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COST BENEFIT ANALYSIS OF MANDATING TIME-VARYING FIT

A REPORT FOR THE ESSENTIAL SERVICES COMMISSION

21 FEBRUARY 2020

Disclaimer

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1 INTRODUCTION

Frontier Economics has been engaged to advise the Essential Services Commission (ESC) on the costs and benefits of mandating the offer of time varying Feed-in Tariff (FiT) rates.

1.1 Background

The Essential Services Commission (ESC) is an independent commission, established to regulate prescribed essential utility services supplied by the Victorian electricity, gas, water, ports and rail freight industries.

The ESC is required under the *Electricity Industry Act 2000 (Vic)* to determine one or more rates to be paid by electricity retailers to customers who feed-in surplus renewable energy generation into the grid. In each financial year since 2018/19, the ESC has published two minimum FiT rates:

- A single flat-rate FiT
- A time-varying FiT (with peak, shoulder and off-peak rates).

Historically, retailers have been able to offer time-varying FiT rates on an opt-in basis, with most Victorian retailers choosing to offer only a single flat rate to their customers.

1.2 Frontier Economics' engagement

As part of its review of the minimum FiT rate, the ESC is considering whether the offer of time-varying FiT rates should be mandated. The ESC has engaged Frontier Economics to advise on the costs and benefits of mandating time varying FiT rates.

Our approach assesses:

- the scope for a time-varying FiT to induce behavioural change
- the benefits associated with these changes (if any)
- the costs associated with implementing time-varying FiT.

1.3 This report

This report is structured as follows:

- Section 2 provides details of our approach to assessing costs and benefits.
- Section 3 provides our results on costs and benefits.
- Section 4 provides our conclusion.

2 METHODOLOGY FOR ASSESSING COSTS AND BENEFITS

This section describes the approach that we have adopted for assessing costs and benefits of mandating time-varying FiT rates.

2.1 Assessing benefit

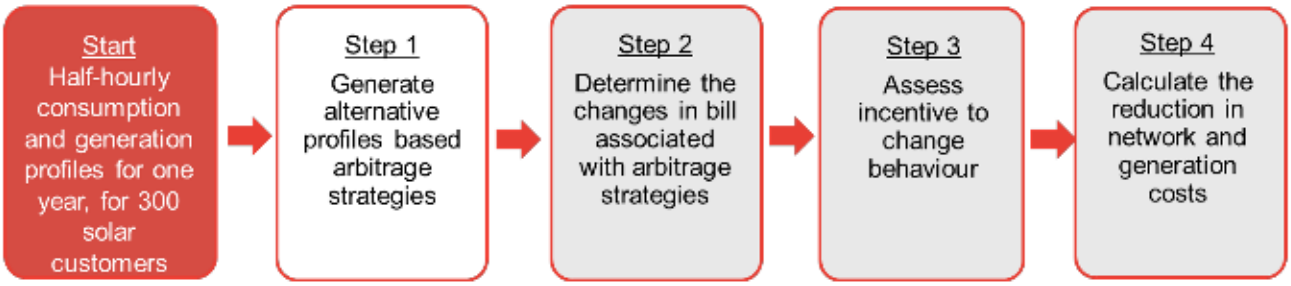
The potential economic benefit of time-varying FiT rates arises from the ability of time-varying FiT rates to encourage customers to change their behaviour. This change in behaviour can, in turn, result in a reduction of the total cost to society of supplying electricity. For instance, offering a higher FiT rate in peak times than in off-peak times might encourage customers to change their behaviour so that they export more electricity at peak times and less at off-peak times. This, in turn, can result in avoided costs of generating electricity to meet demand at peak times or avoided costs of network capacity to meet demand at peak times.

In this section we set out our methodology for assessing this potential economic benefit of time-varying FiT rates. This methodology is summarised in **Figure 1**. Underpinning these steps is the understanding that benefits from a time-varying FiT are realised if:

- Customers change their behaviour as a result of time-varying FiT (steps 1-3), and
- The change in this behaviour results in a change in the costs of generating or supply electricity (step 4)

If at any point during the assessment of benefits, analysis shows that either of these conditions do not hold, there are no benefits to quantify.

Figure 1: Summary of methodology for assessing benefits



Source: Frontier Economics

Our methodology to assess benefits consists of the following our steps.

Step 1: Generate alternative profiles based on arbitrage strategies

We may expect different prices for exports at different times in the day may provide customers the incentive to alter their consumption and generation patterns by:

- Changing the times at which they consume electricity, thereby changing the extent to which they consume their own generation at different times of the day, or
- Orienting their panels to face west, thereby changing the time that they generate electricity.

When it comes to orienting panels to face west, we need to assess whether the benefit of generating later in the day (and thereby tending to export more electricity during peak times and less electricity during off-peak times) is likely to outweigh the cost of reducing the total amount of electricity generated.

When it comes to assessing the incentives that customers have to change their behaviour as a result of time-varying FiT rates, we need to assess how the payoffs to customers of changing their behaviour in this way compare to the payoffs to customers of other ways that customers can change their behaviour. When it comes to customers changing the times as which they consume electricity, the obvious alternatives available to customers are:

- to change the times at which they consume electricity in order to arbitrage time-varying FiT rates, or
- to change the times at which they consume electricity in order to arbitrage time-varying retail tariffs paid for importing electricity.

An important question for us is whether there are any circumstances in which customers will expect to do better by adopting the first of these strategies, rather than the second.

We can undertake this assessment simply based on assumptions about how customers might shift their consumption and generation, and on current rates for retail tariffs and for FiTs. Additionally, however, we undertake this assessment based on historical half-hourly consumption and generation data for a large number of actual customers. We generate examples of alternative profiles that are based on arbitraging time-varying FiT rates by shifting consumption or shifting generation. We generate these examples based on half-hourly consumption and generation profiles that are available for 300 solar customers in Ausgrid's network area. While these customers are New South Wales customers rather than Victorian customers, equivalent half-hourly data is not publicly available for Victorian customers. We consider that our conclusions will not be affected by the use of data for New South Wales customers rather than data for Victorian customers.

Importantly, shifting consumption to arbitrage FiT rates can only occur between net generating times, while shifting consumption to arbitrage import rates is constrained can only occur during periods where there is no generation. Using actual half-hourly consumption and generation profiles for 300 customers enables us to assess the extent to which customers are able to shift consumption to decrease off-peak exports and to increase peak exports. Assessing the extent to which customers can shift the time of exports also ensures that we compare the incentive to arbitrage time-varying FiT rates and time-varying retail tariffs; we want to undertake an assessment of an equal amount of effort (as measured in kWhs shifted). Therefore, to choose a consumption shifting threshold to apply equally to arbitraging import tariffs and FiT, we analyse consumption and generation profiles and test to see how much consumption is available to shift to ensure all customers in our sample could comfortably arbitrage the time-varying import tariff. As we will see, we conclude that 40 kWh per annum is an appropriate assumption for the amount that peak imports can be increased by shifting consumption, but even this amount cannot be shifted to off-peak times in a way that reduces off-peak exports.

Taking these constraints into account, we transform the historical profiles for customers to generate alternative profiles to test the incentives that customers have to change behaviour in response to time-varying FiT rates.

First, to test the incentive that customers have to change their consumption patterns, for each customer for whom we have historical data we do the following:

- Shift 40 kWhs of consumption from peak to off-peak times during net generating times. This enables us to assess the benefits to each customer of shifting consumption to arbitrage the time-varying FiT.
- Shift 40 kWhs of consumption from peak to off-peak times during non-generating times. This enables us to assess the benefits to each customer of shifting consumption to arbitrage the time-varying retail electricity tariff.

By comparing total bills under these two cases, and comparing them both to bills under the base case, we can assess whether customers have an incentive to shift consumption in response to time-varying FiT rates.

Analogous consumption shifting profiles are also generated for shifting consumption from peak to shoulder periods to aid in a sensitivity analysis for the assessment potential benefits of time-varying FiT.

By way of illustration, the figures below demonstrate the primary way the profiles are transformed to generate alternative, based on single, stylised daily profile. **Figure 2** shows a stylised profile for a single customer, analogous to a daily profile of the single customer in our sample of 300. It depicts gross and net consumption and generation and has peak, shoulder and off-peak periods demarked with yellow, blue and pink, respectively.

The first alternative profile generated in this illustration is **Figure 3**, which shows the customer attempting the arbitrage the time-varying FiT. In this case, the customer moves consumption from peak to shoulder in net generating periods, thereby trading off self-consumption of their solar in peak for shoulder, increasing the payoff received from the FiT rate.

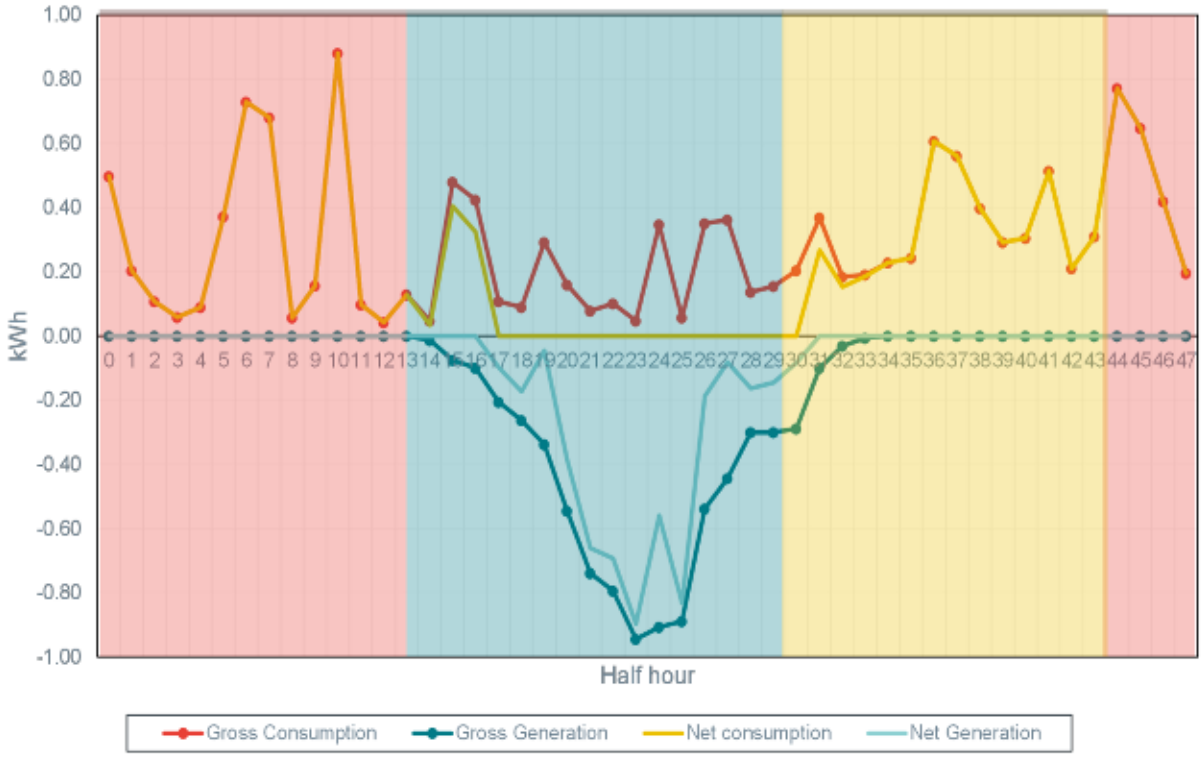
The time of use classifications used to make all transformation in this step are provided in **Table 1**.

Table 1: Time of use classifications

PERIOD	WEEKDAY	WEEKEND
Peak	3pm – 9pm	N.A.
Shoulder	7am – 3pm; 9pm – 10pm	7am – 10pm
Off-peak	10pm – 7am	10pm – 7am

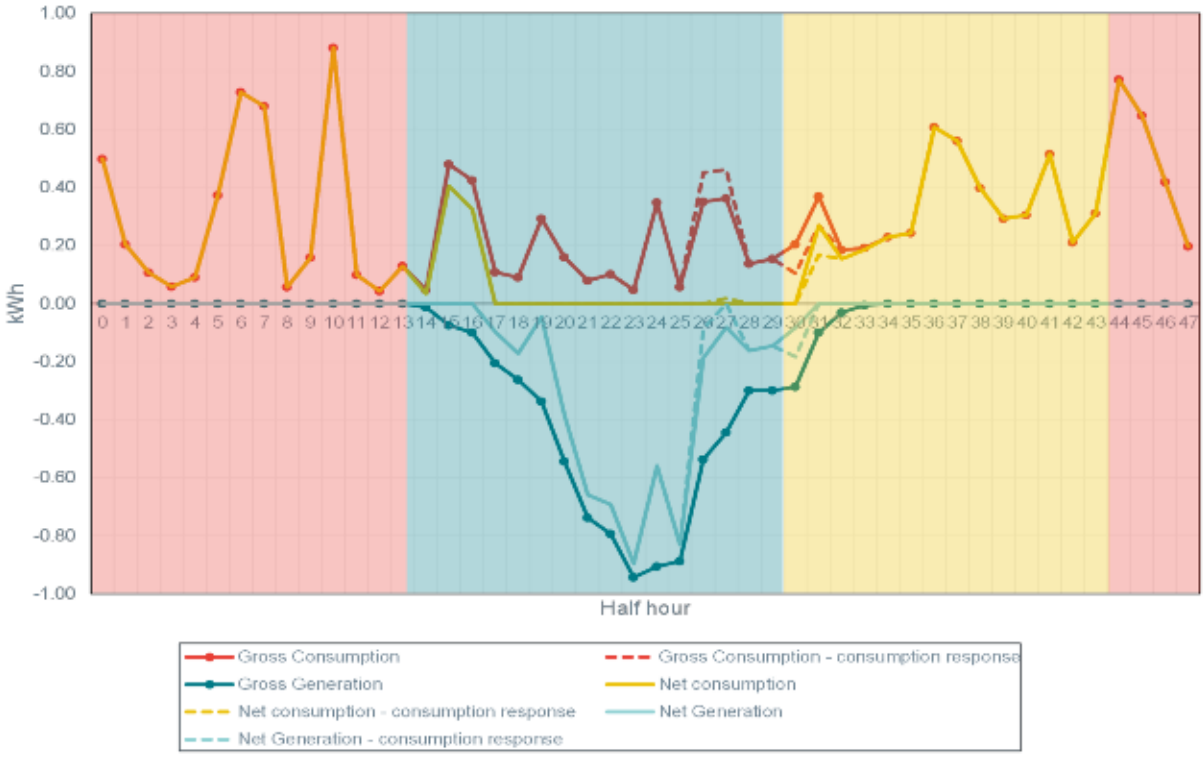
Source: Essential Services Commission

Figure 2: Stylised daily profile for a customer.



Source: Frontier Economics

Figure 3: Stylised daily profile, adjusted for consumption response to time-varying FiT.



Source: Frontier Economics

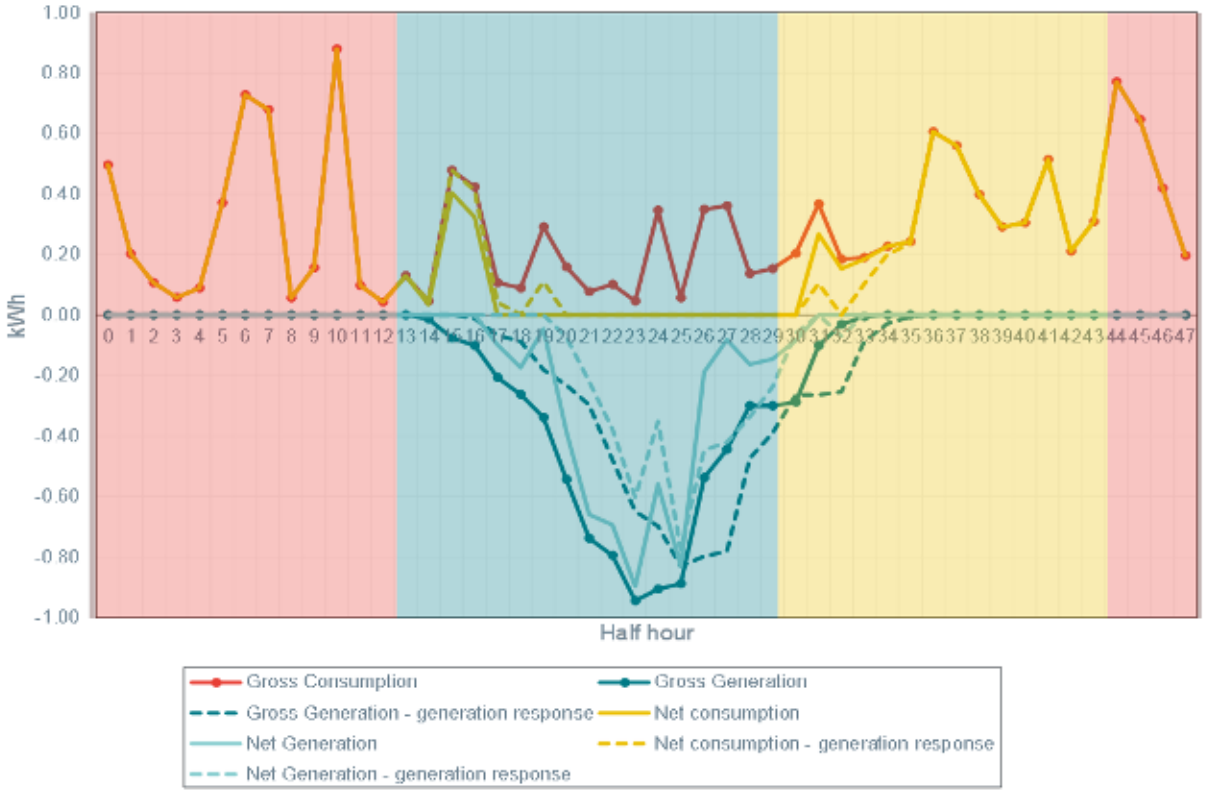
Second, to test the incentive that customers have to orient their panels to face west, for each customer for whom we have historical data we do the following:

- Shift generation back by 1 hour but reduce total generation by 12% (to reflect orienting PV panels to face west rather than to face north).

By comparing total bills in this case with bills under the base case, we can assess whether customers have an incentive to orient panels to face west in response to time-varying FiT rates.

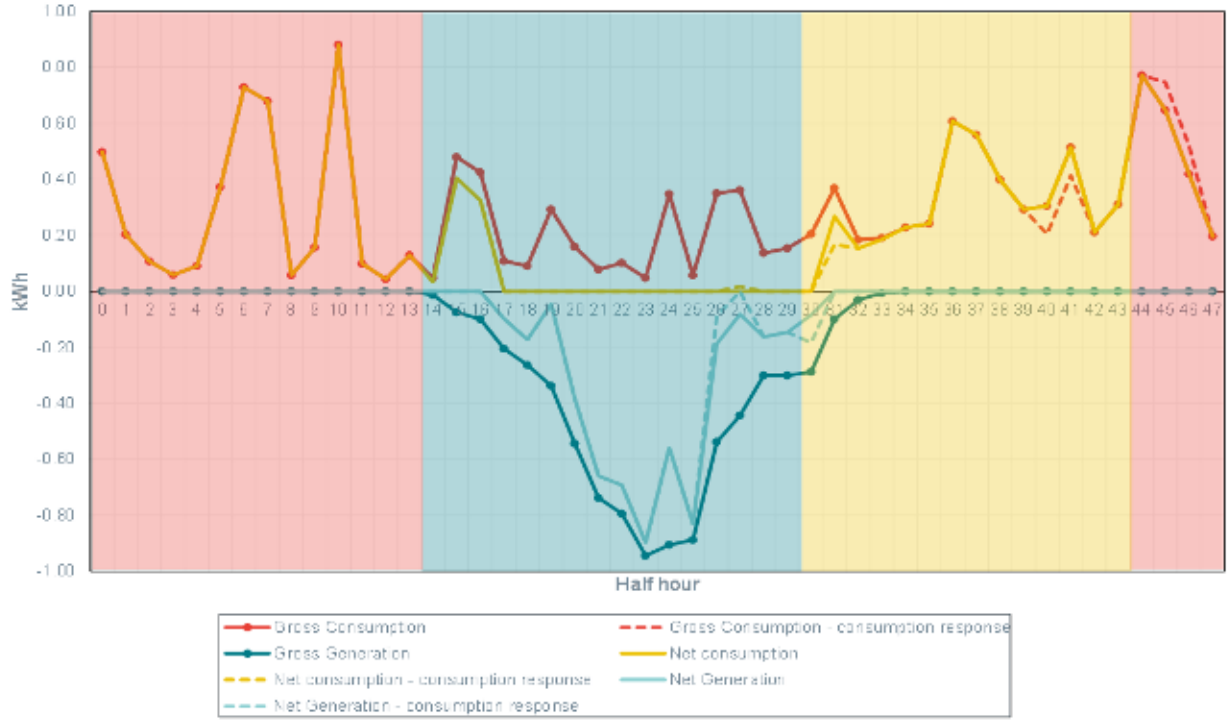
In **Figure 4** the customer instead attempts to arbitrage the time-varying FiT by reorienting PV panels from north to west, thereby reducing generation earlier in the day but increasing it later in the day where it is more valuable. It should be noted, however, that the customer faces the cost of less overall generation as a result, as depicted. Finally, in **Figure 5** the customer attempts to arbitrage the time-varying import tariff, shifting consumption from peak to off-peak times during periods of non-generation, thereby reducing the amount paid for importing electricity.

Figure 4: Stylised daily profile, adjusted for generation response to time-varying FiT.



Source: Frontier Economics

Figure 5: Stylised daily profile, adjusted for consumption response to time-varying import rates.



Source: Frontier Economics

Step 2: Determine changes in bill associated with arbitrage strategies

Once all alternative profiles are generated, an annual total bill for each profile – including for the original, unadjusted 300 profiles – is calculated. This is done for each profile, by multiplying the quantities of net consumption and net generation in each half-hour throughout the year by the relevant import and FiT rates, respectively.

Table 2 provides the import and FiT rates used in these calculations. The FiT rates used to calculate bills reflect the only widely available time-varying FiT rates in Victoria (from Energy Australia). The import rates used have been taken from Victorian Energy Compare,[1] and reflect rates toward the lower end of time-varying rates available to Victorians as found in our research. We used relatively low import rates in our analysis for two reasons:

- Customers engaged with the electricity market to the extent that they would arbitrage time-varying rates are more likely to have low retail tariff rates than others in their distribution area
- To ensure that benefits arising from the FiT are not excluded due to using excessively high import rates that would exaggerate the level of benefit of arbitraging time-varying import rates relative to the time-varying FiT.[2]

Table 2: Import and FiT rates used in analysis

	FIT (C/KWH)	IMPORT (C/KWH)
Peak	14.6	30.25
Shoulder	11.6	25.74
Off-peak	9.9	20.09
Controlled load		19.54

Source: Energy Australia FiT rates, Elysian Energy import rates

At the end of this step, for each customer, we have one original bill, based on their original profile, and three additional bills based on alternative profiles developed in Step 1:

1. A profile that shifts 40 kWhs of consumption from peak to off-peak times during net generating times. This enables us to assess the benefits to each customer of shifting consumption to arbitrage the time-varying FiT.
2. A profile that shifts 40 kWhs of consumption from peak to off-peak times during non-generating times. This enables us to assess the benefits to each customer of shifting consumption to arbitrage the time-varying retail electricity tariff.
3. A profile that shifts generation back by 1 hour but reduce total generation by 12% (to reflect orienting PV panels to face west rather than to face north).

In addition, there are two further additional bills based variations of 1 and 2 above in which consumption is shifted from peak to shoulder. We do this for the purposes of sensitivity analysis.

[1] https://compare.energy.vic.gov.au/

[2] We also conducted our analysis of benefits on less favourable import rates to confirm this intuition. This modelling confirmed that arbitraging less favourable import tariffs mean that there is less scope to realise benefits from arbitraging the time-varying FiT.

Step 3: Assess incentive to change behaviour

The next step is the compare bills based on customer's original, unadjusted profiles with bills from the alternative profiles developed in Step 1. We do this to assess customers' incentives to change behaviour in response to time-varying FiT. A customer has the incentive to change their behaviour by:

- *Shifting generation* to arbitrage time-varying FiT rates if, by doing so, they save money on their annual bill, relative to their annual bill for the original, unadjusted profile.
- *Shifting consumption* to arbitrage time-varying FiT rates if, by doing so, they save money on their annual bill, relative to their original, unadjusted bill **and** relative to the annual bill they would face by putting in equal effort (as measured in kWhs of shifting) to arbitrage time-varying import tariffs.

Step 4: Calculate reduction in network and generation costs

In the event that we confirm that time-varying FiT rates may potential induce behavioural changes, we calculate the benefits associated with these changes. Benefits are realised where changes in the timing of consumption or generation can reduce costs of generating or supplying electricity. Namely, benefits arise from:

- Less consumption / more generation at peak times, which can reduce costs of generating electricity and reduce the need to build additional generation capacity.

  This benefit is estimated by multiplying the expected reduced demand during peak times by the average difference in short run marginal costs (as measured approximately by average wholesale electricity costs) of generation between peak and off-peak times.
- Less consumption / more generation at peak times, which can reduce the need to build additional network capacity.

  This benefit is estimated by multiplying the expected reduced peak demand on the network by an estimate of the long run marginal cost of the network.

2.2 Assessing costs

We conduct a high-level analysis of the costs associated with mandating time-varying FiT rates. This includes all the incremental costs of incorporating time-varying FiT rates into retailers' billing systems and IT systems as well as any ancillary retailer costs (e.g. updating marketing material, legal costs). Since these costs are not directly observable the approach taken to determine these costs was to use data provided by retailers to the ESC.

3 RESULTS

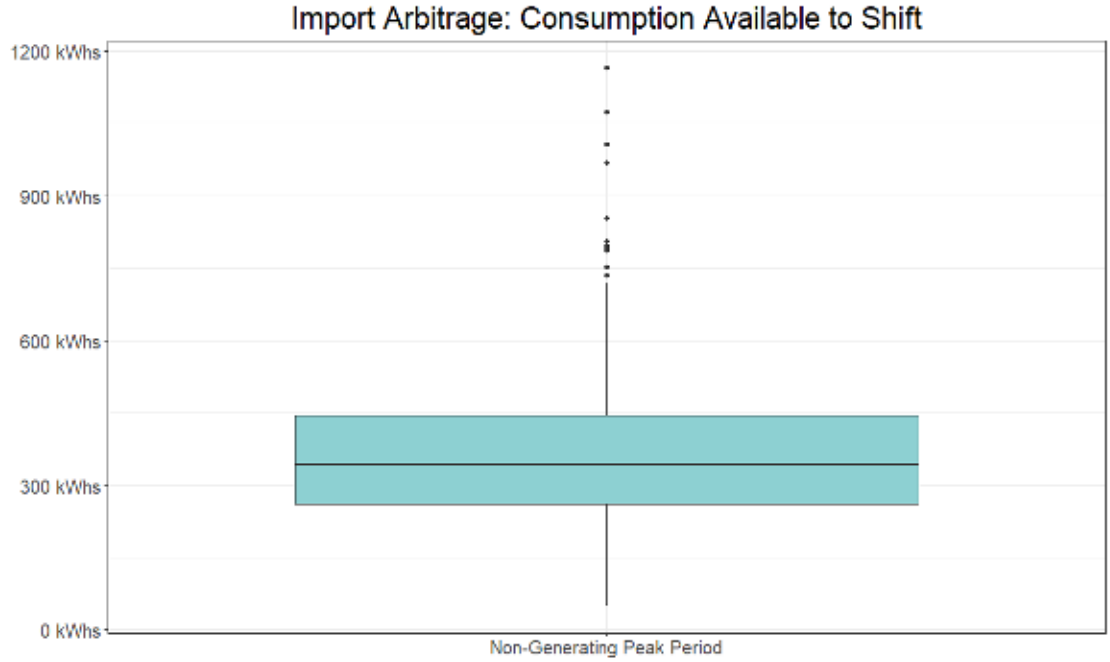
In this section we present the results of our analysis, with our results regarding the benefits of mandating time-varying FiT presented in section 3.2 and costs presented in section 3.3.

3.1 Ability to shift

As described in Step 1 of our methodology, we chose a consumption shifting amount of 40 kWhs per annum to as appropriate to a large number of customers in our sample. We sought a consumption shifting amount that customers could achieve for both arbitrating time-varying FiT rates and for arbitraging time-varying retail prices.

All customers can arbitrage the time-varying import rates by shifting as much of 40 kWhs per annum of consumption from peak to off-peak times. The total consumption available for shifting to arbitrage time-varying import rates is given by the sum of all gross consumption during peak periods that are non-generating.[3] This amount is shown, for all 300 customers in our sample, in **Figure 6**. By design, and as shown in **Figure 6**, all customers in our sample are able to arbitrage their time-varying import tariff, with most having the ability to shift over 100 kWhs away from non-generating peak periods.

Figure 6: Ability to arbitrage time-varying import rates



Source: Frontier Economics

In the case of arbitraging time-varying FiT rates, however, the total level of consumption a customer is able to shift from peak to off-peak times (such as to result in a corresponding change in imports) is given by the minimum of:

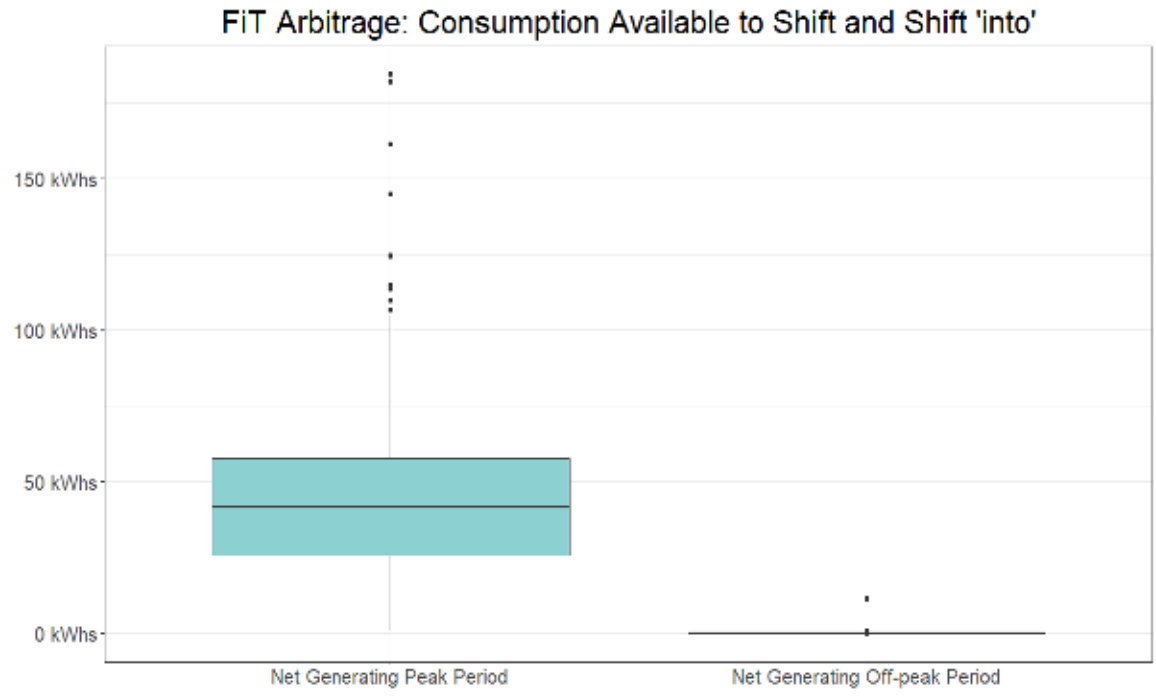
[3] Additionally, we checked that were at least some half hours in the year that are non-generating during off peak periods in the year (where consumption can be shifted 'into').

- the sum of all gross consumption during periods of net generation in peak times (the amount available to shift) and
- the sum of net generation in off peak times (the amount available to shift consumption 'into').

Our analysis of the data showed that even shifting the relatively small amount of 40 kWhs per annum is unachievable for the customers in our group. The ability to shift consumption to arbitrage time-varying FiT rates, as it varies across all customers in our sample, is depicted in **Figure 7**. **Figure 7** plots the total amount of gross consumption during net-generating peak periods (the amount of consumption available to shift) and the total net generation during off-peak periods (the amount consumption can shift 'into').

Figure 7 shows that many customers have available consumption to shift away from peak periods i.e. many customers have more than 40 kWhs per annum of total consumption during net generating peak periods. However, no customer is able to arbitrage this amount without exposing themselves to off-peak import tariffs. This is because no customer has a total level of net generation during off-peak periods into which they could shift their consumption. In fact, most customers have none or very little net generation during off-peak periods throughout the entire year. The reason is that the only off-peak periods that coincide with solar PV generation is the early morning, when rates of generation are low and rates of consumption tend to be high. This means that there is little to no opportunity to arbitrage time-varying FiT rates, between peak and *off-peak* period even if we were to assume a lower amount than 40 kWhs for annual shifting of consumption.

Figure 7: Ability to arbitrage time-varying FiT



Source: Frontier Economics

Given this, as a sensitivity test, we conduct our assessment on the ability to arbitrage time-varying rates by shifting consumption away from peak periods to shoulder periods. In this case, all customers are able to arbitrage up to 40 MWh per annum for their time-varying import rates and 144 customers out of 300 are able to arbitrage up to 40 MWh per annum for their time-varying FiT rates. The results regarding the potential consumption response in this case is also provided in the next section.

3.2 Benefits

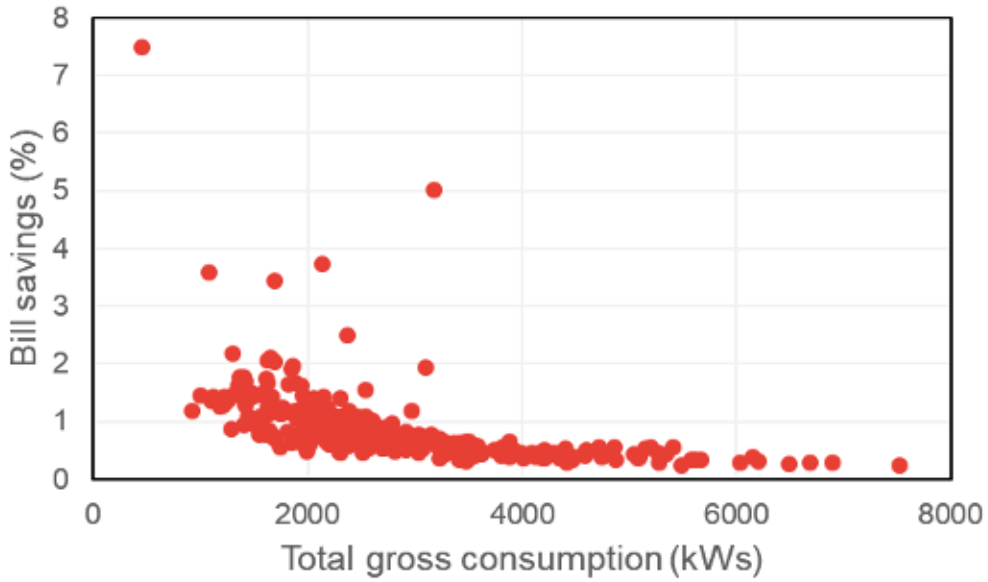
3.2.1 Incentives to respond to time-varying FiT rates

The results on of our analysis indicate that much stronger price signals are provided by time-varying import tariffs than time-varying FiT rates. This means, for a given level of effort, the incentive to reduce import tariff payments dominates the incentive to maximise FiT payments, with customers far more likely to act on the incentives created by the former.

Moreover, as we have discussed, we find that there is practical opportunity for customers to arbitrage a time-varying FiT rate from peak to off-peak periods, as identified in the previous section. In fact, of our 300 customers, not a single customer is able to arbitrage the time-varying FiT by shifting 40 kWhs per annum of consumption from peak to off-peak times.

Our analysis of the bill impacts of shifting 40 kWh per annum of consumption shows that customers realised an average reduction in their annual bill of $4.06. **Figure 8** shows the variation in customer annual bill savings, relative to their annual bill for their original, unadjusted profile, as a result arbitraging their time-varying import rates between peak and off-peak, as a function of total gross consumption. While in absolute terms the results across customers was uniform,[4] the impact as a proportion of their original bills varied widely. As expected, those with lower levels of consumption generally have a lower original bill, and thus have a greater proportional reduction in their bill as a result of this arbitraging.

Figure 8: Percentage bill savings by yearly gross consumption – Import arbitrage (peak to off-peak consumption shifting)[5]



Source: Frontier Economics

[4] This modelling result comes from the fact that all customers in our sample are able to receive the maximum possible payoff from arbitraging time-varying import rates, uniformly given by the difference between the peak and off-peak import rates, multiplied by the consumption shifted (40kWhs).

[5] Though accounted for in our analysis of benefits, one outlier customer at 18% bill reduction was removed to aid in the clarify of the visualisation.

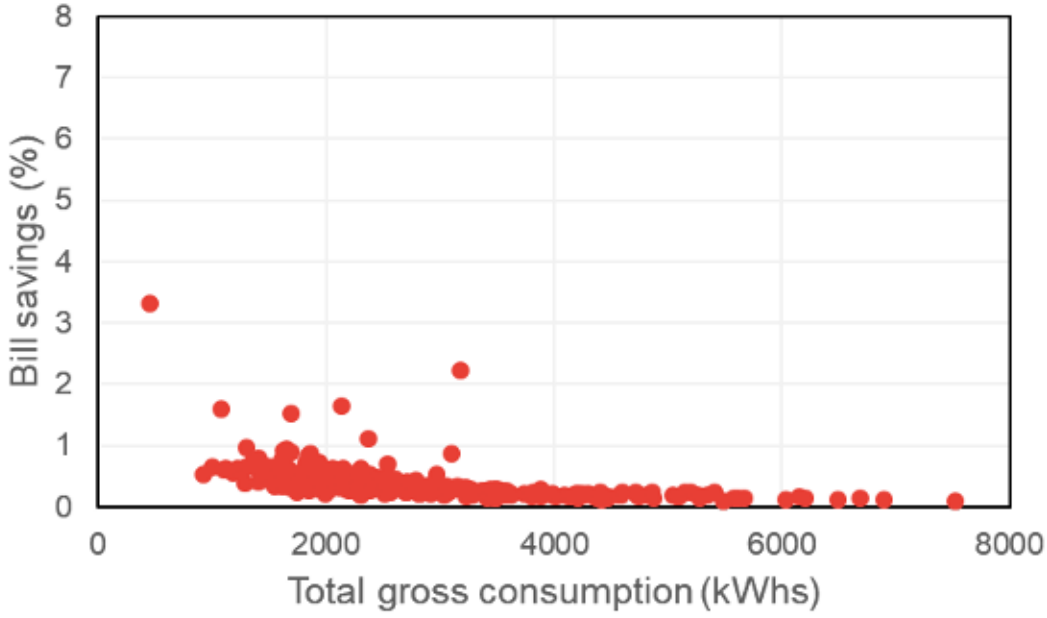
As detailed in Section 2.1, we also conduct our analysis on benefits for consumption shifting to shoulder periods. In this scenario, while more consumers are able to shift their consumption to arbitrage time-varying FiT rates, however, all are able to find slightly higher reductions in their annual bill by arbitraging their time-varying import tariffs:

- on average $1.80 of reductions in annual bills are achieved by shifting 40 kWhs per annum of consumption from peak to shoulder in response to time-varying import rates, while
- on average, $0.19 of reductions in annual bills are achieved by shifting 40 kWhs per annum of consumption from peak to shoulder in response to time-varying FiT rates.

The results pertaining to this sensitivity analysis are depicted in the charts below. **Figure 9** and **Figure 10** show the variation in customer bill savings relative to their original bill as a result arbitraging their time-varying import and FiT rates by shifting consumption between peak and shoulder, as a function of total gross consumption.

There are in total 144 customers that can employ both arbitrage strategies when shifting consumption from peak to shoulder. For each of these customers, **Figure 11** compares the difference in payoff (in terms of percentage reduction in bill relative to original bill), between employing an import arbitrage strategy relative to a FiT arbitrage strategy. It shows that, in every case, a customer is better off by employing an import arbitrage strategy relative to a FiT arbitrage strategy.

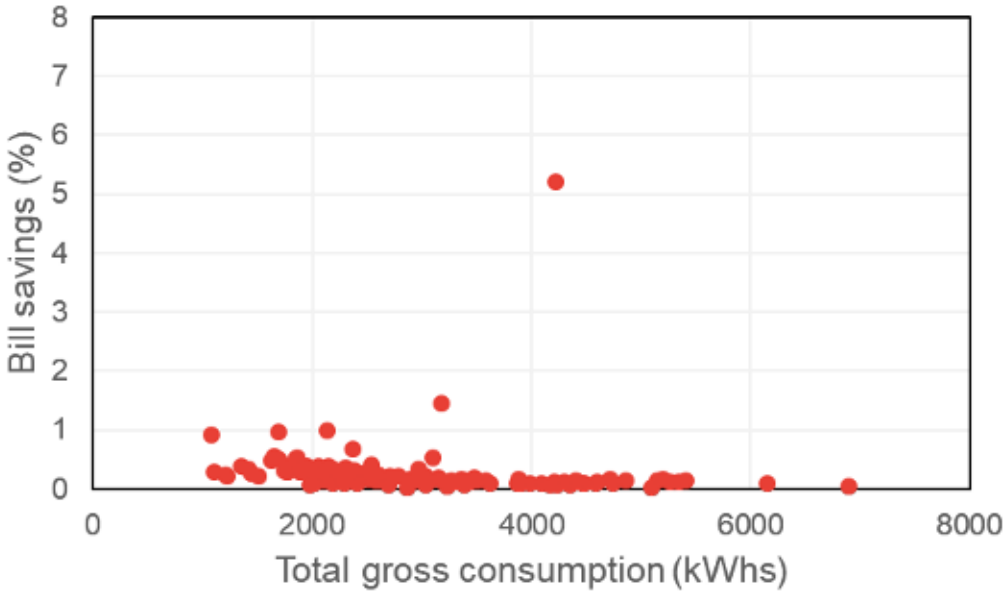
Figure 9: Percentage bill savings by yearly gross consumption – Import arbitrage (peak to shoulder consumption shifting)[6]



Source: Frontier Economics

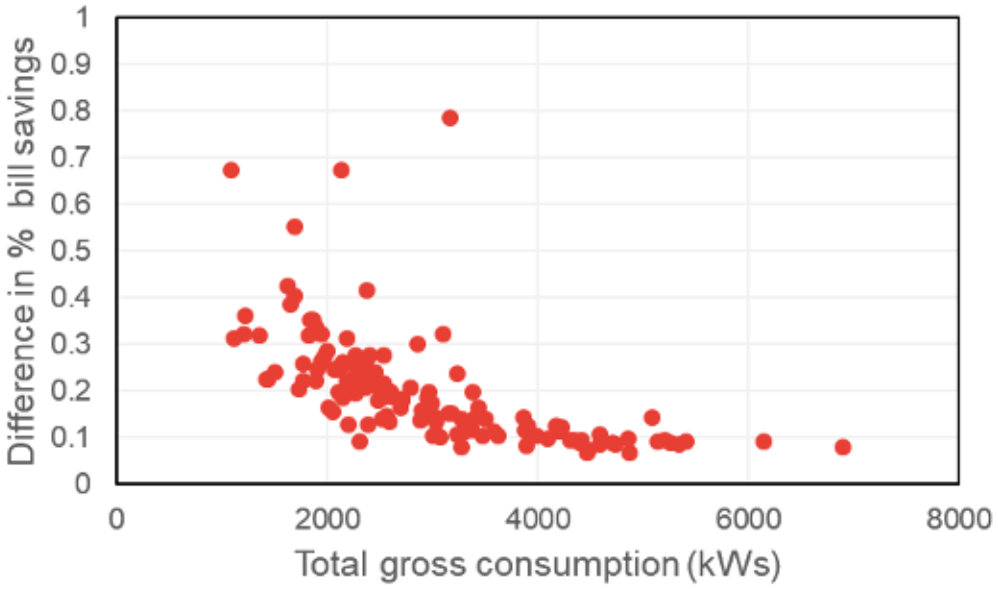
[6] Though accounted for in our analysis of benefits, one outlier customer above 8% bill reduction was removed to aid in the clarity of the visualisation.

Figure 10: Percentage bill savings by yearly gross consumption – FiT arbitrage (peak to shoulder consumption shifting)



Source: Frontier Economics

Figure 11: Difference in percentage bill savings from arbitraging time-varying import relative to FiT (peak to shoulder consumption shifting)[7]



Source: Frontier Economics

[7] Though accounted for in our analysis of benefits, one outlier customer at a of 3% difference in % bill savings was removed to aid in the clarity of visualisation.

It should be noted that the maximum possible payoff from shifting consumption in response to time-varying FiT is $1.20 (the difference between the peak and shoulder FiT rates, multiplied by the consumption shift of 40 kWhs). Despite only shifting consumption from and to periods of net generation, this maximum possible payoff is not realised as some shoulder half hours for customers are not sufficiently net generating, resulting in some exposure to shoulder tariff rates as a result of increased consumption.

3.2.2 Generation response to time-varying FiT

Where a customer previously had panels facing north, re-orienting these panels west results in an approximately 12% reduction in total generation and time shifting of all generation by approximately 1 hour. These two effects have opposite effects on bills:

- **Reduction in generation increases bills** as it decreases FiT payments (due to a reduction in exports and net export) and it increases import payments (due to increases in net consumption)
- **Time-shifting of generation decreases bills** as generation 'covers' less shoulder consumption in the morning but more peak consumption in the early evening, resulting in positive trade off

For every customer in our sample, the bill impact of reduced generation dominates the effect of shifting the time of generation and re-orienting PV panels from north to west results in an increase in annual bill of $16.23 on average in our sample.[8]

If it were possible to reorient PV panels from north to west and only change the timing of generation, without reducing total generation, a decrease in annual bills would be possible. In our sample, the decrease in annual bills would have be approximately $4.15 on average.

3.3 Costs

The quantifiable costs of mandating time-varying FiT are all the incremental costs of incorporating time-varying FiT into retailers' billing systems and IT systems as well as any ancillary retailer costs (e.g. updating marketing material, legal costs). These costs are not directly observable and therefore the approach taken to determine these costs was to use data provided by retailers and apply a net present value analysis.

Cost information provided on a non-confidential basis by AGL suggests that the cost of implementing time-varying FiT rates would be $200,000. If we assume that this cost is the same for all retailers in Victoria that would be required to introduce time-varying FiT rates (excluding EnergyAustralia, which already offers time-varying FiT rates) then the net present value of this cost over 10 years would be around $3,000,000.

Confidential cost submissions from other stakeholders suggested that this cost could be materially higher, potentially up to around $20,000,000 in net present value terms over 10 years.

[8] For a combination of a time-varying import tariff and FiT. For customer with a single, flat FiT, the increase in bill is approximately $24.74.

4 CONCLUSION

There are potential benefits of time-varying FiT rates that depend on behavioural change; however, we find that the price signals provided by time-varying FiT rates are not sufficient to motivate behavioural change. Chiefly, this is because, even where there are savings that can arise from responding to time-varying FiT rates, the potential savings available from responding to time-varying import rates are higher. In our view, the small group of engaged and rational customers that would change behaviour on the basis of time-varying rates, are likely to recognise this fact and choose to respond to time-varying import rates over FiT rates.

Moreover, we find that there is less practical opportunity to arbitrage time-varying FiT rates, highlighted by the fact that none of the 300 customers in our sample were able to shift 40 kWhs of consumption to increase their payments for exports.

Given we assess that time-varying FiT rates are unlikely to induce behavioural change, there are unlikely to be benefits associated with mandating time-varying FiT.

Our sensitivity analysis considered shifting consumption from peak to shoulder periods identified that many more customers can potentially arbitrage their time-varying FiT by shifting their consumption. However, without carefully shifting consumption customers can receive less than the maximum pay-off from arbitraging their FiT due to increased exposure to shoulder *import* rates. More importantly, even if a customer was to carefully optimise their consumption shifting to avoid exposure to shoulder import rates, this would not in any way change our conclusion as the payoff from arbitraging time-varying import rates still has a greater pay off. The sensitivity analysis is nonetheless helpful in highlighting that shifting consumption in response to time-varying FiT can be risky.

Given that there are unlikely to be benefits to mandating time-varying FiT rates, and that there is almost certainly a positive cost associated with its implementation, we conclude that mandating time-varying FiT rates is not net beneficial.

In the future we may not have the same conclusion regarding the costs and benefits of time-varying FiT rates. The current structure of *import tariffs* isn't necessarily efficient – as *network tariffs* evolve, we may see that the *import tariffs* do not continue to provide much stronger price signals than FiTs. At this time, were we to find that time-varying FiT rates would provide appropriate incentives for behavioural change, it is far more likely that mandating time-varying FiT rates would be net beneficial, since only small reductions in peak consumption can deliver major savings in the costs of network investment.

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