information about your electricity use at any time of the day or night. There will not be a need to send someone every month or quarter to read your meter so you can be sent a bill, and when you move and the power needs reconnecting, they will be able to reconnect you almost instantaneously. In addition, when the power goes out, the electricity company will not have to wait until you call to know there is a problem, and similarly will not need to waste time trying to find it on the network. In short, more information means better electricity network management and lower costs of supplying electricity.

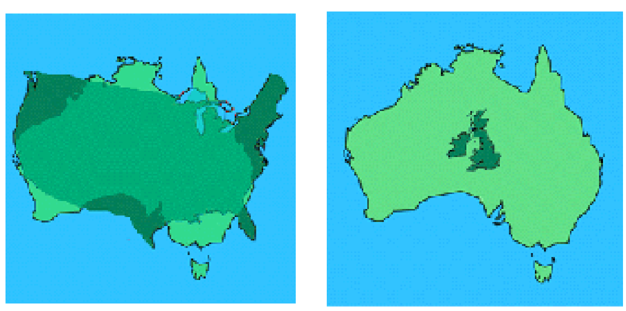
All this new information about electricity use is going to be made possible through the emergence of "smart" technologies and there have been moves to encourage their uptake, including close examination of the costs and benefits. The American Recovery and Reinvestment Act of 2009 included US$11 billion for smart grids, which includes the roll-out of 40 million smart meters to American homes. In the United Kingdom, the government has announced its intention to have smart meters in all homes by 2020, which will involve the replacement of approximately 47 million gas and electricity meters.

This edition of *Energy Market Insights* discusses the results of a recent study undertaken by NERA investigating the costs and benefits of smart metering in rural and remote communities using a series of case studies in Australia.[1] This study follows a 2007-2008 investigation NERA undertook analysing the costs and benefits of a smart meter roll-out across Australia's major electricity grids.[2] The potential to avoid the significantly higher costs associated with servicing remote communities means that a roll-out of smart metering technology to such communities has the potential to offer greater benefits than those associated with major urban areas.[3]

Electricity Supply in Remote Australian Communities

Australia is a very large "island" with a very low population density. Figure 1 shows Australia is approximately the same size as the mainland United States and nearly 25 times that of the British Isles.

Figure 1 Size of Australia Relative to the Mainland United States and the British Isles



Source: CIA World Factbook

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Business efficiency benefits alone are insufficient to support smart metering infrastructure investment in remote Australian communities, even where the cost to serve is high.

The vast majority of Australia's population is situated in or around the major urban centres of Sydney, Melbourne, Brisbane, Perth, and Adelaide, located on the southwest and east coasts, with electricity being supplied via the main electricity grids.[4] However, there are many communities situated in far more remote areas, such as the continent's arid interior or the numerous islands on its periphery, which are not connected to the main electricity grids. The provision of electricity services to these communities can be challenging and is currently a task for a select few electricity businesses.

These communities are provided with electricity via dedicated electrical systems and range from as few as 10 connections to as large as 10,000 connections in some instances. These systems range from a small local network connecting a few houses to a dedicated generator set, to larger urban networks with characteristics similar to larger grid-connected towns. Generally, electricity in these communities is generated via diesel generators, but increasingly renewable generation, such as wind and solar, is being introduced.

The remoteness, isolation, and small size of these communities generally increases the cost of providing electricity in a number of distinct ways, namely:

- by increasing the cost of transporting generation fuel to the community;
- through the loss of economies of scale;
- from the lack of diversity of supply and so an increased risk of service interruption; and
- by increasing the time needed to send maintenance crews to the community, where there are no local tradespeople available to provide repairs and maintenance services.

In some instances maintenance requirements might involve flying a crew into a remote location, taking a barge, or travelling thousands of kilometres to reach a community to investigate and repair a problem. Remoteness and isolation therefore means that the cost of ordinary operational services (such as manual meter reading and connections/disconnections) is more expensive compared to large urban centres.

Another characteristic of these remote communities is that prepayment electricity meters are commonplace. The prepayment meters typically involve the purchasing of disposable cards that are used to transfer credit to a particular meter. These prepayment meters are generally well accepted by communities as a way of providing flexibility and control over the cost of electricity to local residents, as well as a way of managing bad debts. While the cost of prepayment meters themselves is relatively expensive—as much as seven times that of a single phase non-interval meter—the costs of servicing these meters are relatively low given that there is no need to conduct meter reading for billing purposes.

Case Study Analysis and Results

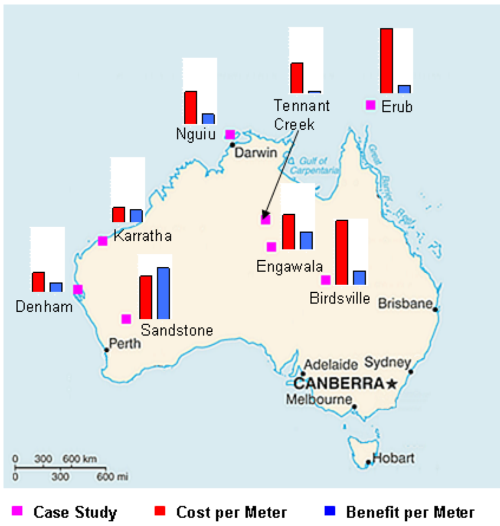
We adopted a case study approach to estimating the costs and benefits of a smart meter roll-out to remote communities in Australia. Working with the businesses responsible for electricity supply in these regions we identified eight remote communities spread throughout Australia which were not connected to the major electrical grids. The case studies were selected to cover the main characteristics that were expected to alter the costs and benefits of a roll-out of smart metering infrastructure in these locations. This approach allowed us to examine the characteristics of communities that affect costs and benefits, but was not intended to be representative of all communities located in remote areas.

Figure 2 illustrates the locations of the eight case studies selected within Australia, in addition to the relative estimated costs and business benefits of establishing a smart meter system in each community.

The potential costs and business-related benefits estimated varied considerably and highlighted that the results are very sensitive to local characteristics, which in turn affect the operational costs of providing electricity services to remote communities. In fact, the benefits estimated ranged from as low as 9% of the costs to slightly greater than the costs.

Importantly, these results do not include the potential benefits from greater energy conservation that might result from the installation of smart metering technology and the associated

Figure 2 Case Study Results Excluding Energy Conservation Benefits

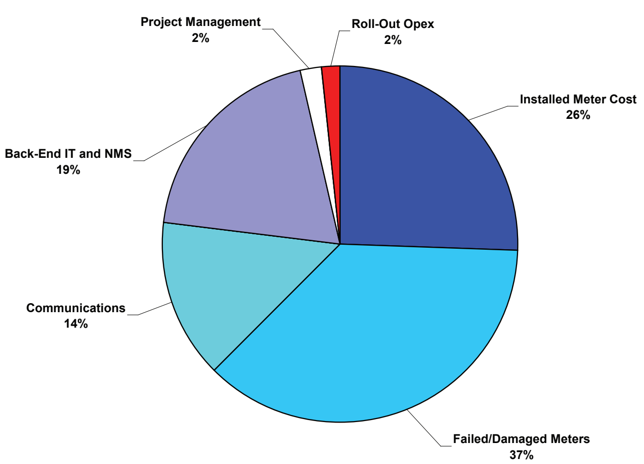


load control capabilities. If providing energy conservation via smart meters is more cost effective compared to alternative approaches (such as information provision or energy appliance buy-back programs), then potentially significant benefits ensue because of the high cost of generating electricity in these remote regions.

What Drives the Costs?

As an indication of the likely costs of a smart meter roll-out in remote communities, Figure 3 presents the results for Nguiu,[5] which is a medium-sized community off the coast of Australia's Northern Territory.

Figure 3 Breakdown of Estimated Costs of Nguiu



A significant cost involved in a smart metering system in remote communities is the cost of the meters and installation. First, the physical smart meter is more expensive than other electricity meters due to the multitude of functions they can perform.[6] For example, a single phase smart meter with an integrated load control device may be as much as seven times as expensive as that of the single phase non-smart meter it might replace.

Second, the remoteness and isolation of these communities will significantly increase the cost of installing smart meters, both through the difficulty of transporting smart meters to the communities as well as the time needed to send maintenance crews to the community to install meters, when there are no local tradespeople available.

In the eight case studies we analysed, the cost of installing a smart meter system ranged from 12 to 46% of the total estimated roll-out cost. The observed differences in installed meter cost reflect the differences in the mix of meters required in each community, in addition to the comparative remoteness and size of each of the communities. Further, there are economies of scale to be enjoyed by larger communities generated by the high fixed costs of sending a team to travel to these locations to complete a roll-out.

The size and location of remote communities also had an influential role in determining the communication costs associated with smart metering infrastructure. The communication systems needed to support smart meters are complex, requiring both communication between meters in a community as well as back haul communication to the electricity supplier. The different communications technologies able to provide this service to remote communities have greatly varying cost profiles (i.e., the relative mix of fixed and incremental costs), meaning that the optimal choice of communications technology for a particular community will largely depend on the community's population. Further, many remote communities in Australia do not have reliable access to wireless telecommunication networks such as 3G, necessitating the use of alternative, more expensive technologies such as satellites to transmit data between the electricity supplier and meters in the community. In the eight case studies considered, the possible communications costs ranged from 14 to 41% of the total estimated roll-out cost, largely reflecting the size and technologies available to each case study.

Remote communities in Australia are largely characterised by harsh climates and living conditions, meaning that meters need to be fixed or replaced more frequently than those located in more hospitable regions of Australia. Repairing a damaged or failed smart meter (or the associated communications infrastructure) must be undertaken by a qualified electrician (or communications technician), which would involve a large cost for most of these communities. There are generally only limited local operational capabilities and so when problems arise and repairs are needed, service crews from other locations need to be dispatched to resolve the problem. These costs ranged between 5 and 39% of the total estimated roll out cost for the eight case studies considered.[7]

For any smart meter system to be effective, two back-end IT systems are needed in order to manage the network and to convert the data collected into bills sent to customers. Typically, these systems have the capability of managing millions of meters and so there are considerable economies of scale available. In the eight case studies considered, these costs ranged from 4 to 33% of the total roll-out cost, as it was assumed that these systems could be provided by a third-party provider, allowing the network business to benefit from the economies of scale involved without investing in the system themselves. Without this assumption, the fixed costs associated with these systems may be prohibitively high, making it unlikely that a small network business could justify the expense of investing in its own system, unless there are other management or process-related benefits that would result.

Finally, the operational costs associated with rolling out a smart meter system are expected to make up a small proportion of total costs. In the case studies analysed, these costs were expected to be between approximately 3 and 14% of the total roll-out costs. The main factors affecting this cost are the expected number of "difficult" meter installations, such as:

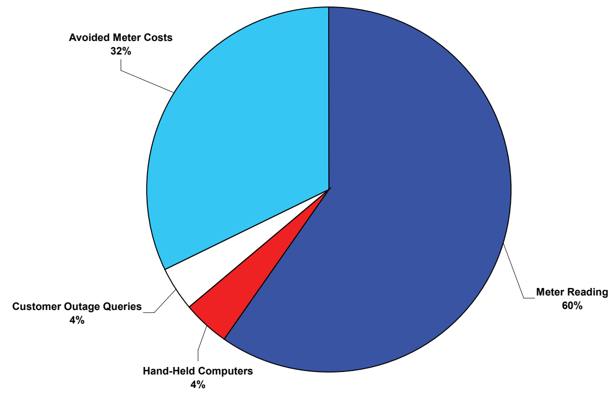
- if the current meter is attached to an asbestos meter board, a technician qualified to handle asbestos needs to be present during installation; or
- if there is faulty or damaged wiring that requires repair or replacement; or
- if the current meter board's configuration makes installing a new meter on the board a more complex task.

Where are the Sources of Benefits?

As an indication of the likely split between the benefits from the roll-out of smart metering infrastructure in remote communities, Figure 4 presents the results for Nguiu.

Possibly the largest business cost reduction associated with any roll-out of smart metering infrastructure is the potential to avoid costs associated with manually reading meters. In our previous national cost-benefit analysis, we found that avoided meter reading costs accounted for between 39 and 44% of the total business efficiencies associated with smart metering infrastructure. In remote communities, the avoided costs associated with meter reading were found to be the largest expected benefit for the eight case studies, accounting for between 27 and 60% of the total expected

Figure 4 Breakdown of Estimated Benefits of Nguiu



benefits.[8] This potential avoidable cost is especially large in some remote communities where suitable meter readers are not usually located, requiring personnel to be dispatched from the nearest town or city. In some other remote communities, the penetration of prepayment meters limits the extent that routine meter reads can be avoided and hence the potential avoidable cost, given that they themselves do not need reading. Further, the frequency with which current meters are read largely affects the scope for avoided costs associated with meter reading.

Another potentially large cost saving to businesses associated with smart metering infrastructure stems from the ability to disconnect or reconnect to premises remotely. Disconnection and or reconnection of a premises may occur as a consequence of non-payment of bills or customers moving in or out of a property. Using smart meters to accomplish this task would negate the need for a special visit to the premises to disconnect or reconnect the property, which in remote communities can involve significant costs. However, in the eight case studies evaluated, these potential savings were found to be relatively low, ranging from between 1 and 18% of the total benefits. The variation in case study results is in part because some remote communities have limited instances of connections and/or disconnections due to the operational approach to move-in and move-out arrangements, i.e., some businesses do not automatically disconnect a premises on move-out. Further, there is limited residential churn in many of these communities as it is common for employers to provide housing services (including electricity) to employees, so that while a household's occupants may change the electricity customer often does not.

A smart metering system operating in a remote community also has the potential to reduce the cost of investigating customer complaints about the quality of service. There is potential to avoid the costs of these complaints where travel to the premise is undertaken only to find that the cause of the complaint is not the responsibility of the business. The capability of a smart metering system to remotely detect whether a connection is operating normally would allow businesses to avoid the majority of these costs by identifying whether the problem is a consequence of the meter connection and so the responsibility of the business, or by default some other cause, which is the responsibility of the resident. However, the case study results indicate that the scope to avoid these costs is likely to be low, with estimated savings ranging from between 1 and 16% of the total expected benefits. This result is driven by the relatively low number of customer supply complaints these businesses receive each year from remote communities.

A further potential benefit associated with the roll-out of smart meters to remote communities in Australia is the avoided costs associated with handheld devices required to manually collect meter information. These potential savings were estimated to be between 0 and 18% of the total expected benefits.

A consequence of establishing a smart metering system in a remote community is that the business servicing that community will no longer have to install new non-smart meters when the existing meters need replacing (i.e., there are avoided meter replacement costs). In the case studies evaluated, these avoided costs ranged from 11 to 100% of total potential benefits from a smart metering roll-out.[9]

In contrast to the results set out in our earlier national cost-benefit analysis, there is likely to be limited scope for smart meters to deliver any benefits associated with network and generation investment deferral in remote communities. This difference is because the growth rates of both average and maximum electricity demand in these types of communities are often very low compared to the national average.

Energy Conservation Benefits

Diesel generation is a very expensive method of generating electricity in these communities, as much as A$460[10] per megawatt hour of electricity generated, meaning that the potential benefits from any energy conservation that might be achieved through a smart metering system could be higher for these communities as compared to major urban areas. In addition to reduced generation costs, energy conservation has the potential to result in considerable benefits associated with reduced greenhouse gas emissions.

Smart meters have the ability to conserve energy in a network by controlling the load of certain appliances. Two of the largest energy-using appliances in these areas are refrigerators and air conditioners, but there is relatively little opportunity to control the load of refrigerators. Hence, for significant benefits to be available there needs to be a sufficient number of air conditioners that are used in a manner that would allow some form of load-control cycling to reduce total energy use and so avoid the diesel fuel and associated greenhouse gas emission costs.

While many remote communities have a high proportion of premises with air conditioners, there are also a high number of communities with little or no air conditioner penetration.[11] Further, in many remote communities local employers provide employees with air conditioner allowances to subsidise or fully cover the cost of the electricity needed to run air conditioners. As a result, there is likely to be a reluctance to introduce a direct load control system in circumstances where there are uncertainties about the implications for the thermal comfort of residents. In addition, over time the benefits from load control may be eroded if customers attempt to circumvent the load control policy by purchasing oversized air-conditioning units.

Smart metering infrastructure is usually also associated with the introduction of innovative tariffs. For example, time-of-use tariffs (i.e., where the tariff differs between peak, shoulder, and off-peak times of the day in line with changes in costs during those periods) and/or critical peak pricing (i.e., where a significantly higher price is charged during extreme peak electricity demand periods, such as, during particularly hot or cold days). Such innovative tariffs are not relevant to the communities that we have studied because these communities are typically serviced by only one type of generation and the network is unconstrained, meaning that the cost of supplying electricity does not vary by time of day or on peak demand days during the year. However, these potential benefits may be significant in other cases.

Partly for the above reasons and partly due to the uncertainties involved, the benefits of a smart metering system we estimate do not include those potentially generated through energy conservation in remote communities.

How Do Prepayment Meters Fit into a Smart Metering Environment?

The existence—and acceptance—of prepayment meters poses a difficulty for the implementation of a smart metering system in some remote communities. Providing a prepayment service via smart metering infrastructure involves using the remote connect/disconnect capabilities of the meter, in combination with information on the amount of credit available for a particular metering connection. Generally, credit can be added to the meter by either calling the electricity provider, or using an online portal and providing credit card details for the amount to be added to the meter. While this approach has the potential to result in significant savings to the electricity provider by avoiding credit retailing services by third-party providers, there are concerns about the practicality of adopting such an approach in remote indigenous communities where prepayment metering dominates. This is because many indigenous customers do not have access to credit card facilities, or the scope to conduct online transactions in order to put credit on the meter.

To maximise the acceptability of any smart metering approach to prepayment in these communities, there is a need to minimise the complexity of payment options. This might involve the development of a prepayment card reader as part of a smart meter so that cards can continue to be used to place credit on the meter. Alternatively, this could involve a central payment station where credit can be allocated to meters by payment at a general store or community centre. The technology for these systems is yet to be developed but we acknowledge that this will be an important part of providing prepayment services via a smart metering system in these remote communities.

Conclusions

Our detailed analysis suggests that the costs involved with a roll-out of smart metering infrastructure to remote communities in Australia are mostly not outweighed by the business efficiency benefits that are expected to result. The differences between the case study results mainly reflect differences in the remoteness and sizes of the eight communities considered, but are also influenced by other local factors such as reliable access to 3G backhaul communications and the presence of local personnel to service meters and communications. Further, for communities with a high penetration of prepayment meters, a smart metering system is likely to fail unless it can realistically provide a prepayment service via smart technology. Currently, there is considerable uncertainty as to whether this technology is available at an acceptable cost.

In addition, for some communities there are likely to be significant benefits from controlling load due to the high costs associated with generating electricity. However, smart meters are not the only option for delivering these benefits. Load control can be provided through a variety of alternative means, and indeed energy conservation can also be achieved through community education and other energy efficiency schemes such as buy-back of older appliances, which have not been evaluated as part of this analysis.

The results of this study highlight the importance of businesses continuing to examine in more detail the technical and operational feasibility of deploying smart metering infrastructure in remote communities. They also highlight that smart metering may not always be the right choice, however politically fashionable the technology may be.

End Notes

1. NERA, "Costs and Benefits of Smart Metering in Off-Grid and Remote Areas", 18 March 2010.
2. NERA, "Cost Benefit Analysis of Smart Metering and Direct Load Control: Overview Report for Consultation", 29 February 2008.
3. The results presented in the paper only count those benefits attributable to distribution/retail electricity businesses, which we label "business benefits". They do not count the benefits from reduced electricity generation associated with any energy conservation that might arise from use of the functionality provided directly or indirectly by smart meters.
4. Australia's major electricity grids are the National Electricity Market (NEM), the South West Interconnected System (SWIS), and the Darwin to Katherine network.
5. Nguiu is primarily an indigenous community located 70 kilometres north of Darwin on Bathurst Island with a population of approximately 1,500. Nguiu has 520 electricity meters, of which approximately 51% are prepayment meters.
6. The national study involved an incremental assessment of each function to recommend a national minimum functionality. The principal functions included as part of the national minimum functionality include: remote reading, remote disconnect/reconnect, and capability to support a home-area-network and so allow for in-home displays. See: NERA, "Cost Benefit Analysis of Smart Metering and Direct Load Control: Overview Report for Consultation", 29 February 2008, pages 14-16.
7. Our results do not take into account our general concerns about the reliability of smart meters and the associated communications units in the extreme temperature and humidity ranges commonly found in these locations. While we have not sought to independently verify the failure rates that have been presented to us, ultimately we would expect these to reduce over time as the metering technology becomes more commonplace and is refined for all climatic conditions.
8. Note that one case study, Erub, offered no scope for avoided meter reading costs because it is predominantly prepayment meters. Annual manual reads of the prepayment meters are undertaken in Erub as part of standard asset management practices, which cannot be avoided by a smart metering system.
9. The ability to avoid these costs was the only potential benefit from a smart meter rollout identified in the Erub case study.
10. Compared to an average wholesale electricity price in the NEM of between $34/MWh and $58/MWh in 2008-09. Source: AEMO website, available at: www.aemo.com.au
11. Further, customers on prepayment systems generally use substantially less electricity than the average non-prepayment customers suggesting there are limited opportunities for load control in many remote communities with high prepayment penetration.

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