A *smart* evaluation of *electricity* investment

Smart grids are all the rage internationally. But what makes a smart grid – and smart meters in particular – a smart investment decision? Stanford Levin outlines an eight-step programme for evaluating the costs and benefits of smart meters.[1]

Electricity utilities and policymakers around the world are all talking about smart grids – a combination of hardware, software, communications, monitoring, and control equipment that's designed to improve the performance of the electricity grid. This 'definition' is not precise, however, and it will evolve as technology develops and as utilities gain additional experience.

A smart grid can help with faster recovery from service outages (although it probably won't help much with reliability and outage notification). It can also help with the integration of variable or intermittent energy sources such as wind or solar technologies and distributed or micro generation; and it can provide consumers with information that allows them to make more efficient energy choices and, if they desire, reduce their electricity consumption.

Is dumb better?

A smart grid sounds like something everyone should have. After all, it's smart. But sometimes dumb is better.

It's helpful to consider a smart grid in its component parts: smart generation, smart transmission, smart distribution, and smart meters (and their associated data and communications requirements). Each part of the smart grid can be deployed independently – smart meters in particular are separate from the rest – but in some cases the potential benefit of deploying smart grid technology in one segment will be increased if it is also deployed in another segment.

All about meters

Benefits can be separated into private and societal benefits. Smart generation, transmission, and distribution technologies are put in place when there is a good business case (which is to say the private benefits to the companies exceed the costs).

The same logic applies in the deployment of smart meters. When the private benefits from these meters exceed their costs, large commercial and industrial customers generally adopt them. Remote meter reading is also often deployed for residential and small commercial and industrial customers because the private benefits exceed the costs. Smart meters, though, are capable of other functions such as communicating (with the customer, retailer, and distribution company); remote connecting and disconnecting service; monitoring of usage,

[1] The author participated in a study which led to the *Alberta Smart Grid Inquiry* report prepared by the Alberta Utilities Commission in January 2011. This article is based in part on that report and in particular on Appendix 5 (the full report is available at www.auc.ab.ca/items-of-interest/special-inquiries/Documents/smart_grid/Alberta_Smart_Grid_Inquiry_final_report.pdf).

quality, and outages; communicating with appliances; and measuring usage in ways that allow for multi-period or real-time pricing. Residential and small commercial and industrial customers are generally not asking for smart meters to be installed for these reasons, however – and this is an indication that the private benefits to these customers from smart meters are less than the cost of the meters. So subsidies would be required.

But subsidies are not automatically beneficial or justified. If they *are* to be justified for smart meter deployment to residential and small commercial and industrial customers, it will be because there are societal benefits that exceed the cost of the meters. These societal benefits would result from more efficient use of resources, primarily from multi-period pricing. In addition, there might be an environmental benefit. A precise methodology is required to measure and compare these costs and benefits in order to determine if a subsidy is justified.

An eight-step programme

1: Determine the extent of deployment. What is the geographic area to be covered – and which customers?

2: Determine the 'time' arrangements. Will there be real-time pricing, or multi-period pricing?

If there is multi-period pricing, how many time periods will there be? The number of time periods might be determined at least in part by an analysis of the costs, because time periods should have significantly different costs in order to generate any societal benefits. If the costs are nearly the same in (say) two time periods, then their resulting prices will be nearly the same – and so there will be little benefit from establishing them as two separate time periods.

In determining the time periods, it is also important to remember that it will only be beneficial to implement time periods *to which customers can respond*. Most customers will find it difficult to remember too many time periods – and if they cannot remember the different time periods and their associated prices, then there will not be a large response.

If there is real-time pricing, customers will not be able to react to it without automated controls – which will be an additional expense.

3: Determine the costs (in net present value). This would include any stranded investment from the removal of non-smart meters – as well as the incremental cost of the smart meters and their installation, data and communications costs, and ongoing expenses.

4: Estimate elasticities. Elasticities will indicate how much the customers will increase or decrease their electricity use in each time period, given the price change in that period. Elasticities should be calculated for each time period and for each customer class. A study could be undertaken, or elasticities could be used from elsewhere or from a pilot study.

5: Calculate each time period's change in electricity use. This is done by combining elasticities, the price change, and the initial electricity use in each period.

6: Determine the benefits (in net present value). Only the additional benefits from the deployment of smart meters should be counted. If there are benefits that could be achieved from the existing meters, they should not be counted. For example, seasonal cost-based

pricing could be charged using dumb meters – so the benefits from deploying smart meters are only those benefits that can be attained from cost-based pricing that goes beyond seasonal pricing.

It does not appear that *private* operational and customer benefits exceed the cost of smart meter deployment (except sometimes for remote meter reading). If they do, however, then the analysis can be ended and the meters can be deployed. When the private benefits do not exceed the costs, then *societal* benefits must be calculated. This will determine whether private and societal benefits together exceed the costs of smart meter deployment.

Societal benefits result from the more efficient use of resources. An example will illustrate this. For simplicity, assume that there are only two time periods during the day: peak and off-peak. Initially, customers are charged 20¢/kwh at all times. Costs, however, are 30¢ during the peak period and 5¢ during the off-peak period. During the peak period, customers consume electricity that is worth, at the margin, 20¢/kwh to them; but society uses 30¢/kwh to generate the electricity. This is a loss to society of 10¢/kwh of value – that is to say, customers consume more than an efficient quantity of electricity. Conversely, in the off-peak period, customers are consuming electricity as if it costs 20¢/kwh when in fact it costs only 5¢/kwh – so customers consume less than an efficient quantity of electricity. Moving to multi-period pricing with a price of 30¢/kwh during the peak period and 5¢/kwh off-peak would result in an efficiency gain to society of 10¢/kwh for each kwh of *reduced* consumption during the peak period and a gain of 15¢/kwh for each kwh of *increased* consumption off-peak.

Societal benefits from the more efficient use of resources will be greater when price elasticities are greater, when current prices are further from cost, and when load and costs vary more over the day and over the year.

However, one further issue arises when electricity retailing is competitive. *If* societal benefits are required for benefits to exceed costs and *if* these societal benefits depend on multi-period pricing, then the (overall) benefit will be difficult to capture in a competitive retail environment because retailers have no incentive to introduce multi-period pricing[2].

7: Determine any other benefits (in net present value). There may be a reduction in greenhouse gases from pricing that reflects costs more closely and hence is more efficient, but this is a complex issue and the effect on greenhouse gases is not always what it may seem at first glance. A change in load (reducing peak use and increasing off-peak use in response to cost-based pricing) will cause a change in the mix of generation facilities used. This means a reduction in peak-load facilities, which generally emit fewer greenhouse gases, and an increase in base-load facilities, which generally (with the exception of nuclear) emit more greenhouse gases.[3] Off-peak elasticities are greater than on-peak elasticities; and so customers will boost their off-peak consumption by relatively more than they reduce on-peak consumption in response to a price change. Therefore, depending on how much prices change to bring them into line with costs, there could be either an increase or decrease in greenhouse gases in most countries.

[2] Capturing the benefits would require re-regulating the retail sector.
[3] New Zealand's hydro power is fully utilised and so cannot be used to meet an increase in off-peak demand.

8: Compare the costs and the benefits. The net present value of the costs of deploying smart meters should be compared with the net present value of its benefits. If the total of the private and societal benefits exceed the costs, then a subsidy would be justified.

It may also be worthwhile to compare the costs and benefits of smart meter deployment for sub-groups of customers, such as large residential customers who have greater electricity use and consequent larger benefits.

Smart and smarter?

Even after the societal benefits are taken into consideration, it is not clear that the benefits from smart meters exceed their costs – and so there may be no justification for subsidies. Yet smart meters are unlikely to be deployed for residential and small commercial and industrial customers (other than for remote meter reading) without subsidies.

Furthermore, competitive retailing makes it difficult to put in place the multi-period pricing that is necessary to capture the societal benefits from smart meters.

In these cases, dumb may be better.

Stanford Levin is Emeritus Professor of Economics at Southern Illinois University Edwardsville in the US.