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Will Energy Storage Arrive Sooner With Demand Charges?

In this edition of IES Insider we consider the electricity tariff arrangements that a home equipped with energy storage and solar PV is likely to receive. We address the question of cost reflective pricing and whether the consumer will be better off with demand charge pricing, or existing pricing structures such as time-of-use. Why does this matter? Electricity tariff structures will have a significant impact on the viability and future take up of energy storage technologies. This article presents the results of a recent analysis by IES which tests the proposition that battery storage will become economically viable sooner under a demand tariff[1].

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[1] Refer to *"Sundown, sunrise: how Australia can finally get solar power right"* Grattan Institute, May 2015, pp29-30

Introduction

Home energy storage systems (or batteries) have the potential to reduce the electricity costs that a consumer pays. This is due to the ability of the battery to shift the supply of electricity supplied for use in peak periods to times when tariff rates are cheaper. Locally generated electricity can also be stored and used in peak times as a substitute for the mains supply.

A range of predictions have been made on when home energy storage will be viable and introduced on a large scale in homes and businesses. These timings not only depend on the installed capital cost but also the electricity tariffs that will apply in the future. Cost reflective tariffs will be introduced by electricity distribution networks in 2017. The definition of what 'cost reflective' means is wide open but there is a requirement that prices be set on a long run marginal cost basis. This would suggest to some that incremental consumer demand may be one way to recover network costs. A demand tariff is different from variable energy rates as it applies to the peak instance of electrical power (in kilowatts or kVA) that a consumer requires from the grid over a month or a year.

What does this all mean for home energy storage? How will the introduction of cost reflective demand charges impact the viability and introduction of this technology? We sought to find out how the viability of home energy storage would change if a demand charge replaced the existing default tariff. To do this two important assumptions needed to be made at the outset of this analysis. These are described as follows:

Assumption 1: Time of Use meters are installed for energy storage systems

Our first assumption is that if a customer were to install a home storage and/or a PV system, it will upgrade to a time of use meter. It is clear that the introduction of cost reflective pricing will require a time of use meter despite there being uncertainty about what is a truly cost reflective tariff structure. Time of use (or interval) meters are becoming increasing common for small customers. For example there are approximately 370,000 customers in the Ausgrid network region who have an interval meter installed at their premises. Most of these customers receive a time of use tariff. In Victoria interval meters have recently been rolled out for all small customers. It's also worth noting here that demand charges require a time of use meter.

Assumption 2: A retailer won't use a demand charge to recover its costs

If a distribution network introduced a demand tariff for small customers, we consider it unlikely that the retailer would also structure its other retail charges as a single rate demand charge. The best case scenario is that the retailer would instead charge lower peak and off-peak energy rates and the distributor's demand charge would be a separate pricing component passed through to the customer. The worst case is that the demand charge would be recovered from retail customers via a postage stamp variable energy rate. In this situation the customer wouldn't receive the demand charge price signal.

Why wouldn't a retailer adopt its own demand charge? In addition to network charges, a large part of an electricity retailer's costs consist of purchasing electricity from the National Electricity Market (NEM). A retailer faces significant exposures and risks in the NEM and it manages these by purchasing hedges or by running their own generators. Passing through these wholesale costs as a demand charge would be very inconsistent with the risks that retailers face from their wholesale cost base.

Our Analysis

With these two assumptions in mind we set out to quantify the electricity costs a household would pay if it installed an energy storage and PV system. To keep the analysis as simple as possible we ran two scenarios; the first for a household with the current time of use structure and the second which included a network based demand charge. The electricity prices (excluding GST) used in the two scenario prices were as follows:

Retail Pricing Component	Scenario 1: Existing Time of Use	Scenario 2: Time of Use with Demand
Daily fixed charge c/day	82.50	82.50
Peak c/kWh	46.06	29.64
Shoulder c/kWh	18.12	11.66
Off-peak c/kWh	9.95	6.40
Demand c/kW/day	0	63.60
Feed-in tariff c/kWh	5	5

The scenario 1 rates are the standing offer prices currently available in the EnergyAustralia franchise area. Scenario 2 introduces a peak demand charge that is calculated on the basis of retailer revenue neutrality. This means that the average customer would be charged exactly the same in both scenarios when there is no technology installed (this comes to $1,307 per year). This demand charge applies to the peak electrical demand as metered over a year.

Our average customer profile is derived from the half-hourly consumption data of 300 homes in the Sydney region. Separate half-hourly profiles were prepared for each month over a year and were split into weekdays and weekends. We believe making this distinction is important as a customer's consumption profile differs depending on the time of year and the day of the week. As is typical in Sydney our average customer uses more electricity in winter than the summer period. Its maximum demand without technology is 1.54 kW over the 12 months.

In the two scenarios the average customer is assumed to have a PV generator with an installed capacity of 3 kW and follow a typical generator output profile for a system located in the Sydney region. The energy storage system is assumed to have a size of 7 kWh and to feature widely agreed assumptions for efficiency, charging and discharging rates, and depth of discharge.

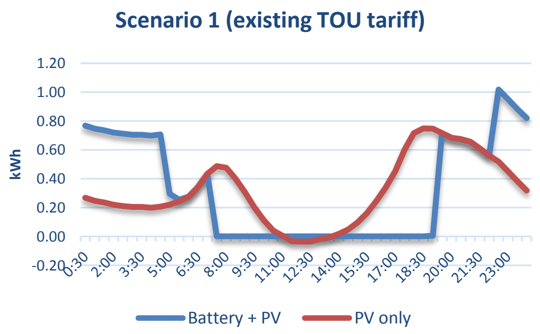
Scenario 1: Existing Time of Use Tariffs

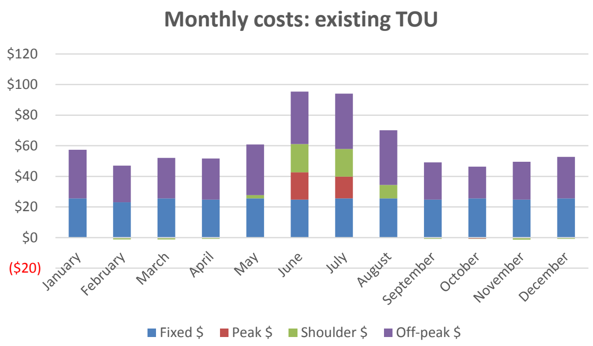
The great advantage of a home storage system is that it can store electricity so it can be used later when the retail prices are expensive. The technology presents two interesting pricing arbitrage opportunities. The first is the opportunity of storing electricity generated off the PV panels and using it to reduce the amount of electricity that would have been supplied from the grid in the peak period. The second is storing electricity in off-peak times so that it can be used in peak times (in place of grid supplied electricity).

On a weekday the marginal benefit of storing electricity generated locally is 41 c/kWh in scenario 1 and 24 c/kWh in scenario 2. These figures are determined by the difference between the peak tariff and the feed-in tariff. Instead of sending surplus electricity into the grid to receive a feed-in tariff the customer can store it and reduce afternoon peak charges by running off the battery.

The benefit of charging the battery overnight is 36 c/kWh in the first scenario and 23 c/kWh in the second, assuming that all the electricity stored is used in the subsequent peak period. These rates represent the difference between the peak and off-peak prices. So the marginal benefits of overnight charging aren't as attractive as storing electricity from the PV panels but they do come close.

Our optimisation model minimises the home owner's daily electricity costs by taking these tariff considerations into account. In basic terms, a priority is given to ensuring the home is supplied by the least amount of electricity from the local network at times when the penalties from retail tariffs are the highest. The key to the optimisation was solving for the optimal balance between overnight and daytime charging. We found that if the home has below average consumption on any particular day, then the battery doesn't need to be fully charged overnight. This occurs in the mid-season months when heating and cooling needs are minimal. However when daily electricity needs are above average (such as in winter) the storage system should be fully charged overnight. The graph (below left) shows the load profile for a July weekday with and without home storage.





In scenario 1 a home equipped with storage and PV would be charged $717 per annum for mains supplied electricity. Most of these costs are the charges from charging the battery in the off-peak period (see graph above right). The home required mains supplied electricity in the peak and shoulder period in July and August given the PV output shortfall and the greater energy needs of the home in winter. Minimal electricity was exported to the local distribution network.

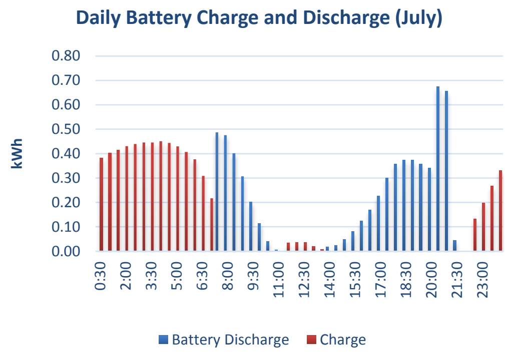
Scenario 2: TOU with a Demand Charge

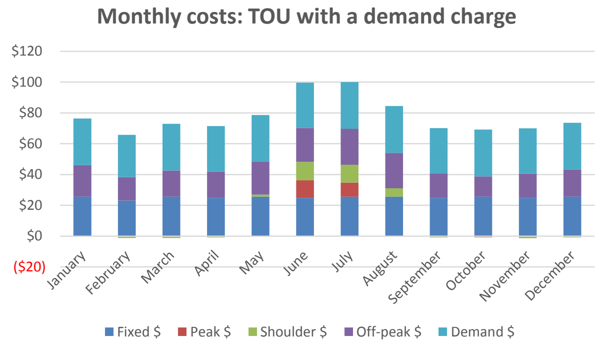
The introduction of a demand charge means that minimising a customer's electricity costs must not only take into account the considerations described above, but there is also a need to keep the consumption profile as flat as possible. The peak demand of our average customer is 1.54 kW when no technology is installed. To achieve any savings from a demand charge the storage and PV system will have to keep the demand as seen at the revenue meter below this threshold. This is because demand charges are applied to the maximum electrical power requirements over a month or year. If the home suddenly required electricity from the local network above the threshold, the penalties would be significant.

This poses a question: when is the best time for the battery to recharge? The most obvious answer is during the day. But situations occur when there isn't enough generated solar PV to do this and the home energy storage system will have to charge overnight. A good example of this is on a winter weekday with overcast weather conditions. The battery is unlikely to have been adequately charged from the solar PV during the day but the home will have electrical heating needs in the early evening.

In our optimisation we attempted to keep the maximum demand required from the mains supply to no more than 1 kW. However there were many occasions when this threshold was exceeded to prevent the home running out of electricity. This particularly occurred in the May to August period. In these winter months the battery was typically empty by the early evening because most of the solar PV energy produced that day was used to meet the afternoon consumption. Perhaps the solution here is to install a bigger battery but we note that this would require additional capital cost for battery capacity that is not regularly used. It is would also be difficult to fully charge a larger battery given the limits on demand. We note that staggering the battery discharge throughout the peak period didn't achieve overall cost reductions due to the increased peak time energy charges. The graph (below left) shows how the battery would operate with this constraint. It raises the question of whether the storage system should anticipate future home consumption levels or operate using current and known data (something for another edition of IES Insiders!).

The penalty for exceeding a demand threshold isn't simply the 63.6 cents per kilowatt in the table above. Any usage above the demand threshold will trigger on-going charges and act very much as a fixed charge, offering no further load deferral opportunities and cost savings. A 0.5 kW overrun in July resulted in an additional $116 per year in electricity charges. Our average customer paid $922 a year in total for their electricity in scenario 2 (see graph below right).





Conclusion

Demand charging will add an unwelcome operating constraint to home energy storage systems. A home's electricity needs vary significantly throughout the year (and day) given seasonal variations and there will be occasions when the battery is empty and unable to meet a short-term spike in consumption. In these situations the demand threshold is likely to be exceeded and will trigger costly penalties for the consumer.

The results from our optimisation model show that a customer equipped with a home energy storage and PV system would be much better off with the current TOU tariffs than with a TOU/demand charge hybrid. Over a 12 month period the residential customer would pay $717 on their electricity charges with the standard time of use tariff (scenario 1) and $922 if they had an annual demand charge applied as per scenario 2. Monthly demand charges structures perform better but none were close to achieving the savings from existing TOU rates.

A final footnote: all of this analysis ignores the impact of electric vehicles. If the home of the future will also need to charge both the electric car and the home energy storage system, then surely an inflexible demand charge will further limit viability and take up of these technology solutions.