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Electric cars, solar panels, and batteries in New Zealand
Vol 3: The social impact

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concept

What this report is about

The energy sector stands on the verge of a revolution. Advances in solar panels, electric vehicles and batteries are making these technologies much more affordable and accessible to consumers.

But these technologies of "tomorrow" are emerging in a legacy environment – particularly in relation to the electricity pricing structures – which don't reflect underlying cost drivers.

This is the final report in a three-part study looking at the impacts of new energy technologies. The first report examined the likely impact on greenhouse gas emissions of these technologies, and the second considered the costs and benefits of these technologies, both for consumers, and society as a whole.

They identified that poor technology uptake (too much of some technologies, too little of others) because of today's out-dated pricing structures could significantly increase greenhouse emissions, and cause inefficient expenditure of approximately $2 billion.

Both reports are available at www.concept.co.nz/publications.html

This third report examines the potential social dimension to this new energy technology revolution, focussing on two key areas:

- Might uptake of new technologies under current charge structures, result in costs being 'shifted' onto the least well-off?
- Will possible changes to more cost-reflective charge structures be likely to exacerbate or ameliorate social issues?

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This report has been prepared by Simon Coates, and David Rohan at Concept.

The opinions in this report are those of the authors, and do not necessarily reflect the views of organisations in the project support group.

Any errors or omissions are the responsibility of the authors.

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Executive summary

Advances in solar panels, electric vehicles and batteries are making these technologies much more affordable and accessible to consumers. Smart uptake of these technologies offers major benefits for society by reducing costs and greenhouse gas emissions.

Our earlier reports showed that these benefits are unlikely to be fully realised with existing electricity pricing structures. Instead, new technology uptake will be artificially stimulated in some cases, and retarded in others.

Our previous reports estimated that skewed uptake decisions could raise New Zealand's energy costs by around $2 billion over the next 20 years, and lead to higher greenhouse gas emissions than otherwise.[1]

In this report, we explore the potential social impacts of new technology uptake – especially the effect on power bills for poorer consumers.

Poor consumers likely to be worse-off on average

One key finding is that poorer consumers are likely to be worse-off on average, if existing electricity pricing structures are retained and there is significant uptake of new technology.

The main reason for this is the expected effect of solar panel uptake under existing pricing structures. When households install solar panels, this reduces the investment required in new power stations and avoids some grid generation costs. On the other hand, the cost of providing wires, poles, customer service and metering for households with solar panels doesn't generally change (and may actually increase).

Under current pricing structures, households that install solar panels typically see a fall in their power bills that is much larger than the true level of cost saving. This creates a cost shortfall that will be 'shifted' to other consumers – mainly onto households without solar panels.

Evidence from New Zealand and Australia indicates that the poorest households are much less likely to install solar panels than others. In part this is because solar panels have significant upfront costs – which poorer households are less able to meet from savings or borrowing. But perhaps more importantly, it is because the majority of our poorest consumers live in rented accommodation – making installation less likely. These factors mean cost-shifting from solar panel uptake is likely to fall much more heavily on the poorest consumers.

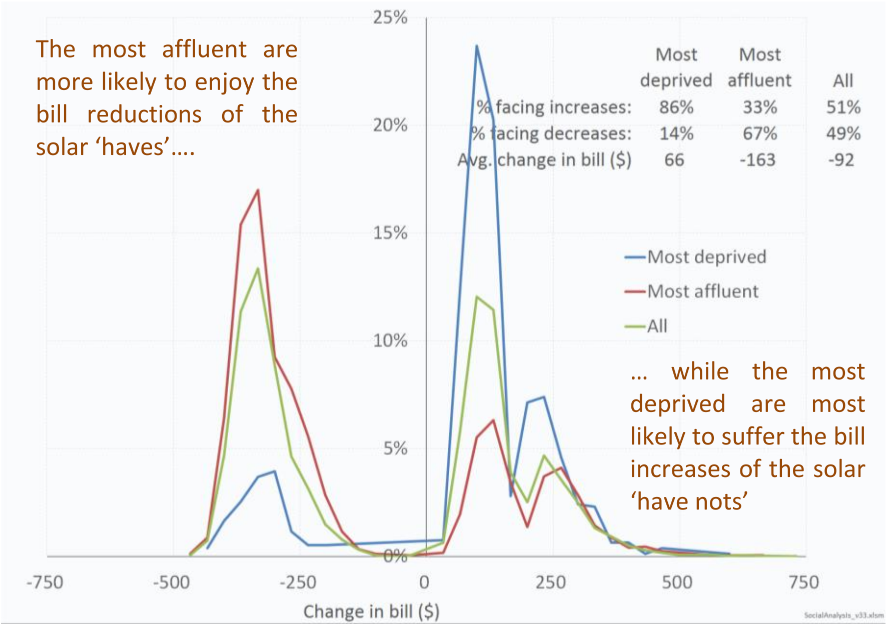
We have analysed actual historical power usage for over 100,000 households combined with socio-economic data to estimate the impact of cost-shifting. This data was from five geographic regions which span New Zealand – Auckland, Christchurch, Wellington, Dunedin, and Hawkes Bay.

[1] See www.concept.co.nz/publications.html for the two earlier reports on environmental and economic impacts of new technology uptake.

In a scenario where existing electricity pricing structures are retained and there is 50% uptake of solar panels[2], we expect power bills for the poorest 10%[3] of households to increase by around $60/year on average, whereas the wealthiest 10% of households will enjoy average bill reductions of ≈ $160/year.

However, these averages obscure much of the real impact of cost-shifting. For example, Figure 1 shows the projected distribution of bill impacts across consumer groups, and for consumers as a whole in the Wellington area.[4]

Figure 1: Change in power bills from 50% solar uptake with existing price structures (excluding panel costs and export revenues – Wellington area)



[2] Some overseas jurisdictions have seen such levels of uptake, and this could feasibly happen in New Zealand over the next 15-20 years as solar PV costs fall and PV becomes increasingly profitable for consumers to invest in if current tariff structures continue.

[3] Strictly, this is the group of households defined as "most deprived" by Statistics NZ based on a range of measures. Henceforth, we refer to this group as the "poorest consumers" or "least affluent" for shorthand. This is the group of consumers likely to be of greatest concern from a social policy perspective, but other deciles of deprived households are also of concern. At the other end of the scale, are the least deprived 10% of households. We refer to this group as the wealthiest or most-affluent households for shorthand.

[4] Results have been calculated for the four other regions, and show broadly similar outcomes. Full results for all regions and decile groups, and key assumptions are set out in the body and appendices of the report.

The ‘humps’ on the left-hand side represent consumers who will see a fall in their power bills because installing a solar panel will reduce their power drawn from the grid, and hence their consumption charges. For a solar uptake scenario of 50% of customers overall, we estimate that 67% of the wealthiest consumers will fall into this category, compared to 14% for the poorest consumers. This difference arises because poorer households are less likely to install panels for the reasons discussed earlier.

The right-hand side of the chart shows the distribution of outcomes for consumers projected to see higher bills – i.e. those who do not install panels. Around 86% of the poorest consumers are projected to fall into this category – with an average bill rise for this group of around $135/year, with a wide spread of outcomes reaching over $400/year in some cases.

Conversely, only 33% of the most affluent customers are projected to not install panels and face bill increases.

Further, Figure 1 only considers the impact on consumers’ power bills. It takes no account of the cost of purchasing and installing solar panels, or the revenue that consumers can earn from exporting power. Figure 2 shows that when these costs and revenues are taken into account, the net benefit for solar consumers is a lot less – with many actually being worse off.[5]

For the poorest group of consumers in the Wellington area, the average increase is $112/year. The average outcomes in Auckland, Christchurch, Dunedin and Hawkes Bay are similar. Again, there is considerable spread of individual outcomes within the decile group.

Figure 2: Change in overall energy costs from 50% solar uptake with existing price structures (Wellington area)

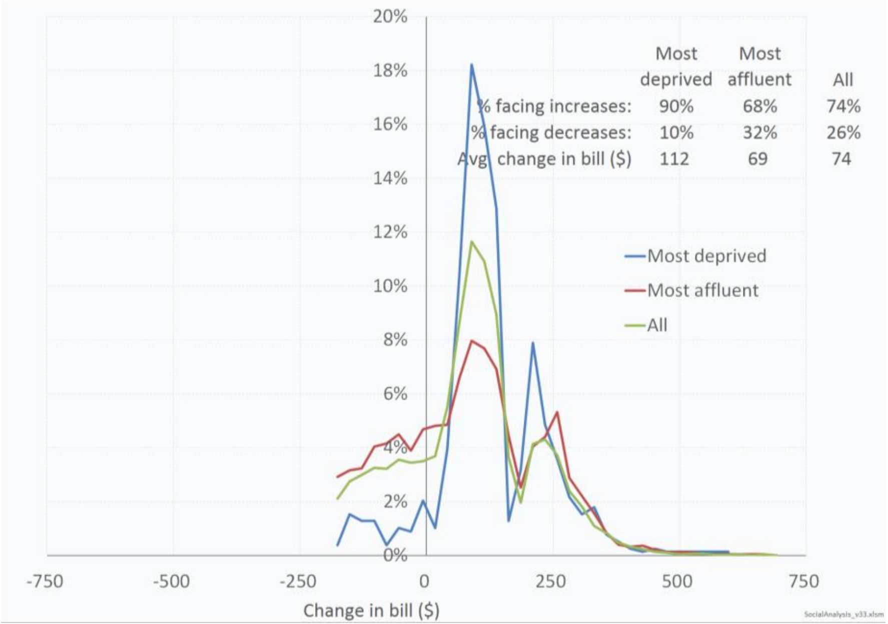


Figure 2 also shows that when the total cost of energy is taken into account (i.e. including the cost of purchasing the panels) significant solar uptake will end up increasing costs for the most households.

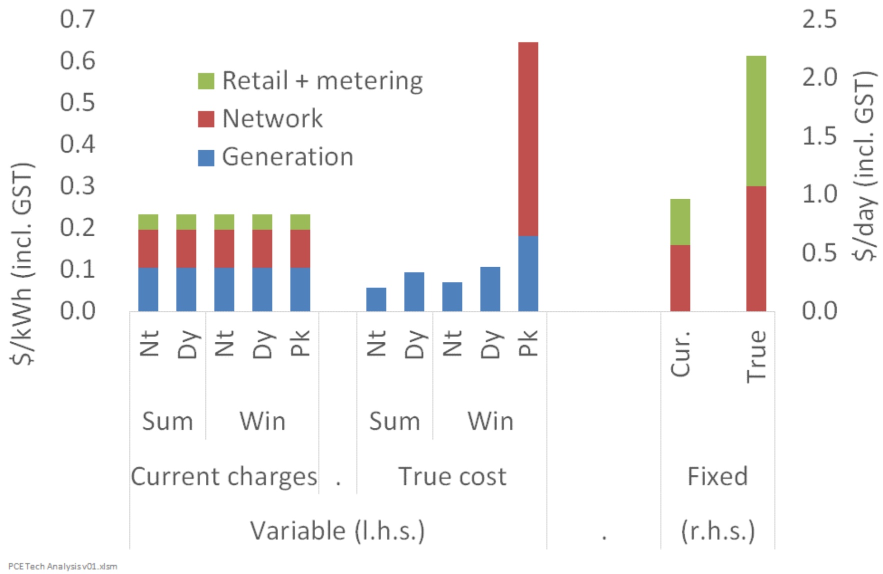
[5] At present, many consumers are investing in panels which do not deliver a positive financial return. Further, as the proportion of consumers with solar rises, some of the associated tariff increases will ‘flow back’ onto solar consumers as well. i.e. the ability for a solar consumer to benefit from cost-shifting is much greater when very few consumers have solar, than when half of all consumers have solar.

Divergence between price structures and cost drivers is the root cause of cost-shifting

The root cause of these impacts is the divergence between existing electricity pricing structures and underlying cost drivers for the supply of mains electricity.

At present, most consumers pay a $/kWh 'variable' usage charge that is constant across the year, coupled with a fixed $/day charge.

Figure 3: Typical current price structures versus true system costs



But, the underlying costs of supplying each consumer vary greatly depending on when they use power, as shown by Figure 3. In particular, supply costs in peak demand periods are much higher than other times. This is because generation and network costs are strongly driven by peak demand requirements, even though such demand might only be experienced for a few hours each year. Figure 4 shows that as a result consumers are typically charged:

- too little for usage at times of peak demand
- too much at other times.

These divergences create potential for cost-shifting whenever there is a significant difference between different consumers' usage patterns. Such differences can occur for a variety of reasons – with adoption of a 'new' energy technology being a major driver.

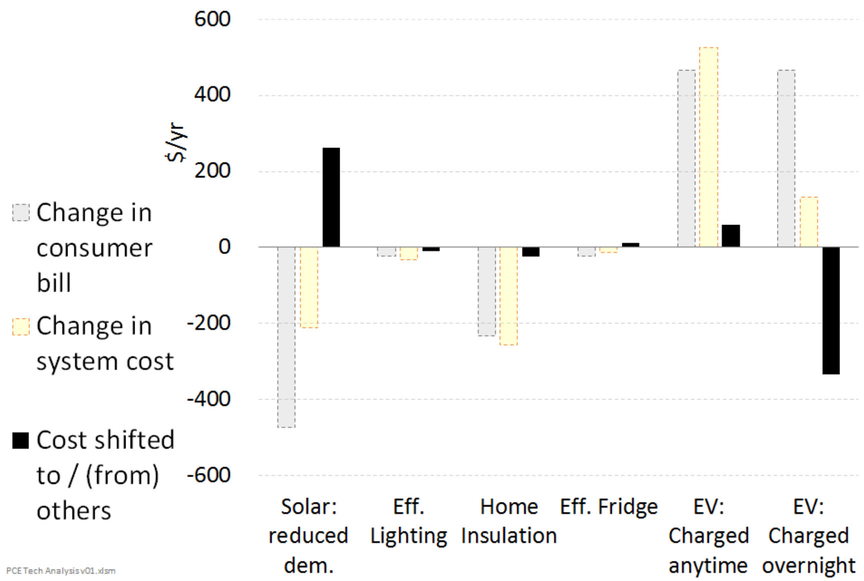
Cost-shifting can occur with all technology options – but solar panels have greatest impact

Figure 4 shows the typical impact on a consumer's bill of adopting a particular energy technology option (hollow grey bars) – such as insulating their home or installing a solar panel. Changes to bills are entirely driven by the effect of the technology on their annual mains-power usage, to which the $/kWh charge is applied.

The hollow yellow bars show the corresponding long-term impact on supply costs. These vary because technologies differ in their scale, and (more importantly) how they affect usage at different times of the year and day.

The differences between consumer bill impacts and supply costs are shown as solid black bars – and represent the typical cost-shifting that will occur when a consumer adopts each option. A positive value indicates costs shifted to others, a negative value indicates the new technology investor is paying too much for their electricity leading to 'benefits shifting' onto others.

Figure 4: Typical cost shifting for different technology options[6]



While some cost-shifting occurs under all options, the impact is much greater for solar panels. This is the only option that shifts significant costs *onto* other customers – on average by around $250/year for each installation. Purchasing an energy efficient fridge will also shift some costs to other customers, but the effect is much smaller. The key reason for the difference is that solar panels yield little or no saving in network costs because they don't operate at peak demand times in cold winter evenings. And yet, they provide a large reduction in bills based on the fall in mains-supplied power.

While an energy efficient fridge also reduces usage, this reduction is much smaller and spread evenly across the year – including in peak demand periods – so there is less divergence between the effect on bills and supply costs.

Some technologies even have 'benefit-shifting' because a consumer who installs them will pay more in additional charges than the change in their supply costs. For example, a consumer that recharges their electric vehicle at night (off peak) times while paying an 'anytime' $/kWh charge will pay more than the rise in their true supply costs. This 'surplus' allows a reduction in power bills for other consumers. Assuming EVs are mainly purchased by middle- and higher-income households, we expect this type of effect to be beneficial on average for poorer consumers.

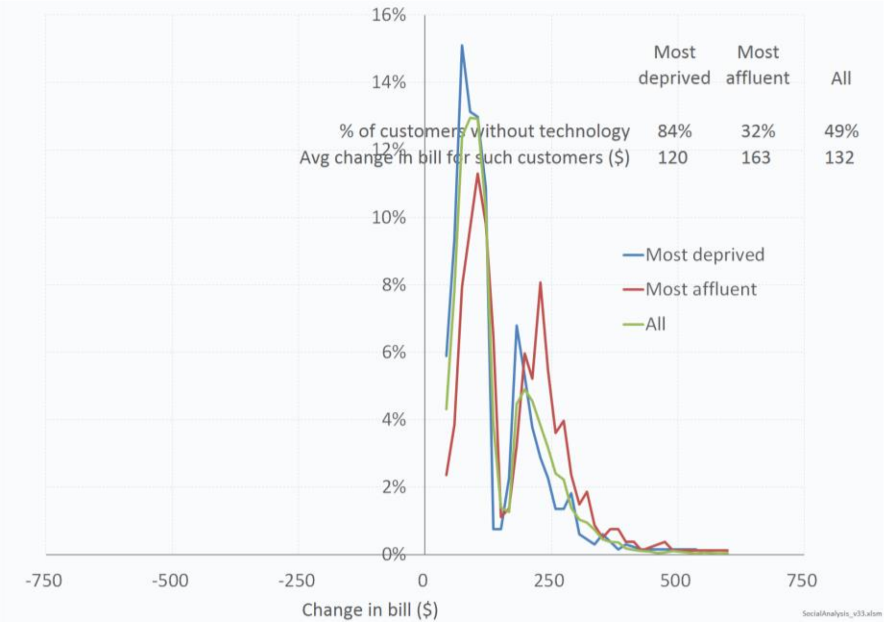
However, we expect benefit-shifting to be limited in practice, because a technology's uptake will tend to be retarded where consumers derive less financial benefit from its use (e.g. pay full rates for electricity but recharge EVs only at off-peak times). And if pricing structures are modified to address such issues (e.g. introducing off-peak prices to facilitate EV recharging at night), then the potential for benefit-shifting is reduced at source.

We have developed an overall technology uptake scenario which accounts for these issues. It assumes that over the next 15 years'

[6] The chart shows 'average' effects from utilising different technology options and assuming a typical electricity pricing structure that is not cost-reflective – impacts can vary and be larger or smaller depending upon individual circumstances.

solar uptake will reach 50% and EV uptake only 4.5%, if existing pricing structures are retained.[7]

Figure 5: Expected impact of 'no change to price structures' on 'non-adopter' power bills in 15 years (Wellington area)



For example, Figure 5 shows the projected bill impacts for 'non-adopter' households in the Wellington area for this mixed uptake scenario. The focus on non-adopters provides an 'apples-with-apples' comparison of how these consumers are affected by cost-shifting by the wider uptake of solar panels and EVs by society.

In this uptake scenario, we expect 84% of the poorest households to see higher power bills through being 'non-adopters'.[8] For these consumers, the average rise is $120/year – a 6.5% increase on the average bill for such customers – with increases of $350/year or more in some cases. Around 32% of the wealthiest households are also projected to be non-adopters and see increases, which average around $163/year and also vary strongly across individuals.[9]

We project the average rise in bills for the poorest households to be similar in the other four regions studied. For this group, we project an average increase of around $100/year across the five regions as a whole.

Improved pricing structures can reduce cost-shifting impacts and provide wider benefits

As we observed earlier, cost-shifting is not caused by new technology – but the underlying divergences between electricity pricing structures and cost drivers. Improved price structures can reduce or

[7] The EV uptake is relatively low because it assumes existing general price structures are retained – and these generally don't provide off-peak and/or 'controlled' rates to encourage EV charging – and there are no 'special' tariffs for EVs. In addition, a 4.5% penetration rate implies that EVs account for approximately 8.5% of new sales by year 15, given the lagged effect on the total vehicle stock of EV purchases.

[8] As noted earlier, the 16% that see a bill decrease do so because they install solar panels, which reduces their mains-power usage and bills. However, once the annualised cost of buying solar panels is taken into account, the proportion who will see a real fall in their total electricity costs (mains-power plus panel) will be substantially lower than 16%.

[9] The average increase is larger for wealthy non-adopters than poorer non-adopters because wealthy consumers tend to have greater overall consumption.

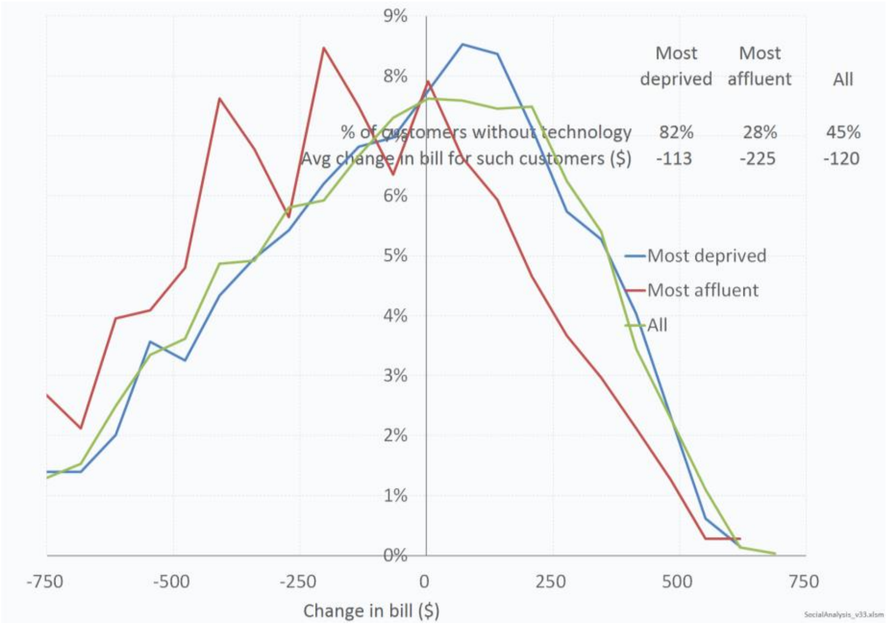
eliminate the scope for cost-shifting that will harm poorer consumers. Improved price structures are also needed if New Zealand is to capture the full economic and emission benefits from new technology.

As a starting point, we considered a scenario where fully cost-reflective pricing structures are adopted. This would have two impacts on consumer bills:

- Direct impact – it would align charges to match the supply costs of different usage patterns – in particular charging more for usage in winter peak periods when supply costs are much higher
- Indirect impact – it would alter the trajectory of technology uptake over time.

Figure 6 shows the projected distribution of outcomes under this alternative future scenario, relative to the projected outcomes from a continuation of existing cost structures, for consumers in the Wellington area. To ensure an apples-with-apples comparison of cost-shifting effects, results are only shown for non-adopters.

Figure 6: Fully cost-reflective – long term bill impact for non-adopters relative to outcomes under current price structures (Wellington area)



In terms of *average* impacts, all consumer groups are better off under fully cost-reflective price structures. In particular, the poorest consumers are expected to have power bills than are on average $113/year lower than otherwise.

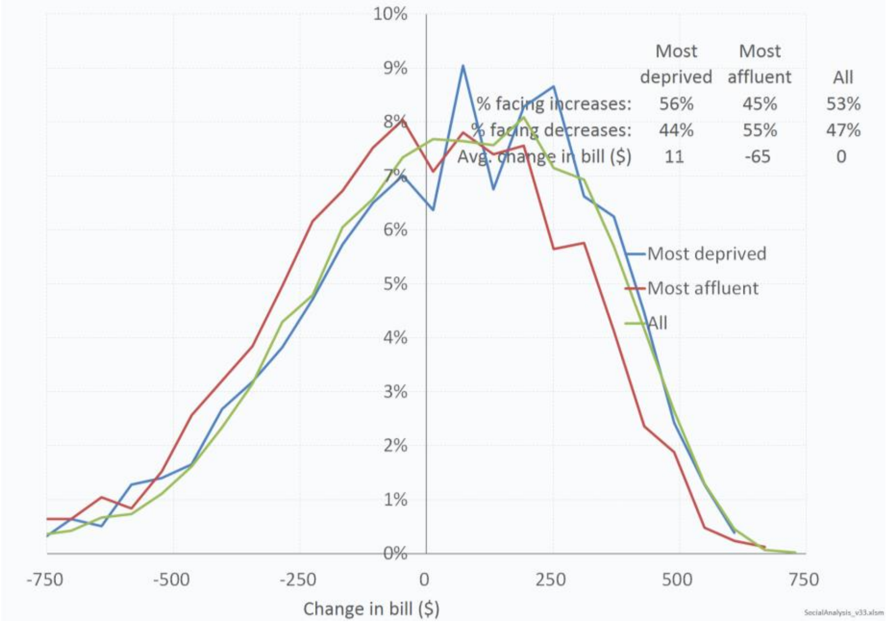
However, there is a wide dispersion of outcomes around the average within each group. Around 14% of the poorest consumers would see bill reductions of $500/year or more, but around 2% would see equivalent annual increases.

This wide range reflects variations in individual situations – especially in patterns of usage across each consumer group (recalling that we analysed many thousands of households) and the poor alignment between charges and costs in current price structures.

It is also important to recognise that Figure 6 shows the impact in approximately 15 years' time of adopting fully cost-reflective tariffs, versus retaining existing structures.

Existing tariffs provide another point of comparison. Figure 7 shows the initial effect on consumers of adopting fully cost-reflective tariffs, assuming this were to occur in one step (although we are not advocating such a move), and consumers didn't immediately change their usage patterns in response.

Figure 7: Fully cost-reflective – initial bill impact (Wellington area)



The impacts have similar 'shapes' to Figure 6, but all have been shifted rightwards indicating that consumers will see lower bill savings, or larger increases in the short-term, compared with the full impact over time. For example, the poorest consumers see an average bill increase of $11/year as the initial effect, compared to an average <u>reduction</u> of $113/year over time.[10]

The difference is because much of the longer-term impact on bills from adopting fully cost-reflective price comes from altering the mix

[10] The initial average net impact on bills is zero because of the need to satisfy revenue neutrality across all customers. I.e. networks and retailers won't recover more or less from customers overall simply from re-structuring their prices.

of technology uptake. Accounting for these influences reduces supply costs, and hence bills for all consumers on average.

Results for Auckland and Hawkes Bay consumers show similar outcomes to Wellington. For the poorest consumers in Christchurch and Dunedin, moving to cost-reflective pricing is expected to provide little or no benefit on average,[11] while the immediate impact would be to increase bills by around $100/year on average.

Effect of low fixed charge scheme

The wide dispersion in outcomes across consumers in both the immediate and longer terms is exacerbated by the lack of cost-reflectivity in current price structures.

Some of this is 'accidental' and simply reflects historic practices – particularly not having charges which vary with the time of consumption.

However, some is intentional, because of the low fixed charge (LFC) regulations. These limit suppliers' ability to use fixed $/day *charges* to recover fixed *costs.* As a result, suppliers have variable $/kWh charges that are higher on average than would be the case with cost-reflective pricing, as shown in Figure 3 previously.

The LFC regulations effectively require electricity suppliers to offer price options that favour consumers with below-average usage. This shifts costs onto consumers with above-average usage. Proponents of the scheme argue that this benefits poorer consumers, because they tend to have below-average usage.

Because the LFC scheme is a current regulatory requirement, we have explored a scenario where price structures are made more cost-reflective (especially to reflect peak versus off-peak supply costs) but the LFC scheme is retained.[12] The resulting price structures would be more cost-reflective than at present, but not fully so.

Figure 8 and Figure 9 show the estimated long-term and initial impacts respectively for Wellington consumers of this partially cost-reflective option.

[11] For the poorest consumers in Christchurch, the average long-term reduction is $27/year and for Dunedin it is an annual average increase of $13/year.

[12] See body of report for detail of how this option was modelled.

Figure 8: Partially cost-reflective – long term bill impact for non-adopters, relative to outcomes under status quo tariffs (Wellington area)

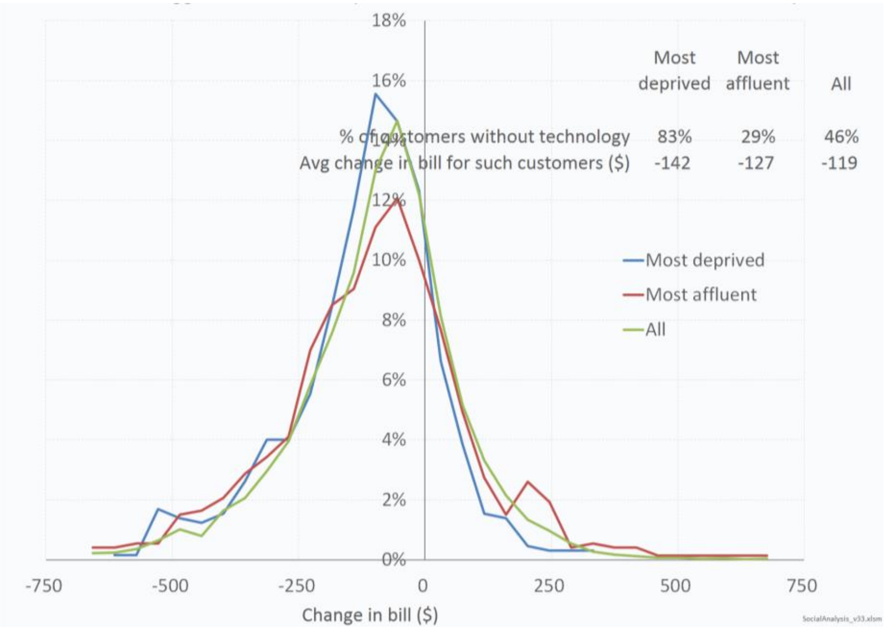
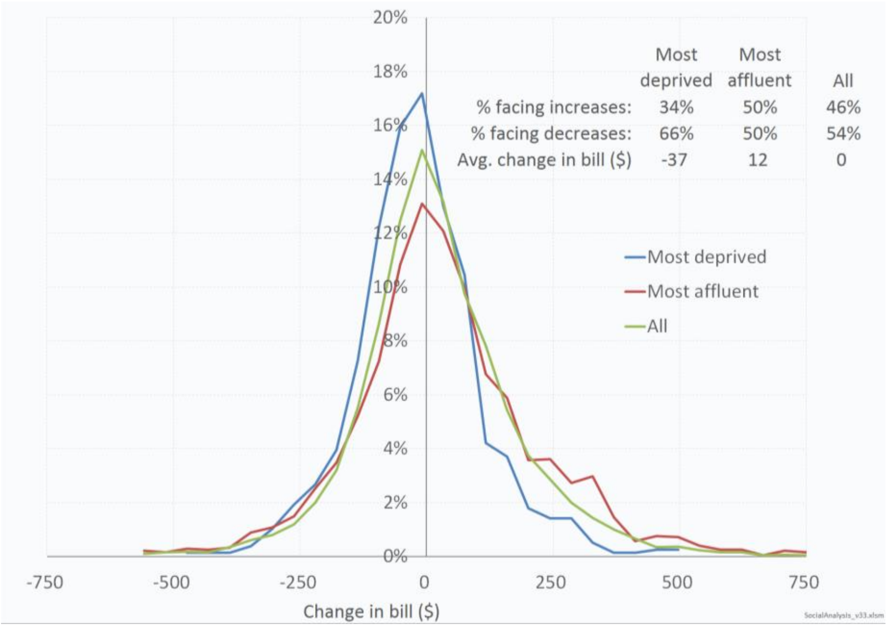


Figure 9: Partially cost-reflective – initial bill impact (Wellington area)



Comparing these outcomes to those under the fully cost-reflective price structures (shown in Figure 6 and Figure 7), the key observations are:

- For the poorest group of consumers who are non-adopters, the *average outcomes* are somewhat better – a reduction of \$142/year compared to \$113/year (long term) and saving of \$37/year compared to increase of \$11/year (immediate impact)
- For the most-affluent group of consumers who are non-adopters, the *average outcomes* are appreciably worse - a saving of

$127/year compared to $225/year (long term) and an increase of $12/year compared to saving of $65/year (immediate impact)

- For all non-adopter consumers, the *average outcomes* are similar - a saving of $119/year compared to $120/year (long term) and zero average net immediate impact in both cases.
- For all groups, there is a noticeably narrower spread of outcomes under partially cost-reflective charges compared to fully cost-reflective charges.

Results for the other four regions show broadly similar outcomes.

More generally, it is important to recall that Figure 6 to Figure 9 only look at the impact on the non-adopter consumers who don't take up new technology.

When adopters are also considered and taking into account the purchase costs and export revenues of panels, the outcomes are not as good: Average long-term energy cost savings of $36 per customer, whereas full cost-reflectivity would result in average long-term energy cost savings of $47 per customer.

This annual difference is modest at an individual level but would amount to around $200 million for New Zealand as a whole over time. The economic cost of moving to partial rather than full cost-reflectivity is therefore significant.

Given that the LFC scheme is intended to assist poorer consumers, it is perhaps surprising that the *average* difference between fully and partially cost-reflective charges is not more marked for these consumers – especially the immediate impacts.

This is because the LFC scheme is a fairly blunt way to help poorer consumers. It is based on usage levels, rather than social factors. Much of the benefit therefore goes to consumers who are middle- and higher-income, and it actually hurts those poorer consumers with above-average usage – some to a significant extent.

Conclusion

Our analysis shows that technology uptake is likely increase power bills for many of New Zealand's poorest consumers, if existing electricity pricing structures are maintained. We expect over 80% of the poorest consumers will face higher power bills due to cost-shifting associated with technology uptake over the next 15 years.

For this group of consumers, we expect an average rise of around $100/year, with increases of $350/year or more in some cases, if existing electricity price structures are maintained.

We think current price structures will also encourage a pattern of technology uptake that causes wider economic costs of up to $2 billion, and contributes to higher emissions (as discussed in earlier separate reports).

To address these issues, we need to adopt electricity pricing structures that are better aligned with the true cost of supplying electricity. This does not mean a rise in average electricity prices – but instead that prices would better reflect the costs for supplying customer's individual electricity use profiles.

Our analysis shows that moving to cost-reflective pricing will avoid the increases that otherwise fall on the poorest consumers due to cost-shifting associated with new technology uptake under current tariff structures. However, individual impacts will vary significantly –

with much greater reductions for some customers and increases for others. And near-term impacts will be less favourable – with smaller immediate savings for those who benefit, and larger increases for others.

These factors highlight the need to carefully consider how best to move to improved price structures. We think that most (if not all) of the benefits can be obtained without requiring a sudden step-change, as long as the direction of change is clear and consumers have sound information on which to make decisions.

Our analysis also invites a deeper consideration of how best to assist the least well-off members of society in relation to power costs. The main specific tool used at present is the LFC scheme. But this is a blunt instrument – while it helps some poorer consumers, much of the assistance flows to middle- and higher-income consumers. We estimate that only 5% of the total benefit flows to households in the most deprived category. The LFC scheme also *hurts* those poorer households that have average- or above-average usage.

And the LFC scheme is likely to become increasingly ineffective as a means of helping poorer consumers if existing price structures are maintained. A rising share of those who qualify for LFC benefits will be the middle- and higher-income households who install solar panels – and the costs of maintaining the scheme will fall increasingly on those (mainly) less well-off households that don't install panels.

While addressing these questions is beyond the scope of this report, we hope this analysis helps to illuminate the issues and trade-offs in the social context, and so contributes to better informed discussion of the options for New Zealand.

1 Introduction

1.1 What is the report about?

This study examines two specific issues:

1. What impact is new technology uptake likely to have on cost shifting between consumer groups, if existing pricing structures are retained?
2. How can industry pricing structures be improved – and what impact will this have on power bills for different socio-economic groups?

For both the above issues, we especially focus on the poorest consumers, i.e. will these consumers generally benefit or suffer from new technology uptake, and/or new pricing structures.

What is cost shifting?

Cost shifting occurs when a consumer pays less than it costs to supply them with electricity. To make up for the revenue shortfall, these under-recovered costs will be 'shifted' onto other consumers.[13]

We recognise that electricity pricing can also be relevant to broader social questions - such as whether some consumers are able to afford to adequately heat their homes. However, we have not considered such broader issues, as this study is focussed on the interaction between new technology uptake and electricity pricing arrangements. That said, this study highlights where pricing arrangements and/or uptake of technologies would result in cost-shifting from more affluent to less well-off households, and thus exacerbate these social issues.

1.2 Study assesses data for over 100,000 households

We have looked at detailed electricity consumption data[14] for over 100,000 individual households to estimate their electricity charges and supply costs in 2016.[15] We used this information to assess the extent to which each household was paying its full cost of supply, or receiving or paying cross-subsidies.

Households were classified into socio-economic decile groups, based on Statistics NZ's published deprivation index. This is a composite index, reflecting various measures of social deprivation (e.g. income, education, employment, housing).

[13] In theory, the 'shifted' cost could be borne by the owners of network and retail businesses who would receive less revenue. However, if these businesses were to incur unrecoverable costs an ongoing basis, they would become financially unsustainable.

[14] Supplied by participating retailers on an anonymised basis with all name and address details removed, but with the census meshblock ID provided. A year's worth of half-hourly meter readings was provided for each household. In all, over two billion data points.

[15] In this report, we use the term 'consumer' to refer to a residential electricity customer. The term consumer and household therefore have an equivalent meaning unless stated otherwise.

Deprivation data – what does it mean?

In the data published by Statistics New Zealand, areas are classified (at meshblock scale) from least deprived (decile 1) to most deprived (decile 10). Note that this order is the *reverse* of the decile ranking used by the Ministry of Education, where education decile 1 schools are the 10% of schools with the greatest proportion of students from low socio-economic communities, and vice versa.

We also use the terms 'most affluent' and 'least affluent' to refer to households that are in deciles 1 and 10 respectively in the NZ deprivation index.

Statistics NZ publishes deprivation index information at the 'meshblock' level.[16]This allows us to analyse the nature and scale of cost-shifting across different socio-economic groups.

Given the large sample size, we have a high degree of confidence in comparisons *across* decile groups. For example, comparing the average impact of adopting cost-reflective tariff structures for the most-affluent households, versus the least-affluent households.

We can also use the data to analyse the dispersion of effects *within* each decile group. These results are slightly less certain because meshblocks can contain individual households that are unusual in terms of their relative deprivation status. However, we don't expect this to lead to any general statistical bias, especially as the overall sample size is large. Nonetheless, the results we present in this study should be interpreted with these general caveats in mind.

1.3 Structure of report

This report is structured as follows:

- Chapter 2 explains how cost-shifting arises, and how it can be affected by technology uptake
- Chapter 3 estimates the extent of cost-shifting associated with technology uptake, if current pricing structures are maintained
- Chapter 4 explains how improved price structures can reduce or eliminate cost-shifting, and looks at the effect of these structures for different consumer groups
- Chapter 5 makes some high-level observations on alternative cost-reflective price structures
- Chapter 6 sets out some issues that could be considered in facilitate the transition to better pricing structures
- Chapter 7 describes our conclusions.

[16] These are groups of 30-60 dwellings in close proximity to one another.

2 Cost-shifting and technology uptake – how are they related?

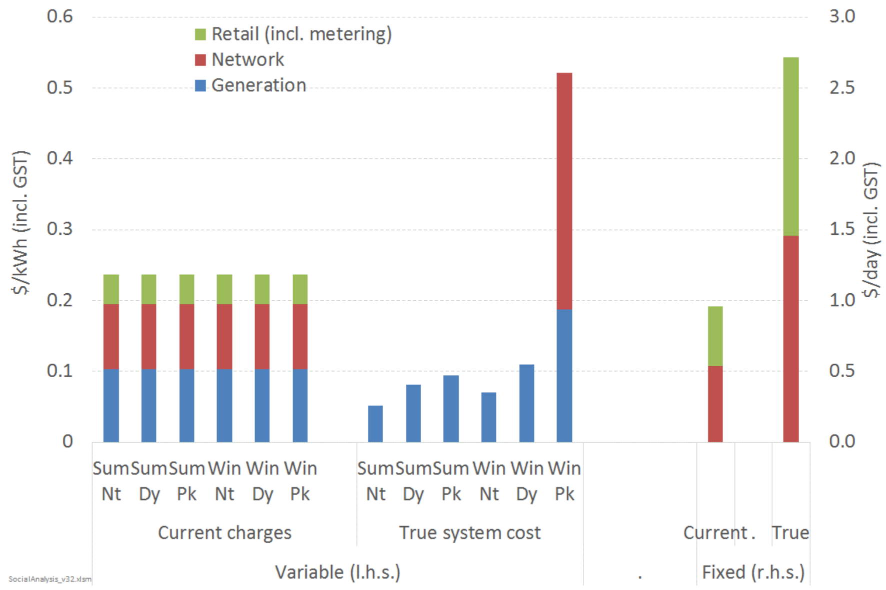
This chapter:

- Explains how current pricing structures enable cost-shifting between different consumer groups
- Describes the level of cost-shifting associated with different technology options
- Explains why technology uptake is expected to vary across different socio-economic groups
- Describes the projected level of technology uptake for different pricing structure scenarios.

2.1 Current electricity pricing structures enable cost-shifting

The vast majority of consumers are charged for electricity via a pricing structure which has remained largely unchanged for over a century – typically a 'flat' $/kWh consumption charge that is constant across the year, coupled with a fixed $/day charge.

Figure 10: Comparison of predominant current pricing structures and true system costs



As Figure 10 illustrates, this simple structure hides the fact that the cost of supply varies a lot depending on when power is used. In particular, the cost in peak demand periods is much higher than other times. This is because generation and (even more so) network costs are strongly driven by peak demand requirements, even though such demand might only be experienced for a few hours each year.

Figure 10 also shows that some costs which don't vary with kWh consumption (and which are essentially fixed per customer) are being recovered via the variable $/kWh consumption charge, rather than a fixed $/day charge. This is principally due to the current low-fixed charge regulations. These require electricity suppliers to offer a tariff option which benefits low users.[17] This results in under-recovered costs from these low-users being placed on higher users – in effect this is a regulated form of cost-shifting.

For a typical consumer, we estimate that approximately 40% of the total costs of supplying electricity are fixed (i.e. they don't vary with kWh consumed), yet on average only approximately 15% of costs are recovered via a fixed charge.

- If consumers who use proportionately more at times of peak system demand don't pay the full cost of their power, the additional cost will need to be met by others whose demand is proportionately less at such times.
- Likewise, the 'variablisation' of fixed costs means that consumers who consume less than average will be cross-subsidised by those who consume more than average.

There is also cost-shifting due to lack of geographic differentiation in tariffs. It generally costs more to supply electricity to rural customers than urban customers, due to the need to build and maintain a lot of poles and wires to supply relatively few customers in rural situations. This difference in costs is typically not reflected in tariffs.

However, because the consequences of this geographic cross-subsidy are not the principal cause of inefficient technology uptake, or systemic cross-subsidy between social groups, this is not the focus of this study.

2.2 Changes in usage patterns give rise to cost-shifting

The extent to which costs are shifted in practice is predominantly driven by <u>when</u> consumers use power. This reflects a mix of customer behaviour (e.g. whether they are at home during the day, or only in the morning and evening) and energy technology choices.

For example, consider space heating. Someone with electric heating will typically pay approximately 23 c/kWh, irrespective of when they use it. However, as shown in Figure 37 in Appendix C, demand for residential space heating is almost entirely in the winter months, and particularly high at times of peak demand (early morning and early evening. i.e. just before going to, and just after coming home from, work). The demand-weighted average system cost of such a pattern of consumption is significantly higher: of the order of 29 c/kWh.

So, consumers using electric space heating in winter will tend to shift some of their costs onto other electricity consumers. Similar outcomes arise for lighting, where the pattern of use is more heavily concentrated in peak demand periods.

Problems also occur for technologies whose impact on a consumer's usage is <u>anti</u>-correlated with system demand. For example, a consumer installing a solar panel will reduce their consumption a lot during daytime periods, particularly in the summer. However, the panel will not reduce their consumption at all during night times, or

[17] Low users are defined as anyone consuming less than 8,000 kWh/year (or less than 9,000 kWh/year in the lower South Island).

during winter peak periods. Solar consumers are being rewarded for such reduced consumption at approximately 23 c/kWh, whereas the avoided system costs from such a pattern of reduced consumption is approximately 10 c/kWh. This 13 c/kWh difference will be 'shifted' onto other consumers who will face an increase in their bills.

Conversely, an EV which predominantly charges overnight on a standard flat tariff will pay around 23 c/kWh, whereas the system costs arising from such a pattern of increased demand will only be around 7 c/kWh. Thus, EV consumers will be paying too much for their electricity.[18]

2.3 Cost-shifting associated with different technologies

Figure 11 shows the typical impact on a consumer's bill of adopting a particular energy technology option (hollow grey bars) – such as insulating their home or installing a solar panel. Changes to bills are entirely driven by the effect of the technology on their annual mains-power usage, to which the $/kWh charge is applied.

The hollow yellow bars show the corresponding long-term impact on supply costs. These vary because technologies differ in their scale, and (more importantly) how they affect usage at different times of the year and day.[19]

The differences between consumer bill impacts and supply costs are shown as solid black bars – and represent the typical cost-shifting that will occur when a consumer adopts each option.

[18] Some networks allow EV customers to be on a controlled tariff, with a discount of ≈ 5 c/kWh for allowing the network to interrupt charging at peak times – in the same way as such networks provide a discount for customers who grant them the rights to control their hot water cylinders. However, if there is still a night component to the residual network tariff, or generation is recovered via a flat tariff, or some proportion of retail and metering is also recovered via a flat variable charge, the EV will still be paying significantly more for charging overnight than it should.

[19] This analysis assumes that 55% of network costs are driven by peak demand requirements, and that these costs are variable over the longer term. Some networks may not face low growth with no need for significant investment. As a sensitivity, we also considered a scenario where 15% of network costs vary with peak demand (see Appendix A). The relative scale of cost-shifting for different technologies did not alter significantly in the sensitivity case.

Figure 11: Typical cost shifting for different technology options[20]

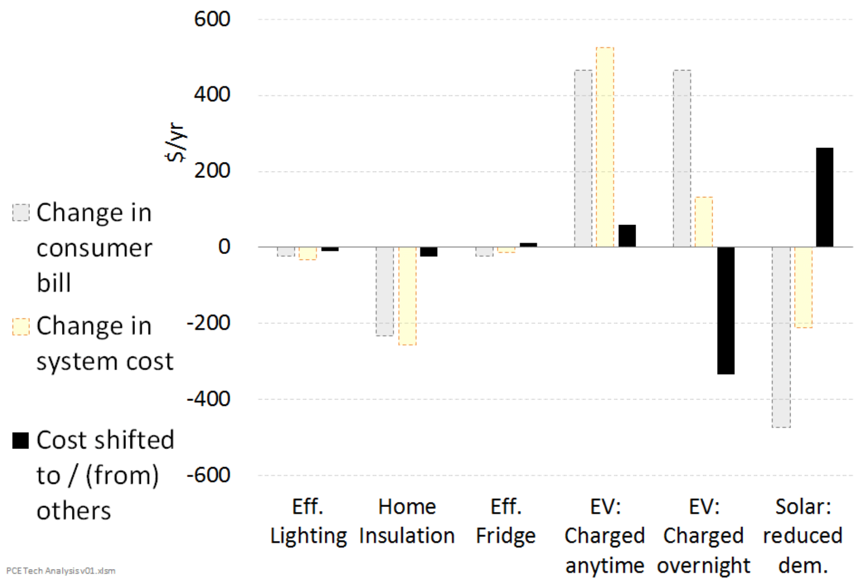


Figure 11 shows there are significant differences in the nature and scale of cost-shifting outcomes from uptake of different technologies.

Technologies which disproportionally reduce usage at times of peak system demand will result in the consumer paying too much for their electricity. This will include efficient space heating technologies (e.g. insulation, or a log burner), or efficient lighting (e.g. an LED light).

Technologies which disproportionally reduce usage at times other than peak system demand will result in the consumer paying too little for their electricity. The principal example of this is solar PV panels, but Figure 11 shows that efficient refrigeration also falls into this category – although to a lesser extent.[21]

Some technologies even give rise to 'benefit-shifting' because a consumer who installs them will pay more in additional charges than the change in their supply costs. For example, a consumer that recharges their electric vehicle (EV) at night (off peak) times while paying an 'anytime' $/kWh charge will pay more than the rise in their true supply costs. This 'surplus' allows a reduction in power bills for other consumers. Assuming EVs are mainly purchased by middle- and higher-income households, we expect this type of effect to be beneficial on average for poorer consumers.

The technologies with the largest cost-shifting impacts (positive and negative) are the two newest technologies: solar PV and EVs.

2.4 Solar panel uptake likely to vary across socio-economic groups

Figure 11 shows why solar panels differ from other options in the magnitude of cost-shifting - around $260 per year under current price structures – or a present value of $3,000 over the life of a panel.[22]

[20] The chart shows 'average' effects from utilising different technology options and assuming a typical electricity pricing structure that is not cost-reflective – impacts can vary and be larger or smaller depending upon individual circumstances.

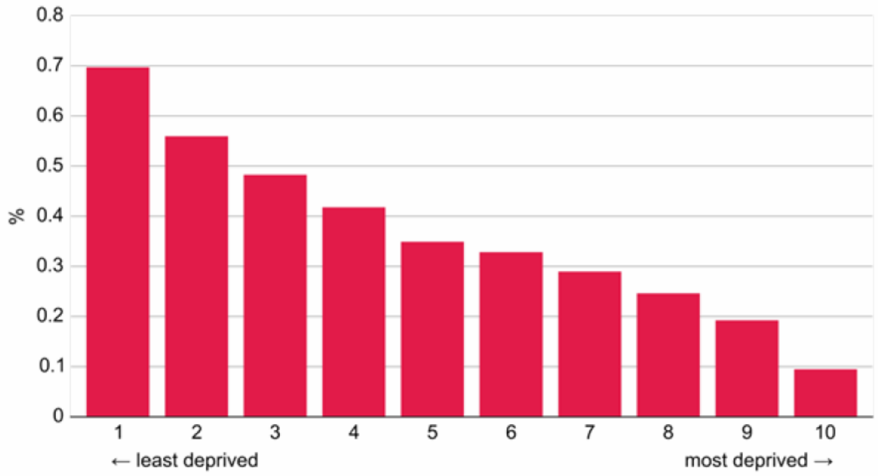
[21] The pattern of refrigeration consumption (and hence, saved electricity from efficient refrigeration) is largely flat throughout the day and year. Conversely, the pattern of solar generation is much more strongly anti-correlated with peak demand on both a seasonal and within-day basis.

[22] Present value calculated using a 6% discount rate over 20 years.

Because the potential for cost shifting is so much greater for solar panels, it is important to understand which types of consumers are most likely to install them.

Figure 12 shows analysis undertaken by the Electricity Authority on uptake across consumers. It shows that wealthier households are much more likely to install solar panels than poorer households.

Figure 12: Uptake of solar panels by deprivation index



Source: Electricity Authority

Part of this is likely to be an income effect – more affluent consumers can more easily afford the initial upfront cost of solar panel installation of around $12,000. They may also place more value on non-financial factors, such as perceived[23] environmental benefits, rather than financial gain.

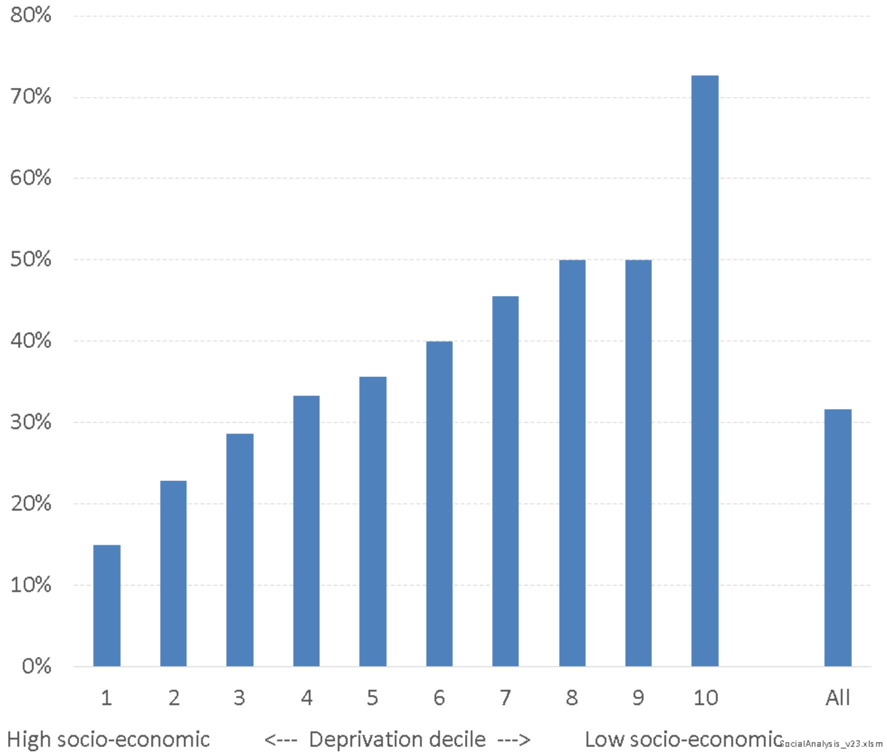
However, as solar costs reduce and, if current tariff structures continue, solar will become financially viable for an increasingly large group of customers. When we reach this point, there may be a narrowing of spread in uptake across income deciles – as has been observed in Australia.

However, Australian experience suggests a significant differential in rate of uptake is likely to continue – particularly for the poorest decile. This is because Australian renters have been observed to be significantly less likely to install solar than people who own their home. This pattern is consistent with observed differential rates of uptake between home-owners vs renters of other energy technologies in New Zealand which need to be 'installed' (e.g. ceiling insulation).

This is an important issue in New Zealand because of the extremely strong relationship between renting and deprivation. Figure 13 shows that approximately 75% of households in the most deprived decile live in rented accommodation, compared to approximately 15% in the most affluent decile, and an average across all consumers of 33%.

[23] See our first report for analysis which indicates that, in New Zealand, solar uptake is likely to primarily displace wind and geothermal plant that would otherwise have been built – thereby delivering limited emission benefits. The flip-side of this finding is that the report found that the electricity used to charge electric vehicles overnight would predominantly be met by increased development of wind and geothermal plant, giving significant environmental benefits.

Figure 13: Relationship between deprivation and likelihood of living in rental accommodation – Wellington[24]



For these reasons, it appears highly likely that households in the poorest decile will continue to have much lower solar uptake than the average level.

2.5 Pricing structures will affect technology uptake

Technology uptake will be affected by a range of factors, including the structure of electricity tariffs. As a result, the structure of tariffs won't just affect the cost-shifting per unit of uptake (e.g. $ shifted for each PV or EV), but also how much technology is taken up (i.e. how many PVs and EVs are purchased).

To illustrate the importance of pricing structures on consumer uptake decisions, Figure 14 shows the effective price signal to the consumer to alter their usage through investing in different technologies under three different pricing structures:[25]

- 'Current' (Flat + Low-fixed charge (LFC)) – i.e. the predominant situation at present with usage charges that are flat and don't vary with time-of-use, and a significant proportion of fixed costs variablised for low-users.
- Fully cost-reflective (Time-cost-reflective (TCR) and no LFC) – i.e. a structure where the cost of supply at different times are

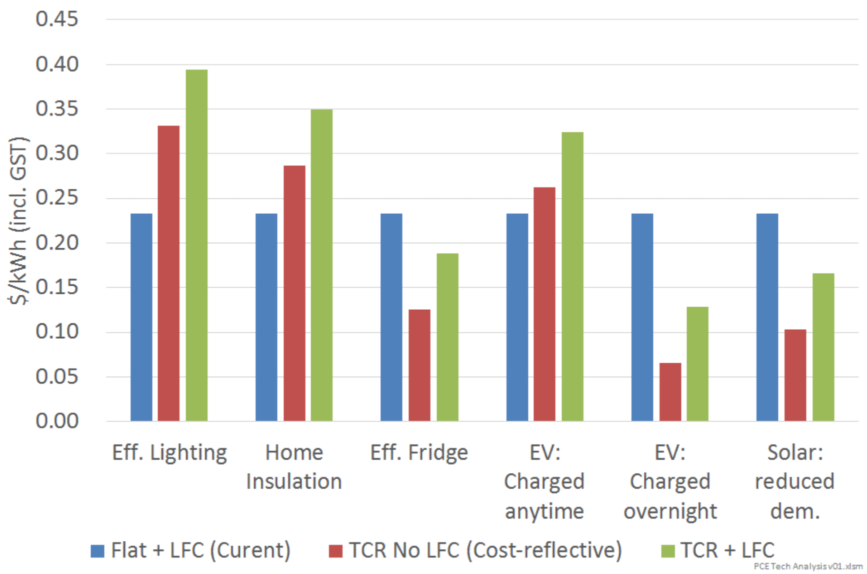
[24] Although this shows data for the Wellington region, the correlation between deprivation and renting is very similar throughout the country. Further examination of historical data indicates that the proportion of people living in rented accommodation is growing – particularly in the lowest income deciles.

[25] The effective price signal is computed by taking the annual change in charges, and dividing this by the annual change in usage. Note the changes can be positive or negative values.

signalled in price, and fixed costs are recovered via fixed charges.[26]

- Partially cost-reflective (TCR + LFC) – a tariff structure which has a strong time-based variation, but where fixed charges are variablised for low-users – thereby increasing these variable charges.

Figure 14: Effective price signal to consumer



Under current pricing (flat + LFC), the returns for investing in LED lighting (i.e. saving 0.23 $/kWh) will be less than under a cost-reflective tariff (i.e. saving ≈ 0.33 $/kWh).

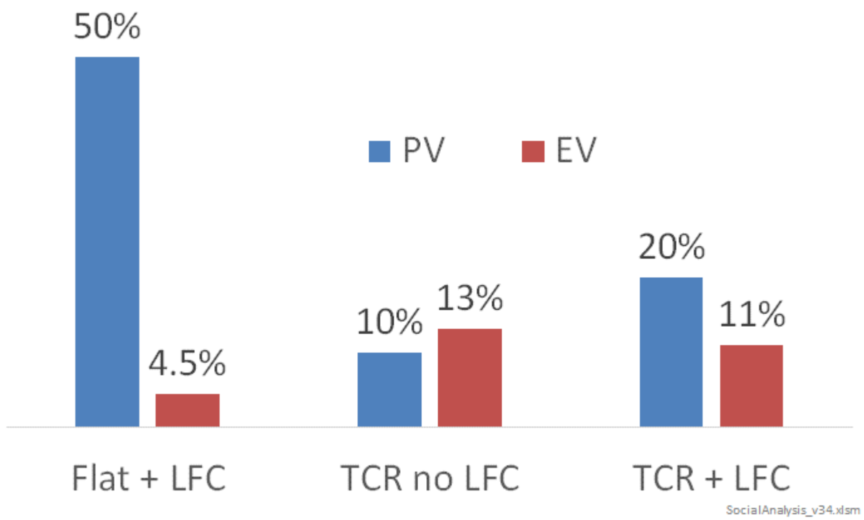
Conversely, the reverse is true for investing in a solar panel in that under a flat + LFC charge solar owners will be saving ≈ 0.23 $/kWh, whereas under a cost-reflective tariff they would be saving ≈ 0.10 $/kWh.

Generally speaking, we would expect uptake to accelerate for technologies that are being under-rewarded with current pricing structures, and vice versa.

Figure 15 shows our central assumptions as to the levels of uptake in 15 years' time of solar PV and EVs under these different pricing structures.

[26] This structure is broadly the same as the 'true system cost' structure shown in Figure 10 previously. The recovery of the network component at times of peak could either be through a highly-structured time-of-use charge, or some form of coincident peak demand charge. See section 5 for a discussion on these different charge structures.

Figure 15: Modelled level of uptake in 15 years' time of different technologies for different tariff structures



There is clearly some uncertainty around these estimates. Accordingly, there could be material differences in the absolute *levels* of uptake for the different technologies compared to that shown. However, there is little doubt that the *relative* impact of the different tariffs will be as modelled, i.e.:

- If tariffs continue with a flat structure, there will be a greater uptake of solar PV, but less of EVs.
- If tariffs move to a time-cost-reflective (TCR) structure, the reverse occurs.
- The variablisation of fixed costs under the LFC will tend to penalise EVs, and over-reward solar panels.

Further, we consider the absolute values shown in Figure 15 to be reasonable given factors such as:

- Typical lifetimes of technologies
- The expected rate of cost-reduction of solar PV (and thus the extent to which investing in solar PV will progressively become 'in-the-money' for consumers) – and further informed by observed rates of uptake overseas where the combination of tariffs and subsidies has meant solar has been a profitable investment for many consumers.
- The extent to which electricity prices impact on the total cost of ownership of the different technologies.

3 Cost-shifting associated with technology uptake under existing pricing structures

This chapter examines the level of cost-shifting expected to arise with technology uptake, assuming existing pricing structures are maintained. We look at three scenarios over 15 years:

1. 50% solar panel uptake
2. 50% electric vehicle uptake
3. Mixed (likely) technology uptake.

The analysis was undertaken using the modelling framework described in Appendix A. This allows examination of different tariff structures and/or different levels of technology uptake on tariffs, and how these factors will impact on the bills for >100,000 customers for whom we have half-hourly usage data.

Full results were computed for all decile groups across five regions (Auckland, Christchurch, Dunedin, Hawkes Bay, Wellington).

For brevity, this chapter describes the summary results for the poorest and wealthiest deciles, and the average over all deciles, for consumers in the Wellington. Results for other regions are generally similar, and are set out in full in Appendix D.

3.1 50% solar panel uptake scenario

To see how solar panel uptake would affect consumers bills in future, we modelled a scenario where solar uptake reaches 50% of homes in 15 years' time, and existing tariff structures – including the low-fixed charge(LFC) – remain in place.[27]

For the reasons discussed earlier, we assumed that solar panel uptake for the poorest decile will be 1/3 of that for consumers overall – and also that the most-wealthy will have a rate of uptake which is 50% higher than average. This represents a narrowing of solar uptake differences, compared to patterns observed to date.

[27] Although this 50% level is by assumption, in some regions overseas, there has been rapid uptake of solar panels, with penetration levels reaching 50% or more in situations where solar is a profitable investment for most consumers. Further, the previous report in this series identified that 50% penetration was a feasible outcome in New Zealand if solar PV continued to decline in costs and tariffs remained as they were. In such a future, solar PV would be 'in-the-money' for the vast majority of consumers.

Figure 16: Change in power bills from 50% solar uptake with existing price structures (Wellington)

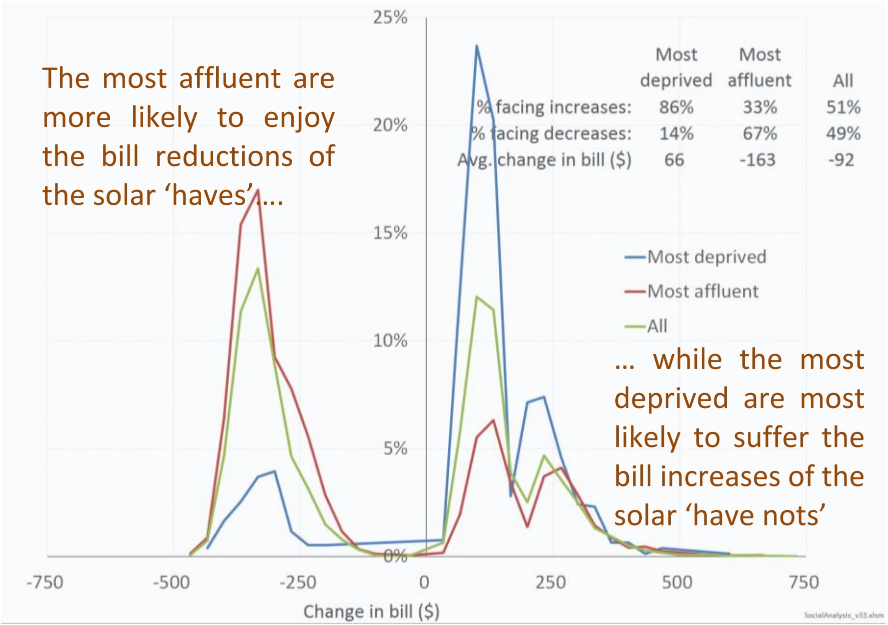


Figure 16 shows results for consumers in the Wellington area. Results for the four other areas are broadly similar.

The 'humps' on the left-hand side represent consumers who will see a fall in their power bills because installing a solar panel will reduce their mains power usage, and hence their consumption charges. We estimate that 67% of the wealthiest consumers will fall into this category, compared to 14% for the poorest consumers. This difference arises because poorer households are less likely to install panels for the reasons discussed earlier.

The right-hand side of the chart shows the distribution of outcomes for consumers projected to see higher bills – i.e. those who do not install panels. Around 86% of the poorest consumers are projected to fall into this category – with an average bill rise for this group of around $135/year, with a wide spread of outcomes reaching over $400/year in some cases.

Conversely, only 33% of the most affluent customers are projected to not install panels and face bill increases.

Further, Figure 16 only considers the impact on consumers' power bills. It takes no account of the cost of purchasing and installing solar panels, or the revenue that consumers can earn from exporting power.

Figure 17 below shows that when these costs and revenues are taken into account, the net benefit for solar consumers is a lot less – with many actually being worse off in financial terms.[28]

[28] At present, many consumers are investing in panels which do not deliver a positive financial return. Further, as the proportion of consumers with solar rises, some of the associated tariff increases will 'flow back' onto solar consumers as well. i.e. the ability for a solar consumer to avoid costs is much greater when very few consumers have solar, than when half of consumers have solar.

Figure 17: Change in overall energy costs from 50% solar uptake with existing price structures (Wellington)

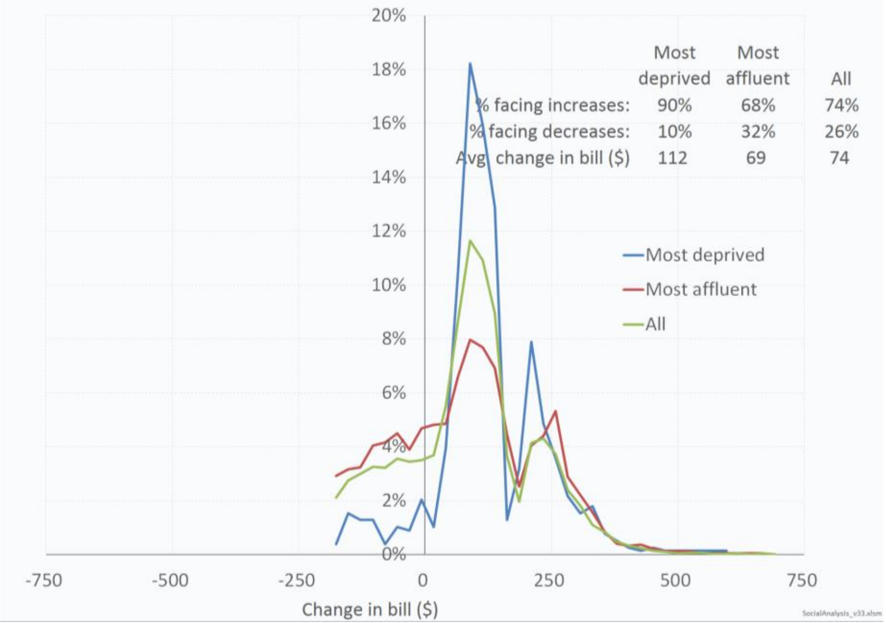


Figure 17 also shows that when the total cost of energy is taken into account (i.e. including the cost of purchasing the panels) significant solar uptake will end up increasing costs for the average Wellington household.[29]

An additional dimension to this cost-shifting which is worth mentioning is that the low-fixed charge regulations are exacerbating these outcomes in terms of shifting of costs from rich to poor. This is because the installation of a solar panel, and the subsequent reduction in demand, is turning some wealthier consumers into low-users. This will exacerbate the bill increase for those low-income consumers who consume above average amounts of electricity.

3.1.1 Would batteries alter the above results?

The above analysis has highlighted that solar PV is likely to cause substantial cost-shifting – particularly from middle- and higher-income households onto poorer consumers.

A number of solar installations are being combined with batteries. These batteries are being charged up during day periods when the output from the solar panel exceeds the consumer's demand, and then being rundown later in the evening and night, when the consumer's demand is greater than the solar output.

This pattern of operation will reduce such a consumer's demand through the high system-cost evening peak periods. On the face of

[29] Note, this is likely under estimate the increase in total energy costs. If 50% of households have solar panels, that would be likely to result in material over-supply of generation during summer day periods. At this level of penetration, there would be limited saving from other forms of generation, because they would still be needed to meet winter evening demand. Appendix B of our second report in this series discusses the nature and scale of this effect. However, modelling of such phenomena has not been undertaken for this report due to the significantly increased complexity that would be required but which wouldn't alter the key conclusions about the nature of cost-shifting from solar PV uptake. As such, the modelling in this study assumes that the value of solar PV in terms of avoided grid-scale generation remains constant – even though with large-scale PV uptake the incremental generation savings from additional solar PV would be a lot less than when there is little PV uptake.

it, by reducing demand at high system cost periods, this could reduce the cost-shifting that occurs with solar PV on its own.

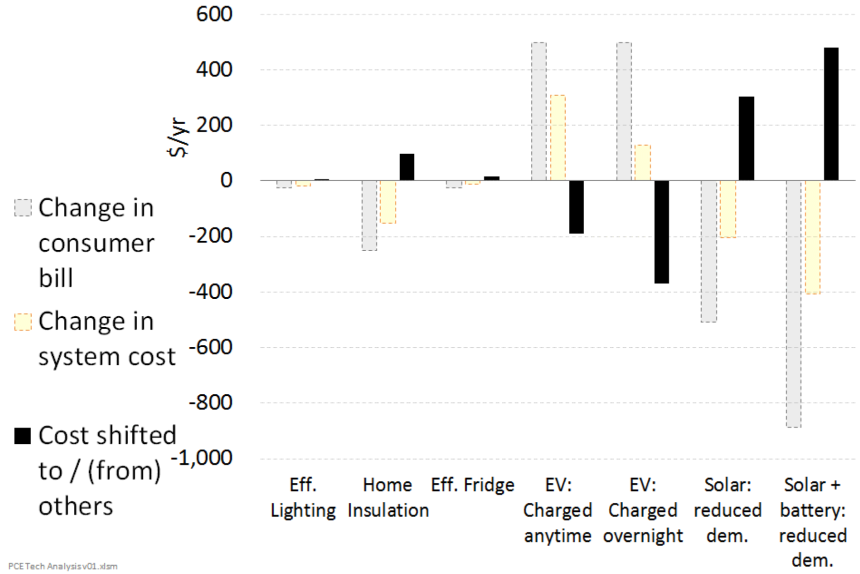
However, while this pattern of operation does reduce the system costs of supplying such a customer, this is offset by the fact that batteries enable solar consumers to significantly reduce their demand even further through minimising exported electricity. A typical impact would be moving from 60% of solar power being exported to only 30% being exported.

This is shown in following chart which builds on from Figure 11. It shows that:

- although the reduction in system costs from a solar+battery installation is much greater than the reduction from a solar-only installation;
- there is a similar scale of extra reduction in a customer's bill under current tariff structures from solar+battery compared to solar-only.

As such, the degree of cost-shifting is broadly similar between solar+battery and solar-only.

Figure 18: Effect of technology options (including solar + battery) on cost shifting under flat + LFC price structures



Further, the above chart is simplified in some respects. It doesn't take into account that peak network demand (which strongly influences the system cost) is driven by <u>extreme</u> weather events. Such an event is typically a 1-in-10 year event of *sustained* (for the period of a week or so) cold, bad weather. During such an event, solar will contribute close to nothing to filling the battery to be used in the evening peak. Thus, the cost savings from the solar+battery in the above chart may be significantly over-estimated.

That said, during such extreme weather periods, batteries may be able to fill up overnight from the grid instead of from solar, in order to release the power in the evening and achieve the level of cost reduction shown in the above chart.

However, that points to a deeper truth: It is the batteries alone which are enabling the extra system cost reduction, not the fact that they are associated with solar. Indeed, our earlier report on economic impacts showed that operating batteries to minimise solar export because of flat tariffs will result in the battery being operated sub-optimally and not saving as much system cost as could be achieved.

Accordingly, the extent of cost shifting caused by solar PV under flat tariffs is considered to be robust to whether the consumer has a battery or not.

3.2 50% electric vehicle uptake scenario

The analysis of cost-shifting impacts was repeated for EVs. The modelling used the same approach as for solar PV, and assumes EVs are used by 50% of consumers in Wellington. We think this level of uptake is unlikely, and our 'mixed' uptake scenario discussed in the next section is based on more plausible projections. However, by looking at the same levels of uptake, it enables more of an 'apples-with-apples' comparison of the effect of the two different technologies.

We assume the same differential pattern of technology uptake across deciles as for solar PV, i.e. consumers in the most affluent decile are much more likely to take up such technologies than consumers in the most deprived decile.[30]

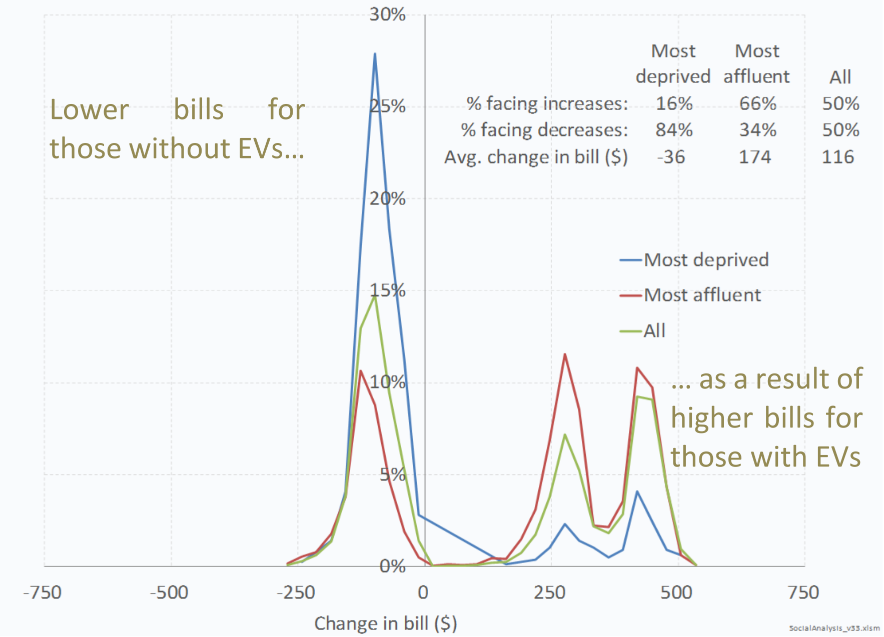
The results for EVs are directly opposite to that for solar PV. As shown in Figure 19, because the 50% of households who purchase EVs are paying too much for their electricity, they cause the 50% of households without EVs to enjoy a *reduction* in their bills.

Because of the assumed differentials in uptake levels across socio-economic groups, this generally helps poorer consumers and is disadvantageous for higher-income consumers.

[30] Unlike the solar PV uptake analysis, this socio-demographic variation in uptake is not based on empirical evidence, but rather other studies which have shown that the same type of barriers which have been demonstrated to impact on the uptake of solar PV for the poorest consumers, are impacting on other energy investments – particularly those which have a high capital cost. Further, there are a couple of specific feature of NZ vehicle purchases and ownership which means it is highly likely that the poorest consumers are going to be much less likely to own EVs over the next 15 years':

- Firstly, the cars which are more likely to be purchased by the poorest households tend to be lower-priced vehicles. EVs, even when imported as second-hand vehicles from Japan, are typically higher priced vehicles.
- Secondly, census data indicates the most deprived deciles are significantly less likely to own a car at all, and even less likely to own two cars – noting that EV uptake is often a 'second car' phenomenon given the range anxiety issue associated with EVs for long journeys.

Figure 19: Change in bill relative to today due to 50% EV uptake with continuation of current flat + LFC tariff structures (Wellington)



3.3 Mixed technology uptake scenario

As discussed in section 2.5, pricing structures will affect technology uptake. It is unrealistic to expect 50% EV uptake under current price structures as owners will pay full rate for power but are assumed to only charge off-peak. Furthermore, for 50% of all households to have an EV in 15 years, the majority of vehicle purchases would need to be EVs from long before that date, given the relatively slow turnover of the car fleet.

We have developed a mixed technology uptake scenario which accounts for these issues. It assumes that over the next 15 years', if consumers continue to predominantly face flat tariffs with the LFC, solar uptake will reach 50% and EV uptake 4.5%, if existing pricing structures are retained – i.e. as per the 'Flat + LFC' values in Figure 15 previously.

Figure 20: Change in bills for non-adopters due to uptake of solar PV, and EVs by <u>other</u> customers in a situation where tariffs continue as flat + LFC (Wellington)

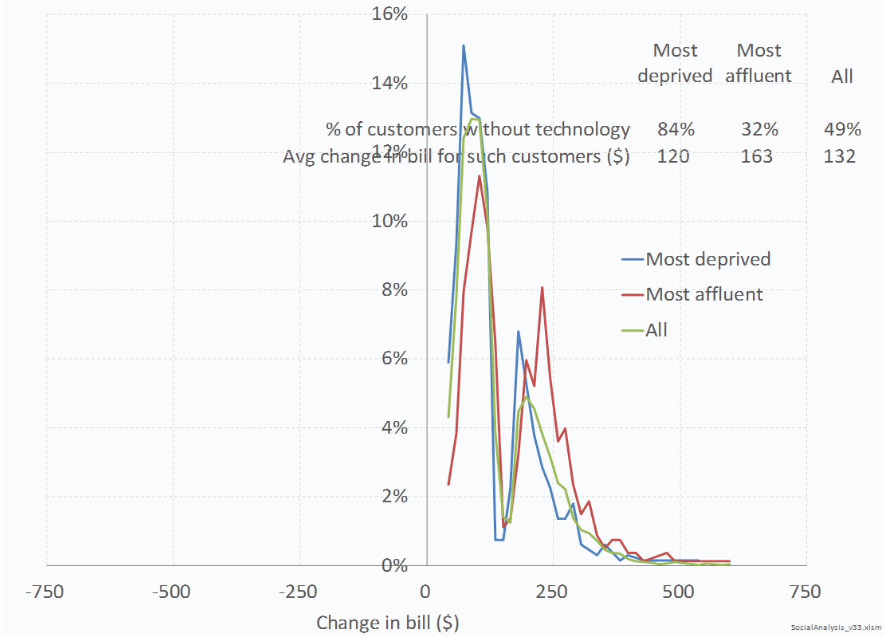


Figure 20 shows the projected bill impacts for 'non-adopter' households in Wellington for this mixed uptake scenario – i.e. those who are modelled as not having purchased either solar PV or EVs. The focus on non-adopters avoids any changes that occur from changes (up or down) in mains-power usage caused by EV or PV use.

This provides an 'apples-with-apples' comparison of how these consumers are affected by cost-shifting by the wider uptake of solar panels and EVs by society.

Under this mixed uptake scenario, we expect 84% of the poorest households to see higher power bills through being 'non-adopters'.[31] For these consumers, the average rise is $120/year – a 6.5% increase on the average bill for such customers – with increases of $350/year or more in some cases. Around 32% of the wealthiest households are also projected to be non-adopters and see increases, which average around $163/year and also vary strongly across individuals.[32]

We project the average rise in bills for the poorest non-adopter households to be similar in the other four regions. For this group of consumers, we project an average increase of around $100/year across the five regions as a whole.

[31] As noted earlier, the 16% of the poorest decile that see a bill decrease do so because they are 'adopters' who install solar panels, which reduces their mains-power usage and bills. However, once the annualised cost of buying solar panels is taken into account, the proportion who will see a real fall in their total electricity costs (mains-power plus panel) will be substantially lower than 16%.

[32] The average increase is larger for wealthy non-adopters than poorer non-adopters because, as detailed in Appendix D, wealthy consumers tend to have greater overall consumption.

4 Improved price structures can address cost-shifting

The previous chapter looked at the cost-shifting associated with technology uptake under *existing* price structures. This chapter examines what would occur under the mixed technology uptake scenario if pricing structures are improved.

We examine two cases:

- Moving to fully cost-reflective pricing structures
- Moving to partially cost-reflective pricing structures – where the current low fixed charge scheme continues to apply.

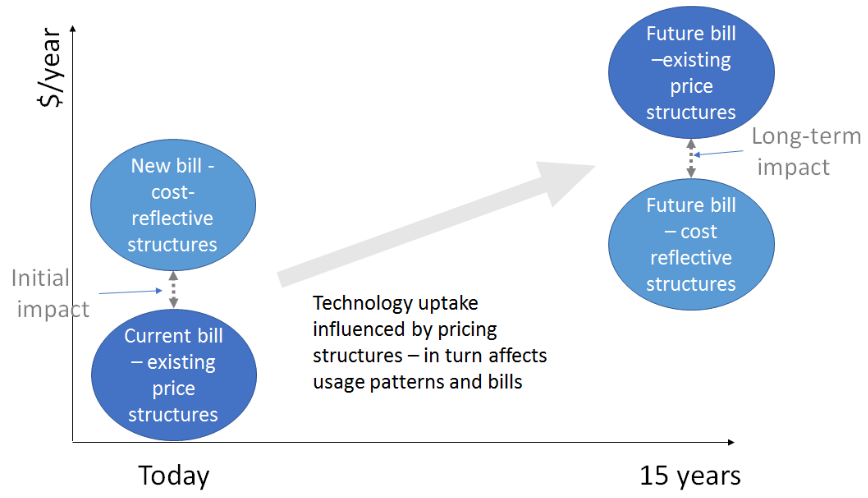
In both cases, there would be initial 'static' effects from rebalancing of prices among consumers, and longer-term 'dynamic' effects via altering uptake trajectories for PVs and EVs. The assumed technology uptake behaviour for these different pricing structures were detailed in section 2.5.

For both pricing cases, we examine:

- Long-term impacts – comparing bills in 15 years' time if current price structures continue versus the cost-reflective alternative
- Initial impact – comparing current bills versus the cost-reflective alternative that would apply today.

These comparisons are shown in illustrative form in Figure 21. The example shows a situation where a consumer faces an initial bill increase from a move to a cost-reflective structure, but is better-off in the long-term. However, different consumers may have different initial and long-term bill impacts from a move to cost-reflective pricing structures).

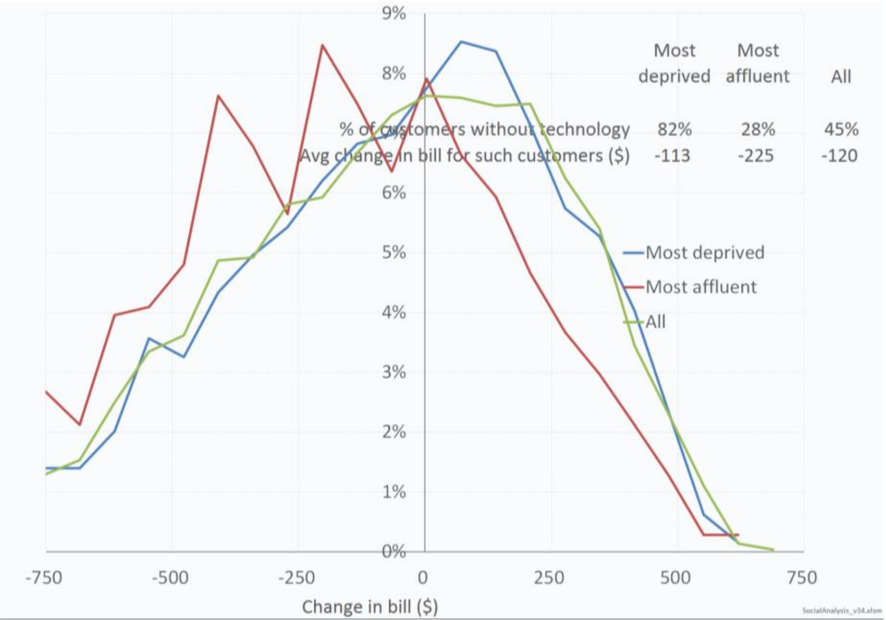
Figure 21: Initial and long-term effects (illustrative)



4.1 Long-term impact – fully cost reflective price structures

Figure 22 shows the long-term impact under fully cost-reflective price structures for non-adopters in Wellington. The chart focuses on non-adopters to enable an 'apples with apples' assessment of bill impacts.

Figure 22: Long-term impact of fully cost-reflective prices (Wellington)



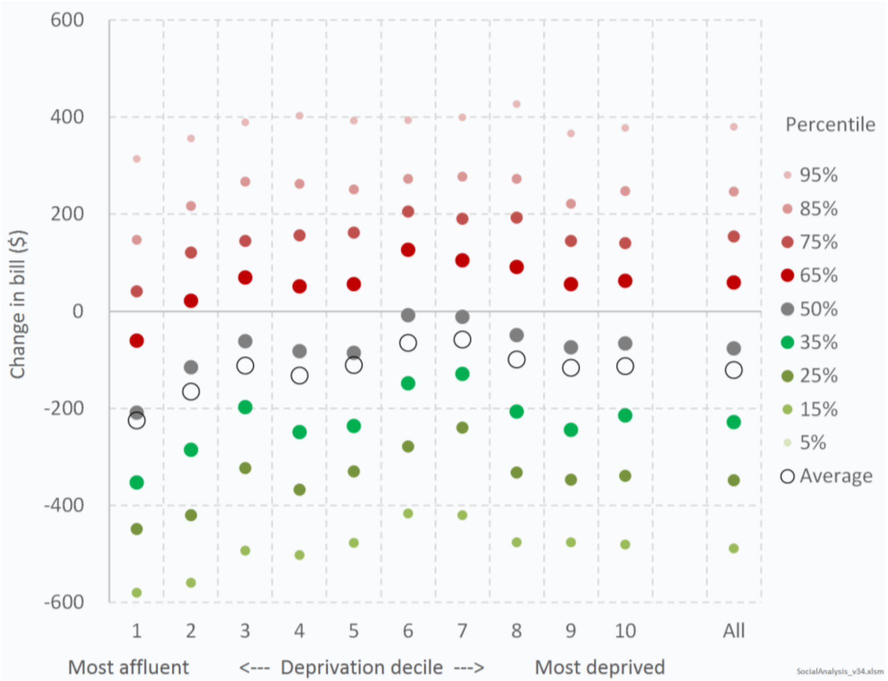
On average, non-adopter consumers will have lower bills under a move to fully-cost-reflective tariffs than from a continuation of status quo tariffs structures: approximately $120/year less for the average non-adopter consumer.

However, some non-adopters will have greater bills than they would have under a continuation of status quo tariffs and there is a very wide spread of outcomes.

Figure 23 which shows the same type of data as in Figure 22, but the change in bill is represented on the y-axis, with the x-axis representing deprivation deciles. Each dot in the graph shows the bill outcome for a particular percentile on the distribution.

Figure 23 shows that although the majority of non-adopter consumers in all deprivation deciles will have lower bills from a move to fully-cost-reflective tariffs, some will face higher bills than they would have done.

Figure 23: Long-term impact of fully cost-reflective prices – all decile groups (Wellington)



This wide spread of outcomes is due to the unwinding of the inherent cross-subsidies within current tariff structures. Thus:

- Consumers who use proportionately more at times of system peak will face bill increases due to the introduction of time-cost-reflective tariffs (and vice versa for those with flatter consumption); and
- Consumers who use less than average will face bill increases due to the removal of the low-fixed charge regulations (and vice versa for those who consume more than on average).

4.2 Initial impact – fully cost reflective price structures

Figure 24 and Figure 25 illustrate the extent of this <u>initial</u> unwinding of cross-subsidies from a move to cost-reflective tariffs in the Wellington area. It shows the bill impacts if cost-reflective tariffs were introduced 'overnight', and there were no change in consumers behaviour or technology use.

Figure 24: Initial impact of fully cost-reflective prices (Wellington)

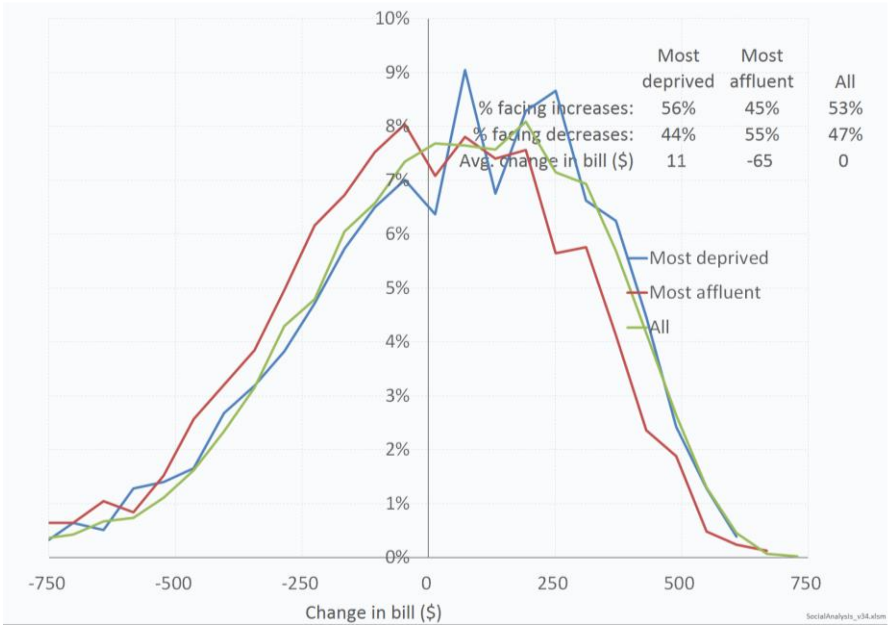


Figure 25: Initial impact of fully cost-reflective prices – all decile groups (Wellington)

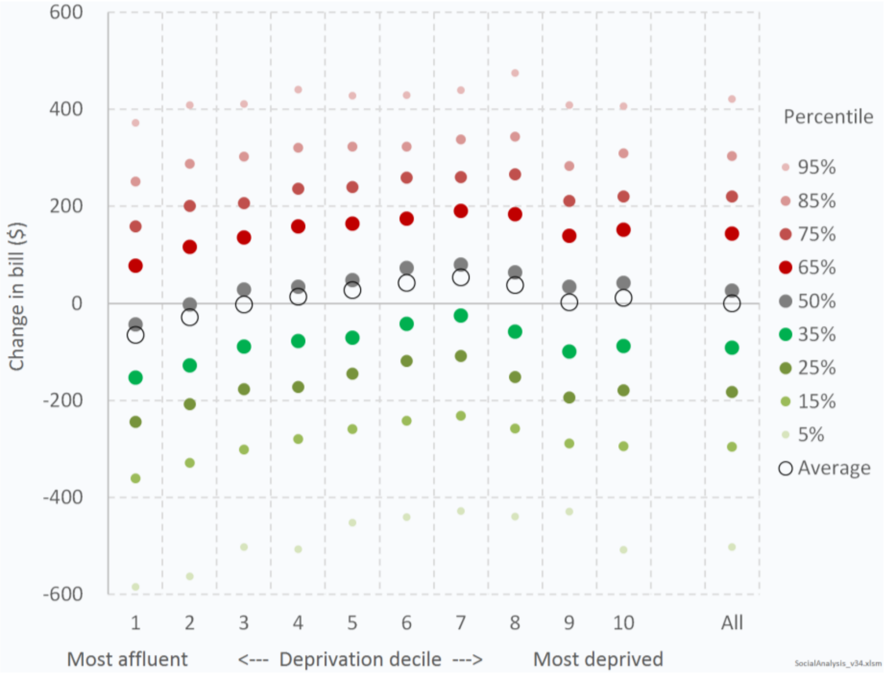


Figure 24 and Figure 25 show that, while the initial change in bills is broadly neutral across socio-economic deciles *on average*[33], there would be some consumers in all deciles who would experience significant shifts in bills. Some facing relatively large increases, and others enjoying significant decreases.

4.3 Isolating the effect of the low-fixed charge regulations

Because the LFC regulations are a current legal requirement, we have considered a case where current pricing structures are modified to make them as cost-reflective as possible (i.e. to introduce more of a time-cost-reflective structure for generation and network cost recovery), while maintaining strict adherence to the LFC requirement.[34]

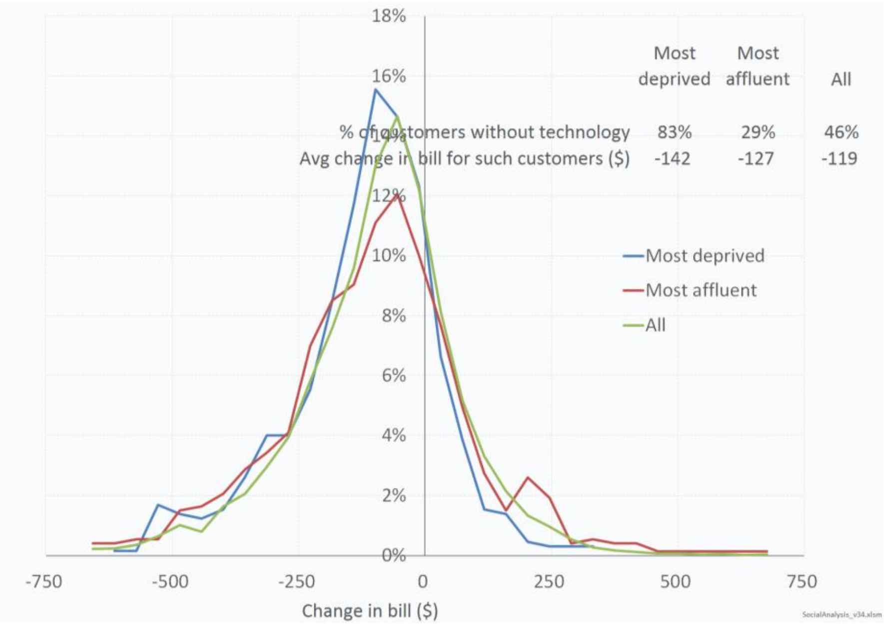
This allows us to isolate the effect of factors other than the LFC regulations on cost shifting. It also allows us to see how much benefit the LFC regulations provide to poorer consumers, all other factors being equal.

4.4 Long-term impact – partially cost-reflective prices

Figure 26 shows the difference in long-term outcomes for non-adopter customers in Wellington relative to a continuation of present tariff structures.

[33] Indeed, there is no change in the average amount charged across all customers.
[34] The LFC regulations define fixed charges as any charge levied "in currency per time period" (e.g. cents per day). It could be argued that a charge that varies with a consumer's capacity is not a fixed charge for the purpose of the regulations, even if it was expressed in (say) cents/day for differing levels of capacity. For the purposes of our analysis, we have not considered this possibility.

Figure 26: Long-term impact – partially cost-reflective prices (Wellington)



Comparing Figure 26 and Figure 24, the average outcome for non-adopter consumers is are similar – i.e. in both cases the average change is a reduced bill of approximately $120/year. However, the poorest decile consumers are better off in this scenario than for the fully-cost-reflective scenario (savings $142/year on average compared to $113/year), and the spread of outcomes is not as great.

The reduced spread has both positive and negative effects. On the positive side, there would be fewer consumers facing sizeable bill increases. On the other hand, there would also be fewer consumers facing large reductions in their bills.

Low-income consumers are better off on average because, as detailed in Appendix C, they tend to consume less electricity than wealthier consumers. Hence, they tend to benefit from the LFC scheme which favours consumers with below-average usage.

The reduction in the spread of outcomes is because in this scenario only one set of cross-subsidies is being unwound – i.e. the lack of time cost-reflectivity – whereas a move to full cost-reflectivity would additionally unwind the LFC cross-subsidy.

4.5 Initial impact – partially cost reflective prices

That said, as Figure 27 below shows, even if the LFC is retained, unwinding the cross-subsidy associated with the lack of time cost-reflectivity would result in some significant initial bill impacts – albeit smaller than that associated with a move to full cost-reflectivity.[35]

[35] This analysis also shows that in general, low-income customers will be slightly better off from a move to time-cost-reflective charges. i.e. they have a $37/year average bill decrease – albeit with a wide spread of outcomes. As set out in 0, this is because it appears that low-income consumers in general consume proportionately less during system peak periods than average consumers.

Figure 27: Initial impact – partially cost-reflective prices (Wellington)

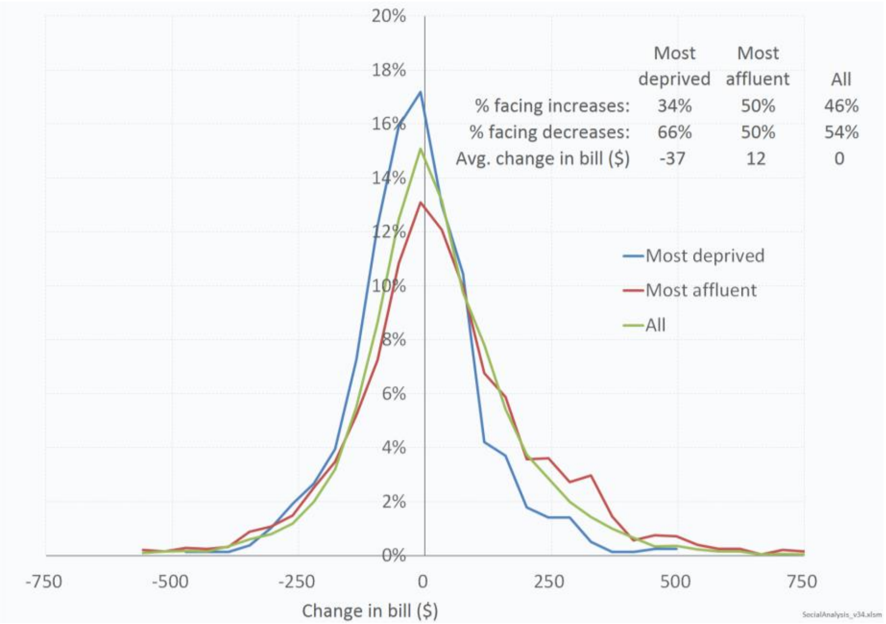
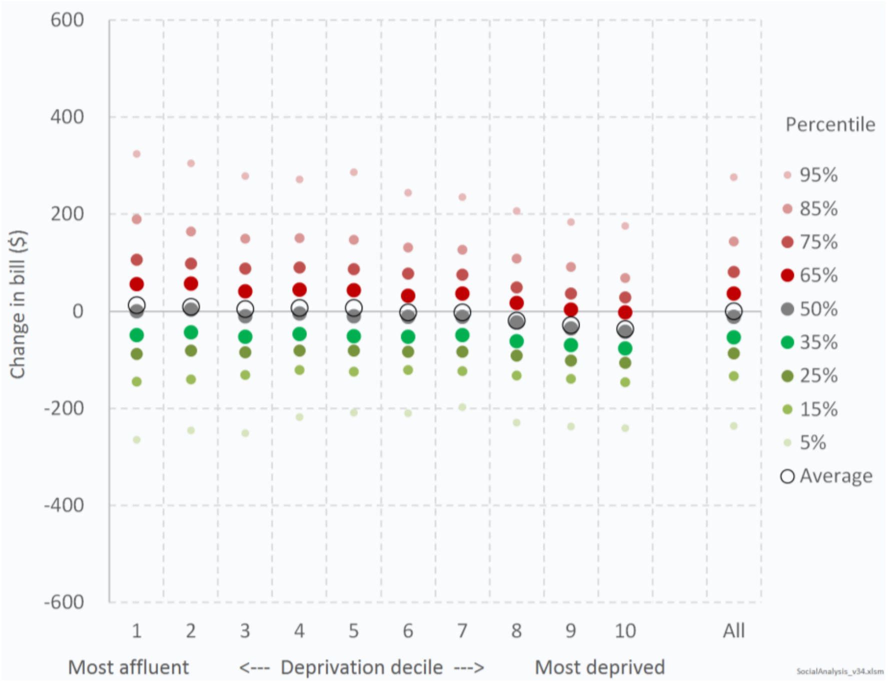


Figure 28: Initial bill impact -partially cost-reflective prices – all decile groups



4.6 Wider benefits of full cost-reflectivity

The above analysis has focussed on the initial and long-term bill impacts of different price structures on *non-adopters*. This shows that:

- Non-adopters would on average enjoy similar benefits from a move to time-cost-reflective tariffs, with or without a continuation of the low-fixed charge; but

- The lowest-income non-adopters would *on average* benefit more from a move to time-cost-reflectivity but with a continuation of the low-fixed charge regulations; and
- The spread of bill impacts from partial cost-reflectivity is less than moving to full cost-reflectivity.

Given the above result, the question could be asked why move to full cost-reflectivity?

Part of the answer lies in consideration of outcomes for all consumers (non-adopters and adopters) and their total cost of electricity – i.e. electricity bills and plus capital costs incurred from purchasing solar panels, minus solar export receipts.[36]

Figure 29 below shows the long-term impacts on total electricity costs (i.e. bills + capex) for all consumers in Wellington from a move to full cost-reflectivity. On average, we expect consumers will be $47/year better off, but with a wide spread of outcomes, including some being worse off.

Figure 29: Long-term impact of fully cost-reflective prices – adopters and non-adopters (Wellington)

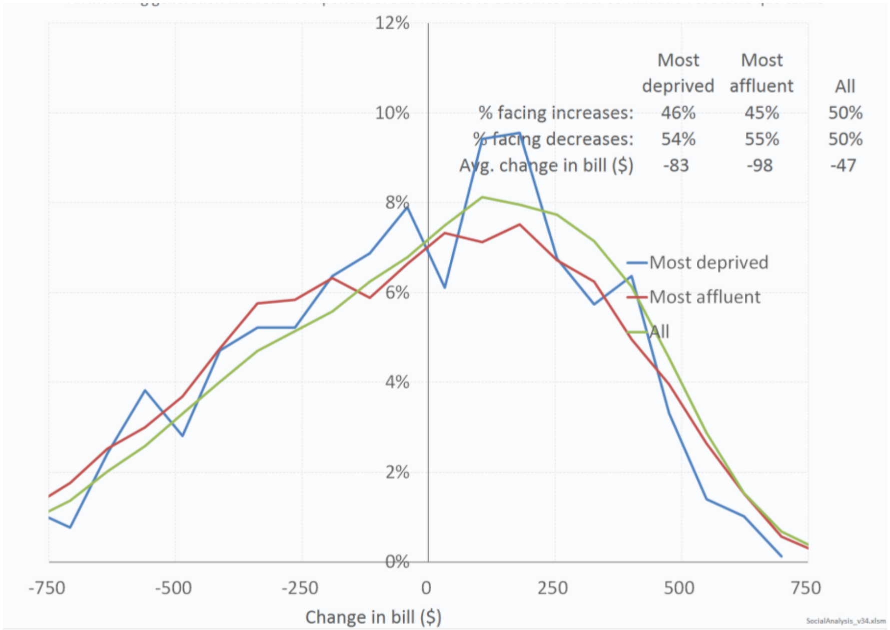
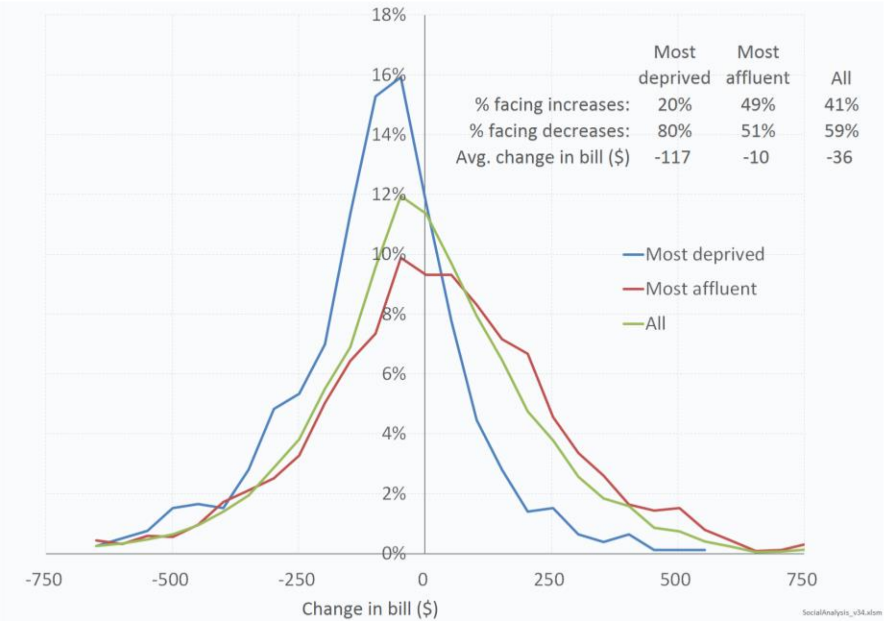


Figure 30 shows the same analysis of long-term outcomes for partially cost-reflective tariffs (i.e. the low-fixed charge is retained).

[36] In principle, there should also be recognition that increased mains-power usage associated with EVs provides a value to consumers in the form of reduced expenditure on conventional vehicles and fuels. We have not identified a suitable way to account for this in the analysis. However, given that EV uptake is projected to be relatively modest in the mixed uptake scenario and not change radically across pricing cases, we expect this will not materially alter the overall results.

Figure 30: Long-term impact of partially cost-reflective prices – adopters and non-adopters (Wellington)



Again, we expect consumers will be better off on average, with a spread of individual outcomes. However, the average gain is $36/year compared with $47/year under full cost-reflectivity.[37]

While this difference may appear small, when multiplied over 1.7 million residential consumers, and accumulated over 15 years, this represents a difference in outcomes of approximately $200 million in present value terms.

Put another way, we project that maintaining the low-fixed charge regulations (but otherwise moving to time cost-reflective tariffs) would cost New Zealand consumers approximately $200 million in higher energy supply costs.[38]

4.7 Results for other network areas

As noted earlier, this chapter has presented results based on household usage and deprivation data from the Wellington region.

The results for the four other network areas (Auckland, Christchurch, Dunedin, Hawkes Bay) are generally similar to those for the Wellington area, in terms of patterns of outcomes.

One issue where differences do arise is the effect of moving to fully cost-reflective pricing. For Christchurch and Dunedin, our modelling indicates that the initial impact for the poorest decile would be to increase bills by around $100/year on average (compared to $11/year in Wellington). As with all network areas, such increases for the poorest decile would be offset by reductions in wealthier deciles, resulting zero average bill change across all consumers.

[37] It is likely that this estimate of the scale of difference in total cost of-supply between the two price structures is an under-estimate for the reasons previously mentioned in footnote 29 on page 13. i.e. the avoided generation cost value of solar uptake is likely to be progressively over-estimated in this analysis for greater levels of solar uptake – and noting that the partially cost-reflective scenario projects 20% solar uptake in 15 years' time, compared with the 10% uptake projected for the fully-cost-reflective scenario.

[38] If the benefit of EV usage could be accounted for, this difference is expected to be larger.

The long-term impact is also less favourable for these consumers with a saving of $13/year (Christchurch), an increase of $27/year for Dunedin – compared to a reduction of $113/year for Wellington.

These types of differences are likely to reflect factors such as:

- The extent of correlation between deprivation and total consumption – which will affect the degree to which the LFC regulations benefit low-income consumers in different network areas
- The extent to which low-income consumers use proportionately less power at peak times– and which will affect the extent to which a move to time cost-reflective pricing will initially impact on low-income consumers.

Appendix C sets out analysis on these types of issues.

However, it remains the case that in all five areas, our modelling indicates that the poorest group of consumers will face higher bills due to cost-shifting associated with technology uptake, if present pricing structures are maintained. Across these five network areas, we estimate that the increase for such consumers would be around $100/year on average.

5 Which time-cost-reflective tariff structures are likely to give greatest benefit?

The previous analysis indicated that time-cost-reflective (TCR) tariffs are expected to provide significant long-term benefit:

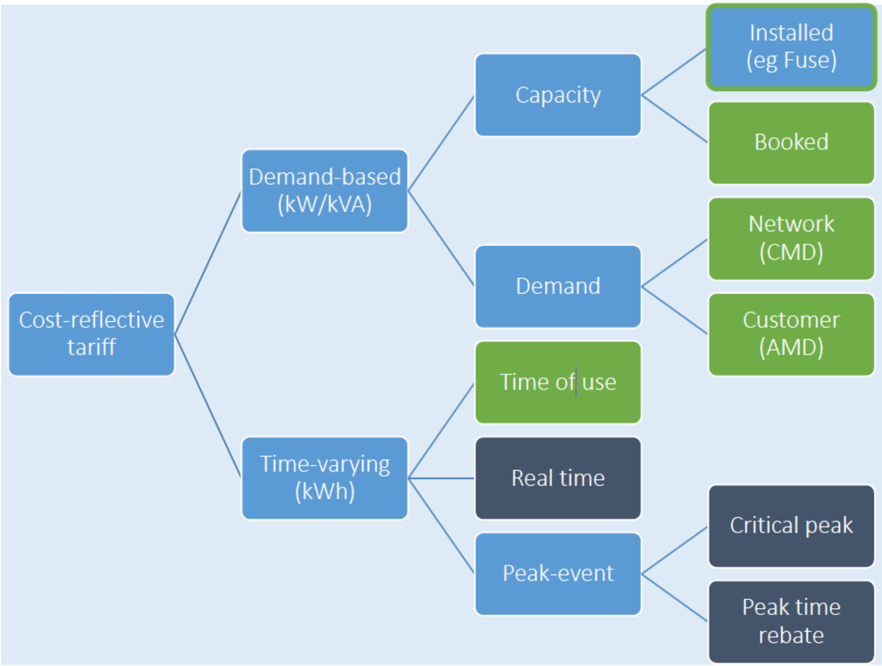
- To New Zealand consumers generally through encouraging uptake of the most cost-effective energy technologies
- To the least affluent consumers by reducing the currently over-strong reward to install solar PV (given this uptake is associated with costs being shifted from the middle- and higher-income to poorer households).[39]

The ENA has identified a range of tariff options that are more time-cost-reflective than the current tariff structures.

These options are summarised in Figure 31, and fall into two main categories:

- Demand-based options that place a charge on a measure of peak capacity or demand (these tend to be measured in kW, reflecting the "size of the wire" required to meet customers' needs).
- Time-varying options (or 'time-of-use' (TOU)) where prices differ according to the time of usage (these are based on the amount of electricity (kWh) that go 'through the pipe' during different time periods).

Figure 31 - Different cost-reflective network tariff structures



Source: "*New Pricing Options for Electricity Distributors*", Electricity Networks Association, Sep-2016

For each of these options, there are sub-options. For example:

- What structure to use for time-of-use pricing?
  - What time blocks to use. Seasonal (e.g. summer / winter), within-day (e.g. day / night / peak)

[39] To a much lesser extent time-cost-reflective tariffs will give low-income consumers some small average benefit because, as detailed in Appendix C, such consumers tend to have consumption which is less correlated with system peak than other customers. However, there is a significant spread of consumption patterns, and this correlation is relatively weak.

- Whether to only recover variable network costs in the winter peak time block

- How many ‘x’ periods will be used to determine a customer’s demand for CMD and AMD pricing. E.g. If x was 100, this means a customer’s demand would be measured in the top 100 half-hours of network demand (for CMD pricing) or the customer’s own demand (for AMD pricing).
- What proportion of costs to recover from these ‘variable’ charges – i.e. charges which are based on measures of a customer’s demand – versus fixed (i.e. $/day) charges. (Noting that LFC regulations may restrict networks (and retailers’) ability to implement cost-reflective pricing).
- Whether any *combination* of the above variable charge structures could be used? E.g. TOU in conjunction with a booked capacity charge.

It is out of scope to consider the relative merits of these different approaches in any detail. However, Concept has done some provisional analysis and modelling which has reached the following high level conclusions.

1) Charges which recover the variable component of network costs via a measure of customer’s demand at times of network peak (i.e. CMD pricing, and winter-peak-focussed TOU pricing), are likely to deliver the greatest long-term benefit to consumers generally, and low-income customers specifically.

This is because:

- Such charges will best signal the network cost-implications of peak demand, and thus best incentivise the cost-effective uptake of technologies which will reduce peak demand (e.g. efficient lighting, insulation, wood burners, smart appliances, etc.). This should reduce the cost of network provision in the long-term.
- Conversely, charges which recover network costs from variable charges based on measurement outside of network peak – e.g. having a material time-of-use charge for summer periods and/or night periods – will tend to result in the uptake of technologies which result in cost-shifting (e.g. solar PV, or inefficient electric heating), or suppression of cost-effective technologies such as electric vehicles.
- Because low-income consumers’ electricity demand tends to be relatively more peaky on an AMD basis, but less peaky on a CMD basis, they will tend to incur a greater proportion of costs from AMD and booked capacity charging approaches.[40] (Noting that the characteristics of booked capacity charging are very similar to that of AMD charging).

2) *How* network charges are implemented, and their inter-relationship with other components of charging, will significantly determine their effectiveness. In particular:

- Whether a network charge is more or less likely to be ‘re-packaged’ by retailers before being included in final customer charges. In this respect, it is notable that some CMD charging (e.g.

[40] Appendix C details this analysis of the relative AMD and CMD peakiness of less affluent customers.

that implemented by Orion) is being re-packaged by retailers in such a way as to completely lose the price signal for demand sources which aren't subject to direct control (e.g. efficient lighting, space heating, etc.). Conversely, it is appears that simple time-of-use pricing is starting to result in retailers offering tariffs with the same structure.

- Whether a network charge approach means it is more or less likely that retailers will adopt a time-of-use structure for recovery of generation charges. In this respect, it appears that where retailers face a time-of-use structure for network charges, they are more likely to adopt such a structure for the recovery of generation charges. Otherwise, they tend to recover generation charges via a flat variable charge. This is important, as not having a time-of-use structure for generation cost recovery will tend to incentivise the uptake of technologies which result in cost-shifting, and the suppression of cost-effective technologies such as EVs, efficient lighting, insulation, and the like.
- The time-structure of TOU charges. Our modelling indicates that a TOU structure where the variable costs are predominantly recovered via very high prices in winter peak periods, and little or no charge at other periods, deliver significantly better long-term outcomes than options which have moderate prices in winter peaks and low-ish prices at other times.
- Whether CMD approaches are implemented with supplementary measures to alert customers that a network peak period may soon be approaching. (e.g. in-home displays, smartphone apps, text alerts, etc.). While such alerts are not required for appliances where customers have granted the rights to the network company to *directly* control the appliance (e.g. hot water heating), they are extremely important for helping customers avoiding using appliances where the network doesn't have direct control.

In summary, the range of different possible approaches for the more time-cost-reflective pricing options identified by the ENA, results in a significant range in effective price signals to consumers for consumption at different times.

Our modelling indicates that effective price signals can deliver significant benefits in terms of costs and long-term bill outcomes.

We consider that pricing structures that effectively signal network *and generation* costs are likely to perform the best, and could significantly lower customer bills on average, compared to options which poorly signal these costs.

6 Moving to more cost-reflective pricing

6.1 Cost-reflective pricing is important

We think current price structures are likely to encourage a pattern of technology uptake that shifts costs from wealthier customers onto poorer customers – raising bills for the poorest consumers by approximately $100/year on average.

Our earlier reports also highlighted that current tariff structures skew technology uptake in a way that is likely to:

- Substantially increase greenhouse emissions;
- Substantially increase the cost of meeting New Zealand's energy and transport needs – of the order of $2 billion over the next 20 years.

While moving to cost-reflective tariff structures is the solution, it is not without its challenges.

6.2 Individual bill impacts will vary

While customers in total will be substantially better off over time, some individual customers will face bill increases. For a small 'tail' of customers these increases could be of the order of several hundred dollars a year (up to $500 in some cases) – albeit offset by bill decreases for other customers of similar orders of magnitudes (indeed generally bigger decreases for most customers over the long-term).

Any measures which result in some consumers facing bill increases will inevitably be harder to implement – even if the majority of consumers will be better off.

The fact that some of those facing substantial bill increases could be among the most deprived, adds an additional social welfare dimension – even though on average the most deprived consumers will be among the biggest beneficiaries from a move to more time-cost-reflective tariffs.

It is beyond the scope of this report to consider in detail the relative merit of approaches to managing the implementation of cost-reflective tariffs. However, we make some high-level observations.

6.3 Change can be phased

A move to cost-reflective tariffs could occur through a transition over a number of years. This should reduce the extent of bill 'shocks' and, if communicated properly, still retain effective signals for consumers about the likely long-term benefits of investing in different technologies.

The signalling effects could be reinforced by adopting a fast pricing transition for consumers installing technologies with strongly adverse cost-shifting impacts. This would reduce the risk of technology uptake which relies on continued poor pricing structures, which would in turn make further progress toward improved pricing more difficult.

While a transition would appear sensible for helping manage the potential bill shocks for existing consumers, there may not be the same need to have such transitional pricing for new properties. Instead, such properties could move directly to cost-reflective structures. Such an approach could potentially also be extended to people moving properties.

6.4 Opt-in could be offered

Likewise, it may be beneficial to allow some customers to elect to immediately transition to the fully cost-reflective tariffs. This may be attractive for those customers who want to utilise options that don't give rise to adverse cost-shifting – e.g. electric vehicles charged overnight.

However, making it entirely voluntary for customers to elect whether to transition over time to cost-reflective tariffs is likely to be problematic. Experience suggests that this is likely to result in 'adverse selection', where only those who benefit will voluntarily adopt new pricing structures, leaving a rump who may be even more difficult to address in isolation.

In particular, a substantial proportion of customers may wish to stay on flat tariffs in order to benefit from purchasing technologies which have the effect of shifting costs onto other consumers. This would be undesirable.

Further, there is likely to be considerable customer inertia around switching to alternative tariff structures – particularly if their structure is more complex, and the scale of benefits to individual consumers is hard to evaluate.[41]

6.5 Alternative to the LFC scheme to help poorer consumers

Improving pricing structures will inevitably create winners and losers, and the key focus should be on poorest consumers, as they will have the least capacity to deal with adverse bill shocks.

At present, the main electricity-sector specific tool to help this group is the low-fixed charge (LFC) scheme. We estimate that this transfers approximately $180 million annually from users with above-average usage to those with below-average usage. And yet it appears to provide limited assistance to the poorest consumers.

We estimate the average bill reduction for the most deprived decile to be around $60/year – an aggregate transfer of approximately $10 million/year to these customers.[42] Put another way, for every $1 that is 'collected' under the scheme, on average 5 cents flows to the poorest 10% of consumers. Although the scheme is not designed to exclusively benefit this group, they are the most vulnerable and this ratio is indicative of the relatively poor targeting of benefits under the LFC scheme.

A further indication of the relatively poor targeting of benefits under the LFC scheme is the fact that it will have *penalised* those poorest consumers who have above-average consumption – some by substantial amounts. It seems undesirable for a policy aimed at helping the poorest consumers to actually make matters worse for a significant number of them.

[41] The fact that after two years only a dozen or so customers have elected to move to Vector's time-of-use tariff option appears to demonstrate the extent of this inertia.

[42] Based on 1.7 million households x 10% x $60/year.

The LFC also significantly exacerbates the cost-shifting effect of solar PV uptake under flat tariff structures. Given that the poorest are the least likely to install solar panels on their properties, this effect of the LFC will be to progressively increase the bills of the poorest sections of society.

This begs the question of whether and how assistance can be provided to the poorest consumers in a more targeted manner. If an alternative can be identified, that could also be used to ease the transition to cost-reflective tariffs including the removal of the LFC, this would be a significant 'win-win' for New Zealand generally, and the poorest segments of society specifically.

It is beyond the scope of this report to consider alternatives, but this issue warrants consideration by policy makers – including drawing upon the significant experience from overseas where a large number of different approaches to targeting assistance for fuel bills have been tried.

6.6 Policy guidance and facilitation

Lastly, it would appear sensible for there to be regulatory and governmental involvement in this transition to cost-reflective tariffs:

- 'Legitimising' in the public eye the move by suppliers to more cost-reflective tariffs by being able to provide objective information demonstrating that such initiatives are in the best interests of New Zealand.
- 'Encouraging' those networks and retailers who, for whatever reason, are reluctant to transition to tariff structures that are in the best long-term interests of consumers.[43]

[43] In recent consultations on such issues, there are a mix of views as to whether networks and retailers (for the recovery of retail & metering, and generation costs) costs are inherently incentivised to transition to cost-reflective tariffs. It is beyond the scope of this report to consider the relative merits of these arguments, and what regulatory actions may help deliver the best long-term outcomes.

7 Conclusion

Our analysis shows that technology uptake is likely increase power bills for many of New Zealand's poorest consumers, if existing electricity pricing structures are maintained. We expect 84% of the poorest consumers will face higher power bills due to cost-shifting associated with technology uptake over the next 15 years.

For this group of consumers, we expect an average rise of $129/year, with increases of $350/year or more in some cases, if existing electricity price structures are maintained.

We think current price structures will also encourage a pattern of technology uptake that causes wider economic costs of up to $2 billion, and contributes to higher emissions (as discussed in earlier separate reports).

To address these issues, we need to adopt electricity pricing structures that are better aligned with the true cost of supplying electricity. This does not mean a rise in average electricity prices – but instead that prices would better reflect the costs for supplying different usage profiles.

Our analysis shows that moving to cost-reflective pricing will avoid the increases that otherwise fall on the poorest consumers – saving them around $113/year on average over time. However, individual impacts will vary significantly – with much greater reductions for some customers and increases for others. And near-term impacts will be less favourable – with smaller immediate savings for those who benefit, and larger increases for others.

These factors highlight the need to carefully consider how best to move to improved price structures. We think that most (if not all) of the benefits can be obtained without requiring a sudden step-change, as long as the direction of change is clear and consumers have sound information on which to make decisions.

Our analysis also invites a deeper consideration of how best to assist the least well-off members of society in relation to power costs. The main specific tool used at present is the LFC scheme. But this is a blunt instrument – it helps many households that have middle- and higher-incomes. It also hurts poorer households with average- or above-average usage.

And the LFC scheme is likely to become increasingly ineffective as a means of helping poorer consumers if existing price structures are maintained. A rising share of those who qualify for LFC benefits will the middle- and higher-income households who install solar panels – and the costs will fall on those (mainly) less well-off households that don't install panels.

While addressing these questions is beyond the scope of this report, we hope this analysis helps to illuminate the issues and trade-offs in the social context, and so contributes to better informed discussion of the options for New Zealand

Appendix A. Sensitivity of cost-shifting impacts and network costs

Section 2.3 explained that cost-shifting arises because of misalignment between pricing structures and underlying cost-drivers - particularly in relation to usage at times of peak system demand.

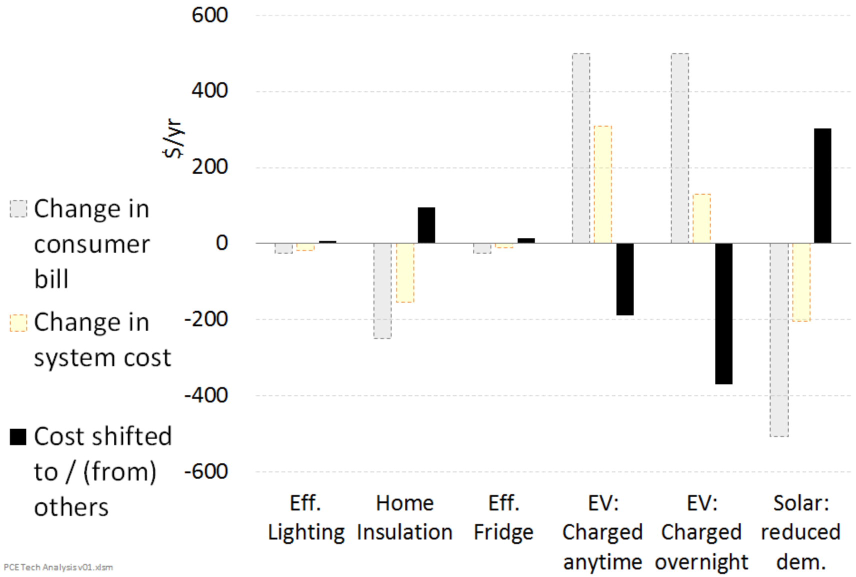
The analysis in that section (shown in Figure 10 previously) assumes that 55% of network costs (the combination of distribution & transmission) are driven, over the long-term, by consumption at peak. This is based on analysis undertaken in the past by Orion.

It is important to recognise this variability is over the long-term (e.g. over a 40-year period), and assumes that over this time period a 1 kW reduction in peak demand will result in a 1kW reduction in network capacity needing to be built (or worn-out assets replaced) with consequent cost savings.

However different networks face different circumstances. In particular, some networks are facing underlying reductions in demand (e.g. due to population decline in their area). Accordingly, it is possible that in some parts of the country with declining demand, a reduction in peak demand wouldn't lead to a 55% long-term reduction in network costs but some significantly lower amount.[44]

To test whether this may alter the technology cost-shifting outcomes, Figure 32 below repeats the cost-shifting analysis, but assuming that only 15% of network costs are driven by peak demand.

Figure 32: Effect of technology options on cost shifting under current price structures – assuming only 15% of network costs are driven by consumption at peak



This analysis shows that the mis-match between benefit and cost is changed for the peak-focussed energy efficiency measures (LEDs and insulation), but the mis-match is largely unchanged for solar panels and EVs charged overnight.

[44] However, if there was significant EV uptake, the likelihood of no peak demand growth in the absence of time-cost-reflective tariffs would seem unlikely – even in those networks that otherwise face declining demand.

As such, the conclusions as to the cost-shifting effects of current tariff structures for these technologies are considered robust - even for networks where there is unlikely to be peak-driven network investment for the foreseeable future.

Appendix B. Modelling approach to examining the impact of alternative charging structures

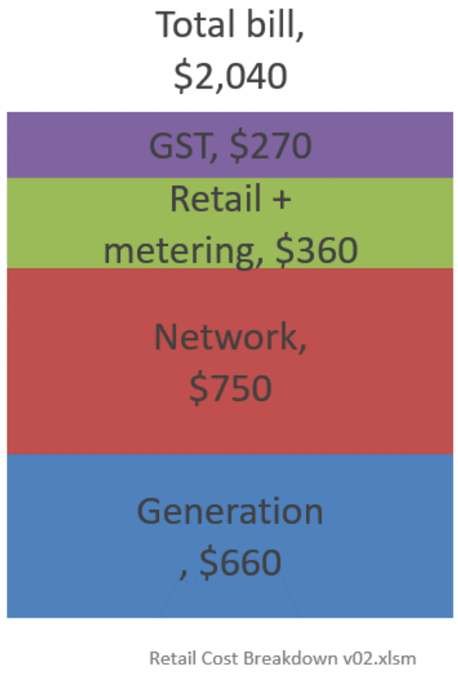
This appendix describes the detailed modelling approach used to examine the impact on real customers from potential changes in tariffs.

7.1 Design a 'status' quo charge

The initial step was to set appropriate tariff rates for recovery of network, generation, and retail & metering charges.

MBIE data was used to determine the average total bill for the average residential consumer, and the split between the three main components. The results are shown in Figure 33

Figure 33: Breakdown of average residential bill[45]



Source: Concept analysis of MBIE data

These average bill amounts were then translated into variable \$/kWh and fixed \$/day charges as follows:

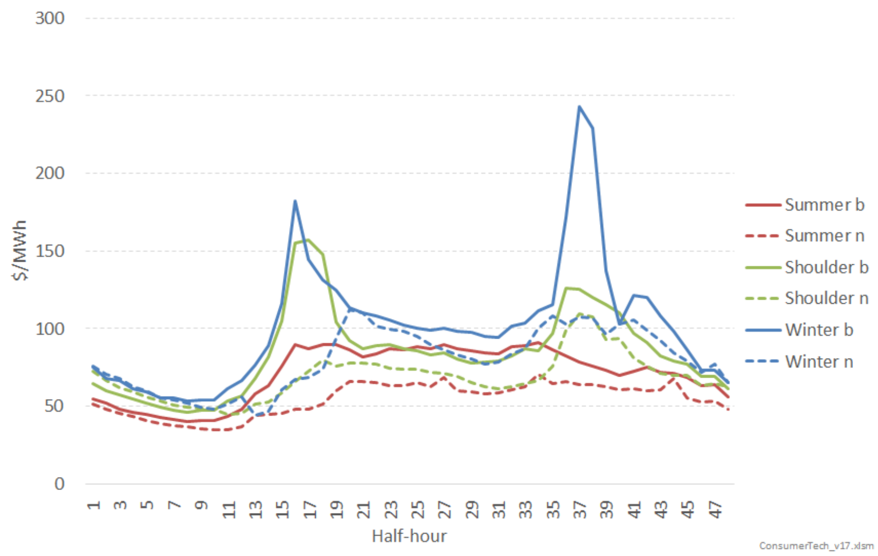
- For ***network*** charges, two tariffs were created for 'standard' and 'low-users'. The fixed \$/day charge for the standard tariff was initially set at a level which would recover 45% of revenue from fixed charges if the standard charge would apply to all consumers. The low-user fixed charge was set at the mandated \$0.15/day

[45] 'Retail' covers retail cost-to-serve and metering costs.

level. The variable charges were then set to achieve bill equivalence between the two tariffs for the threshold low-user customer (9,000 kWh/yr for all customers located in the Lower South Island, and 8,000 kWh/yr for all other network areas), while ensuring that when applied to the consumption data for the tens of thousands of ICPs for each network, the overall revenue recovery exactly equalled $760 per customer. This required the development of slightly different tariffs for each network area, given the variation in customer consumption in each area.[46]

- For recovery of ***generation*** costs, a single demand-weighted average $/kWh tariff was created for each network area. The demand shape for each network area was based on the average within-day shape across all the tens of thousands of ICPs in each network, with the price shape being that shown in Figure 34 below. This price shape is based on observed historical temporal variation in wholesale prices, factored in order to achieve a time-weighted average of $75/MWh (which is consistent with the current ASX electricity forward curve).

Figure 34: Modelled seasonal and diurnal shape of energy prices



- For recovery of the ***retail and metering*** costs, a 'standard' option was created where approximately 50% of costs would be recovered from fixed charges if applied to all customers,[47] and a 'low-user' version with a regulated fixed charge of $0.15/day. Again, the variable charges were set to ensure that the total cost recovered was identical for a customer with annual consumption

[46] A further layer of complication was that it was necessary to create Uncontrolled, Controlled and Inclusive versions of these tariffs, with the Controlled and Inclusive tariffs having a discount to reflect the value of control to the network company. (Noting that the level of the inclusive tariff required assessment of the proportion of controlled to uncontrolled load in each network area.). The creation of these three different versions was considered necessary given that the data was provided in this form.

[47] Although the cost-reflective tariff would have 100% of retail and metering costs recovered via fixed charges, it has been observed that there is significant variation among retailers as to the proportion recovered via fixed charges for their standard customers – some close 100%, some at the low-fixed charge levels. This may be due to some retailers wanting to simplify matters for compliance with the low-fixed charge regulations. An average value of 50% recovery via fixed was chosen.

at the low-user threshold, whilst also ensuring that the average per customer revenue recovered across all the tens of thousands of customers in the network area under evaluation was exactly $360.

All of the above charges had GST applied.

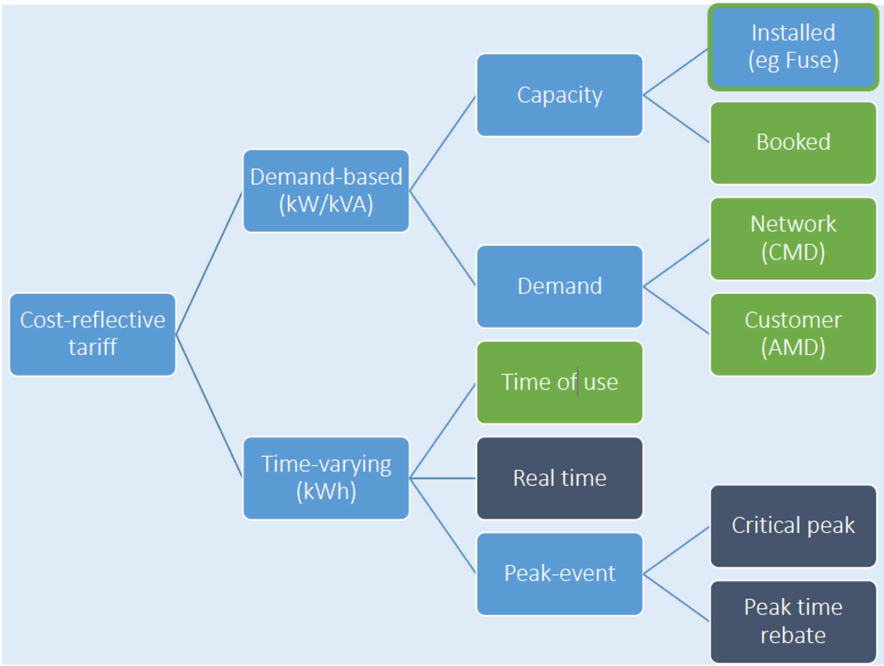
7.2 Assess the impact of an alternative charge.

7.2.1 A range of different charging options were considered

The Electricity Networks Association (ENA) have identified a variety of different charging structures as being more "cost-reflective".

An illustration of the types of charging approaches which have been examined is shown in Figure 35.

Figure 35: Different cost-reflective network tariff structures



Source: "*New Pricing Options for Electricity Distributors*", the ENA, September 2016

A key characteristic of all these tariff structures is to better align the amount that consumers are charged to measures of their consumption at the times which drive network costs – i.e. periods of peak system demand.

At a high level, the main approaches to charging consumers on such a basis are:

- ***Time-varying kWh consumption-based*** charges based on the kWh consumed at different times. There are various options within this:

- *Time of use* tariffs, with different prices for time blocks which are set in advance. These can vary across the year (i.e. summer / winter) and/or within the day (e.g. day / night, or day / night / peak)
- ***Peak event*** charges based on consumers' consumption during *actual* peak events, with the timing of when such peak events occurring not being known in advance[48].
- ***Real time*** pricing. This only applies to the recovery of wholesale energy costs, whereby consumers go onto 'spot' tariffs based on the half-hourly wholesale spot market.

- ***Demand-based charges*** based on some measure of consumers' peak demand, measured on a kW or kVA basis.[49] There are variations within this family of approaches:
  - ***Capacity-based*** charges, based on the amount of network capacity consumers are deemed to be paying for. In turn, this can either be based on:
    - The ***installed*** fuse at the property (typically 14 kVA for a residential property), with all consumers that have the same size fuse getting charged the same amount; or
    - The ***booked*** capacity, noting that advanced meters open up the potential for consumers to elect to go onto a lower capacity setting, and customers incurring some form of penalty if they exceed this level (or even the advanced meter acting like a 'virtual fuse' through interrupting the consumer if their consumption goes above the booked capacity level).
  - ***Demand-based*** charges are based on some actual measure of consumers' maximum demand.
    - ***Network peak demand*** charges (also known as coincident maximum demand (CMD) or coincident peak demand (CPD)) are based on a consumer's measured demand during periods of network-wide peak demand.
    - ***Consumer peak demand*** charges (also known as anytime maximum demand (AMD)) are based on the maximum demand recorded for each consumer, irrespective of when that maximum demand occurred during the year.

Among these different cost-reflective distribution charging approaches, the ENA has identified a sub-set which it has identified as being most appropriate to progress. These are shaded green in Figure 35, i.e.:

- Time-of-use charging
- Network peak demand charge (referred to as a coincident peak demand, CPD, approach)
- Anytime maximum demand (AMD) charging

[48] E.g. The peak event(s) may predominantly occur in July one year, and August the next, depending on whether the respective months were particularly cold or not.
[49] The difference between kW and kVA relates to a consumer's power factor. However, for the purposes of considering tariff structures, power factor is a relatively second order effect, and thus kW-based and kVA-based approaches can be considered broadly equivalent.

- Booked capacity charging

The model was designed to enable examination of moving to any of these ENA-identified preferred options (or any combination), including whether such options were to be compliant with the low-fixed charge regulations, or not.

Further, it was designed to enable examination of the implications of the various design choices for each of these options, including:

- The proportion of network costs to recover from fixed charges. Thus, irrespective of which of the above consumption/demand-based charging approaches are chosen, the tariff consequences will be very different depending on whether the vast majority of costs were still recovered via a fixed $/day charge, or whether the vast majority of costs were recovered via consumption and/or demand based charges.
- The proportion of costs recovered from consumption versus demand-based approaches. Thus, even if a network were to adopt demand-based charging for the recovery of the majority of its costs, it may still choose to recover some of its costs via consumption-based charges.
- The level and structure of time-of-use charges. Key design choices relate to:
  - The temporal structure of the tariff, i.e. whether to have:
    - Any *seasonal* structure (e.g. summer/winter, or summer/shoulder/winter)
    - Any *diurnal* structure (e.g. day/night, or day/night/peak[50])
  - The extent to which tariffs should vary between these different time periods. Thus at one extreme network prices could be zero for all periods except the winter peak period, whilst at the other extreme, there could be relatively little variation in the level of prices between different time periods.

7.2.2 A small sub-set of charging approaches was used for detailed analysis

Although designed to look at the implications of these different options, in the end the analysis focussed on a very small sub-set of options which evaluated the outcomes from changing the structure in two dimensions

- Time cost-reflectivity, with one option being a continuation of the flat structure, and the other being a highly time-cost-reflective approach, where:
  - a time-of-use structure was used for the recovery of generation costs (with the $/kWh price for each time block

[50] 'Peak' periods are typically the morning and evening periods around the time when people go to/from work.

being based on the demand-weighted average price for that timeblock)

  - recovery of those network costs deemed to be driven by peak demand was through charges that applied almost entirely during winter peak time periods
  - no time differentiation in any $/kWh costs for recovery of retail and metering

- Whether the tariffs were low-fixed charge compliant, or not. In futures where the LFC requirements were removed, the recovery of 45% of network costs, and 100% of retail & metering costs was achieved by the $/day fixed charge.

Focussing on this sub-set of options enabled examination of changing the key factors impacting on the cost-reflectivity of tariffs, without getting lost in the 'noise' of the various sub-options. That said, as set out in section 5, our analysis identified that the range of different approaches would have different outcomes – largely being differences in degree than absolute nature.

In summary, the four main tariff structures that were considered were

- Flat + LFC compliant (the status quo)
- Flat but LFC removed
- Time-cost-reflective + LFC compliant
- Time-cost-reflective and LFC removed (fully cost-reflective)

7.2.3 Evaluate the impact of alternative structures

In producing each alternative tariff structure, it was necessary to achieve internal consistency for recovery of both network and retail & metering costs.

With regards to network tariffs this required.

- Ensuring that each option was revenue neutral. I.e. recovers exactly the correct amount of network revenue from across the tens of thousands of customers modelled.
  - For the initial 'static' evaluation of altered tariff structures, this means that each tariff option recovers exactly the same amount of network revenue from across the tens of thousands of consumers modelled.
  - For the 'dynamic' evaluations considering possible changes to consumer demand, due to technology uptake, this also required determining the change in network costs due to a change in peak demand, and then setting the network tariffs for a given structure to ensure that exactly that amount of revenue is collected from across the tens of thousands of customers modelled.
- Ensuring that the tariffs meet the low-fixed charge requirements in the options where the low-fixed charge regulations continue –

i.e. bill equivalence for customers whose annual consumption is at the level of the LFC threshold.[51]

- Ensuring that the level of network discount given to controlled load is consistent across the different charging approaches, and for the different metering configurations.

  For new tariff structures (i.e. time-of-use, capacity, or demand-based) the tariffs have been set such that the same overall discount is achieved for controlled load relative to uncontrolled load.

For recovery of retail & metering costs, the main complexity was ensuring the tariffs were low-fixed charge compliant, yet recovered the target $360/customer across all of the tens of thousands of customers modelled, for scenarios where customer demand was evaluated as changing due to technology uptake.

Developing tariff structures which satisfy all the above constraints is not trivial, and has required the development of a relatively complex tariff model. However, initial analysis of the problem revealed that not to take account of such complexity risked the production of results which either missed important phenomena, or potentially produced misleading results.

Each tariff structure would then be combined with the half-hourly demand for each of the thousands of customers in each network area, to work out the bill impact for each individual customer.

In scenarios looking at technology uptake, a random function was developed which would simulate the uptake of such technology by individual ICPs which overall would deliver the total level of uptake across all consumers, and yet achieve the differential rates of uptake across the different deprivation deciles.

Each customer that was modelled as having taken up the particular type of technology (e.g. solar PV, EV, peak efficiency measures) would then have their consumption profile altered accordingly, which would feed through into a revised bill for the tariff structure under examination.

This ICP-specific modelling approach allowed for examination of the range of likely outcomes – something that would be lost through considering customer segments using average profiles.

[51] Capacity and demand-based charges were not considered to be fixed charges for the purposes of meeting the low-fixed charge regulations. This is consistent with the Electricity Authority's guidance on such matters, where it stated that, because consumers have the ability to alter their demand at times of peak, or alter the amount of capacity they book, such charges should not be considered fixed.

Appendix C. Characteristics of consumers which will drive the nature and scale of bill impacts, and the extent of correlation with social deprivation

The main body of the report highlighted that changes in the structure of tariffs and/or significant uptake of certain technologies (e.g. solar PV) could result in some consumers facing significant bill increases, while others would see bill decreases.

It further identified that the key characteristics which will drive whether a consumer will face an increase or decrease (and by how much) are:

- The size and shape of their consumption. i.e. do they consume a lot or little, and is their consumption relatively flat or 'peaky'
- Whether or not they take up a technology that would result in significant cost-shifting under certain tariff structures.

This appendix presents analysis of the extent to which there is any correlation between socio-economic deprivation and the above factors.

Extent of relationship between deprivation and key consumption characteristics

This sub-section presents the results of the analysis looking at the half-hourly consumption data provided for over 100,000 ICPs and comparing with census data on deprivation.

Results are shown for five network areas:

- Auckland
- Wellington
- Christchurch
- Hawkes Bay
- Dunedin

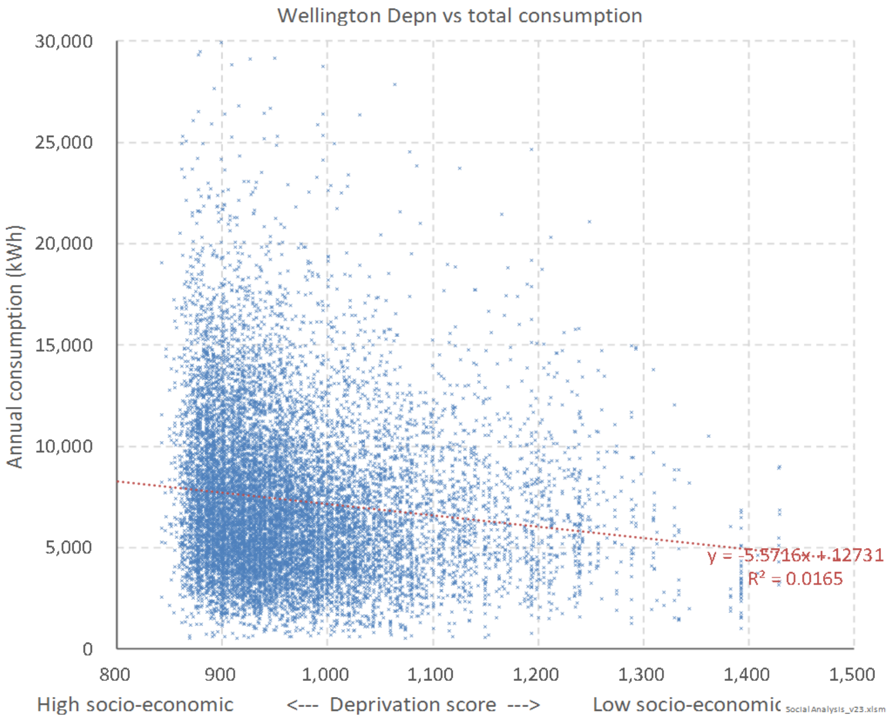
ICP data was provided for other networks, but the relatively small number of ICPs for these networks (< 5,000) was deemed insufficient to be statistically robust. This was assessed through doing statistical analysis on random smaller samples from the networks with larger numbers of ICPs, and finding out that relationships that are apparent with 10,000+ ICPs, start to break down with only a few thousand ICPs.

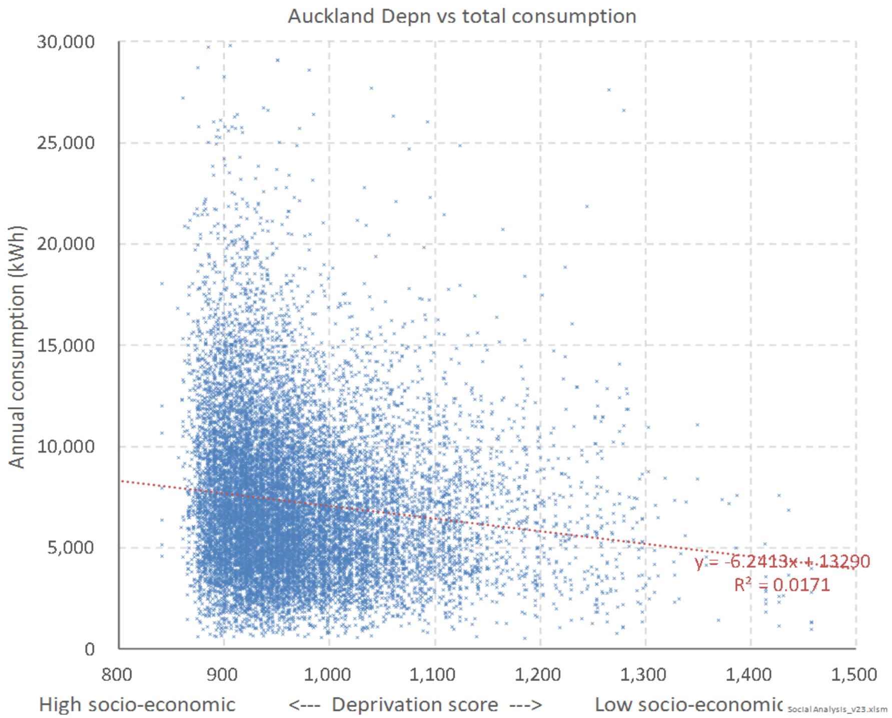
Results for the Powerco network have been excluded, even though there were large numbers of ICPs. This is because the 'network' is in fact several networks which are geographically dispersed, with differences in meter and tariff configurations across this area. This could affect the nature of consumption patterns making it harder to compare like with like.

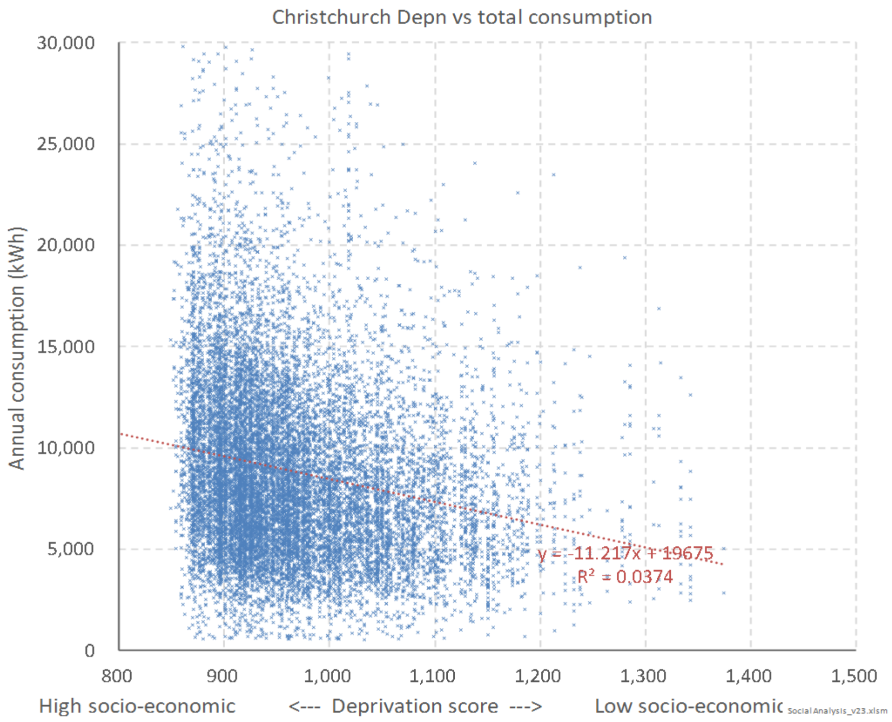
Relationship between deprivation and total consumption

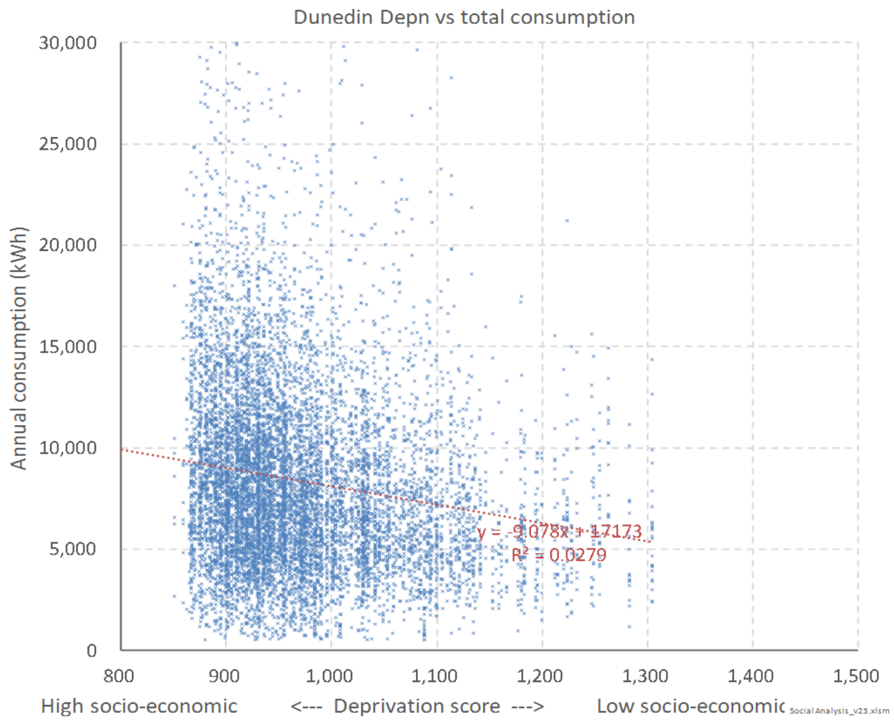
Firstly, there appears to be a positive correlation with socio-economic status and electricity consumption. i.e. in *general* higher socio-economic households consume more than lower socio-economic households. This is shown in the figures below which expresses this relationship as being an *inverse* correlation between deprivation score and consumption – noting that the higher the deprivation score, the lower the socio-economic status.

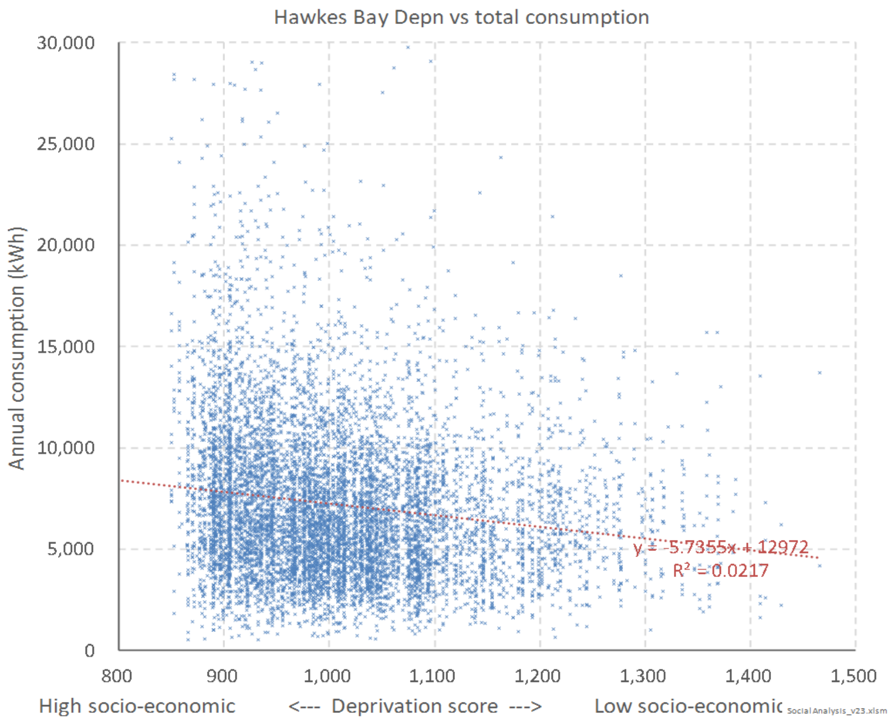
However, this correlation is not very strong, and the graphs show that there are a significant number of consumers in the most deprived decile who have consumption that is considerably above the average, and likewise some very affluent consumers who have much lower than average consumption.

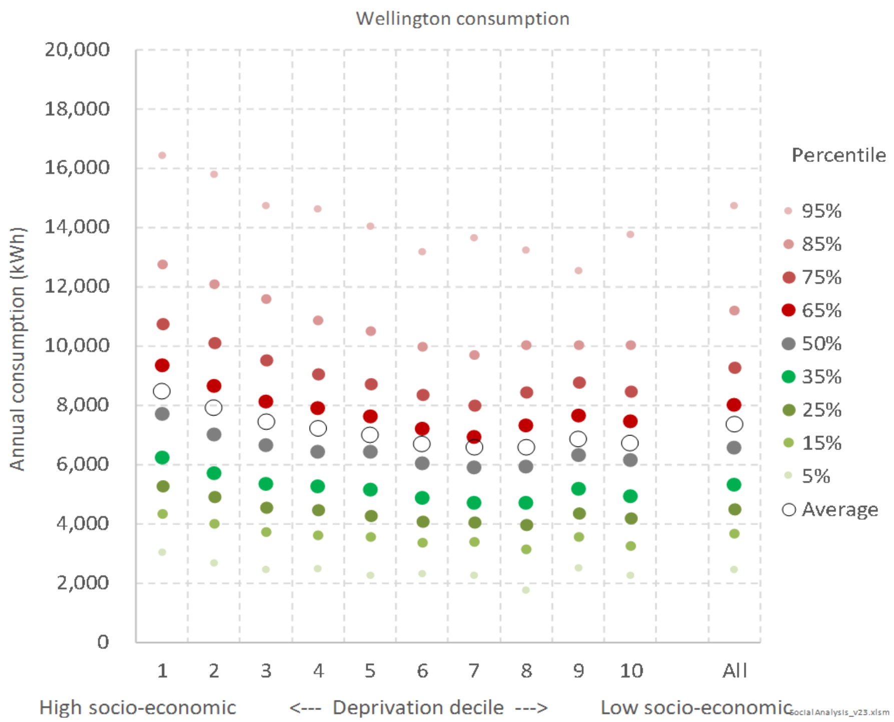




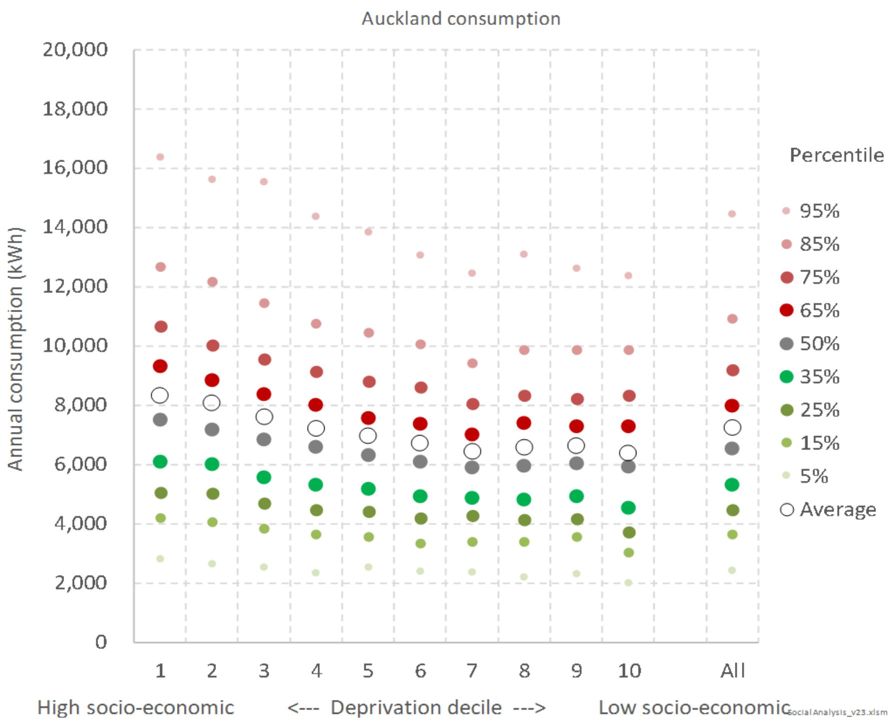

Christchurch Depn vs total consumption
Annual consumption (kWh)
30,000
25,000
20,000
15,000
10,000
5,000
0
800
900
1,000
1,100
1,200
1,300
1,400
1,500
High socio-economic <--- Deprivation score ---> Low socio-economic
y = -11.217x + 19675
R^2 = 0.0374
Social Analysis_v23.xlsm


Dunedin Depn vs total consumption
Annual consumption (kWh)
30,000
25,000
20,000
15,000
10,000
5,000
0
800
900
1,000
1,100
1,200
1,300
1,400
1,500
High socio-economic <--- Deprivation score ---> Low socio-economic
y = -9.078x + 17173
R^2 = 0.0279
Social Analysis_v23.xlsm

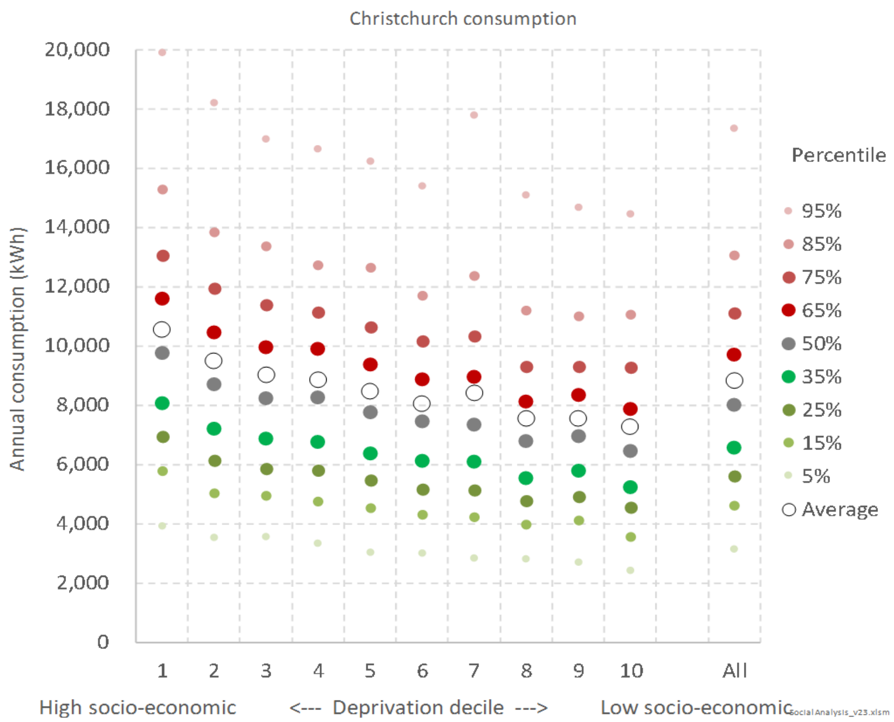




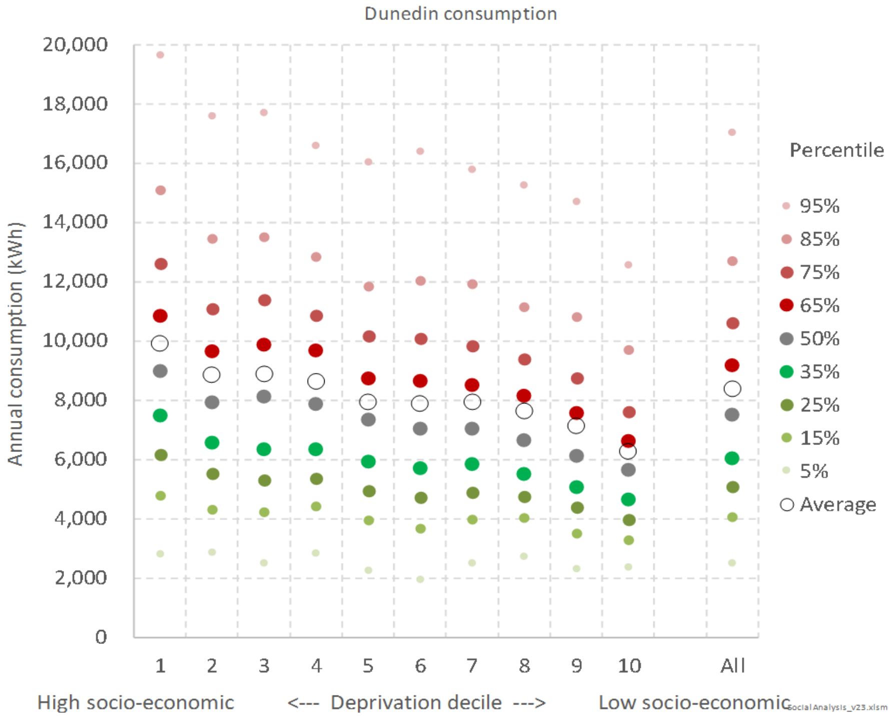
This data is shown in a different form, focussing on the different deprivation deciles, in the following graphs.

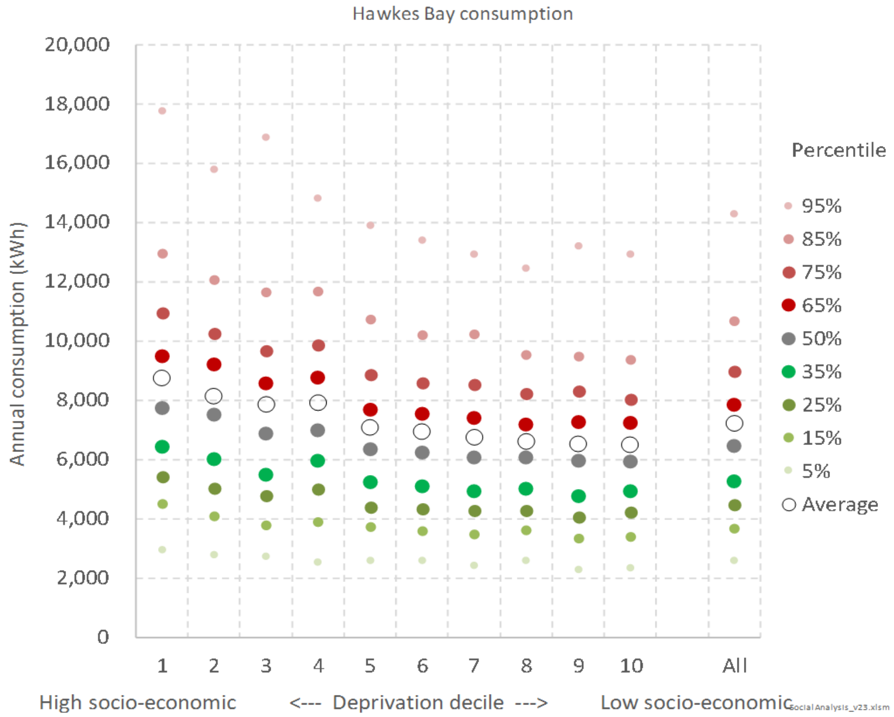


Auckland consumption
Annual consumption (kWh)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1 2 3 4 5 6 7 8 9 10 All
High socio-economic
<--- Deprivation decile --->
Low socio-economic
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average



Christchurch consumption
Annual consumption (kWh)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1 2 3 4 5 6 7 8 9 10 All
High socio-economic
<--- Deprivation decile --->
Low socio-economic
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average


Dunedin consumption
Annual consumption (kWh)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1 2 3 4 5 6 7 8 9 10 All
High socio-economic <--- Deprivation decile ---> Low socio-economic
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average

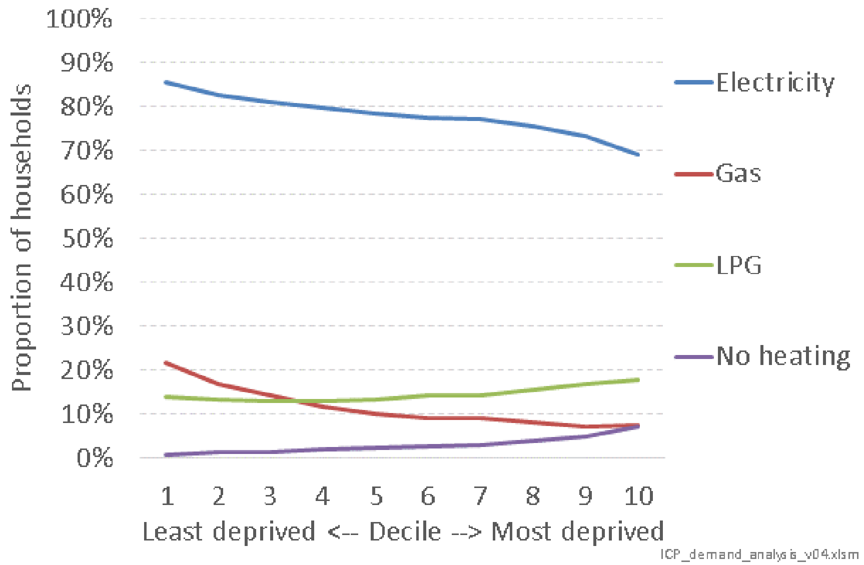

Hawkes Bay consumption
Annual consumption (kWh)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1 2 3 4 5 6 7 8 9 10 All
High socio-economic <--- Deprivation decile ---> Low socio-economic
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average

There are a number of probable causal factors for this relationship between deprivation and consumption, including the fact that higher socio-economic households:

- tend to live in larger houses that require more heating and lighting;
- can afford more appliances; and
- are unlikely to be budget constrained in terms of ability to paying energy bills. i.e. Some individuals in the lowest socio-economic groups will be foregoing energy services (including heating and lighting) because they are unable to pay for them.

This last point is illustrated by Figure 36 which shows that the proportion of households in the most deprived decile that were reported as having no space heating was nine-times greater than those in the most affluent decile.

Figure 36: 2013 Census reported proportion of households with different types of heating



In terms of the tariff implications of the relationship between annual consumption and deprivation, this relationship suggests that lower fixed charges will *generally* be better for low socio-economic households.

However, while this will generally be the case, there are a significant number of low socio-economic consumers who have consumption that is considerably above the average (e.g. large households who have electric heating), and thus will have been worse off from low fixed charges – some of whom will have faced higher bills of the order of several hundred dollars.

Similarly, while more wealthy consumers will generally have faced bill increases because of the LFC, a very large number of the most affluent will have enjoyed substantial bill decreases.

Overall, it is estimated that the LFC has resulted in approximately $180 million being transferred annually from one set of customers to another set of customers, in order to deliver:

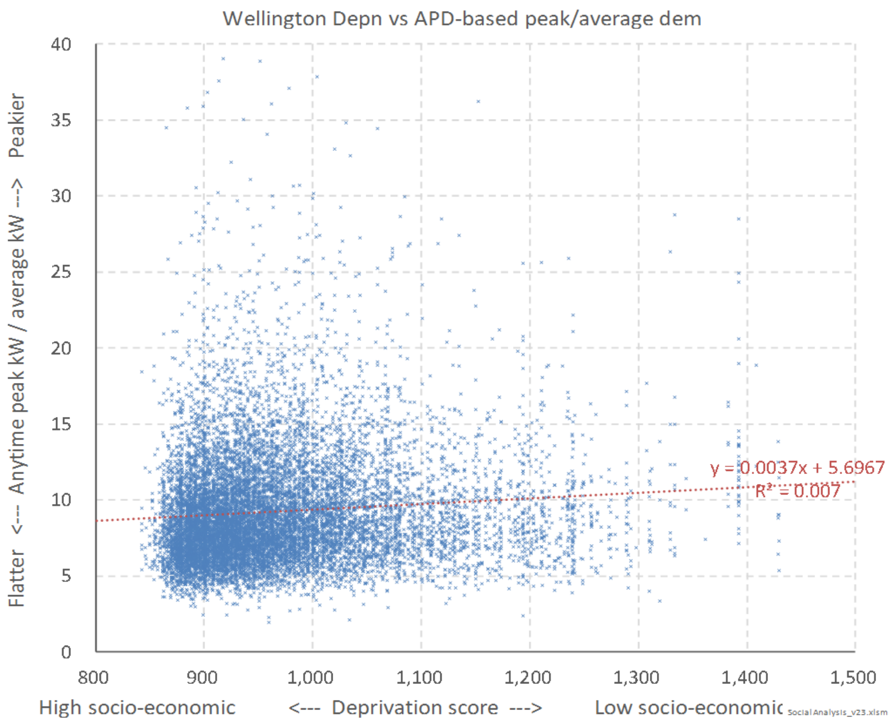
- an average bill reduction for customers in the poorest decile of $60/year; but
- with some of the poorest customers facing bill increases of several hundred dollars a year.

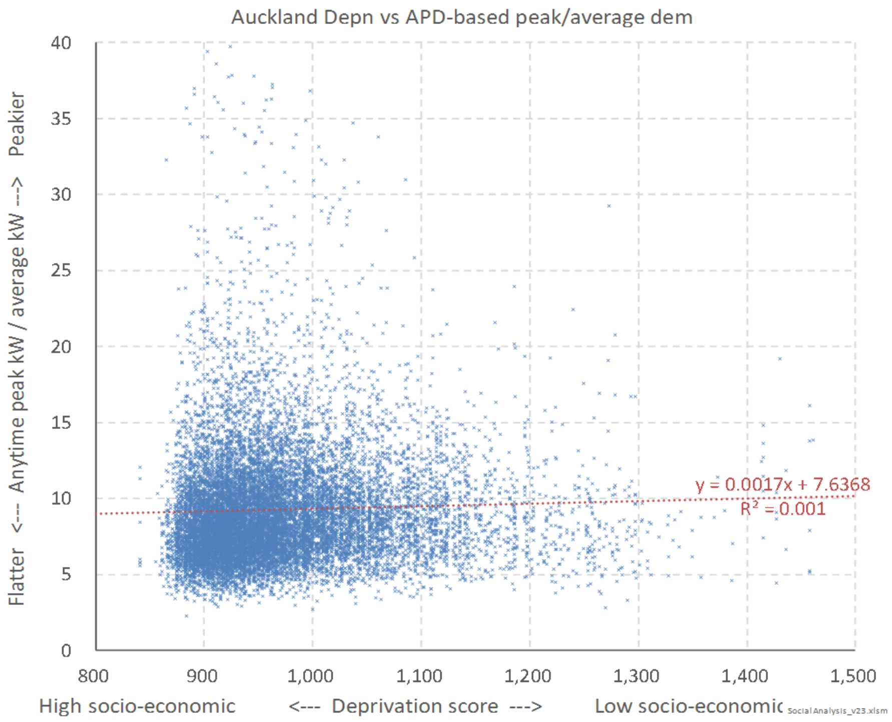
Relationship between deprivation and consumers' individual peakiness

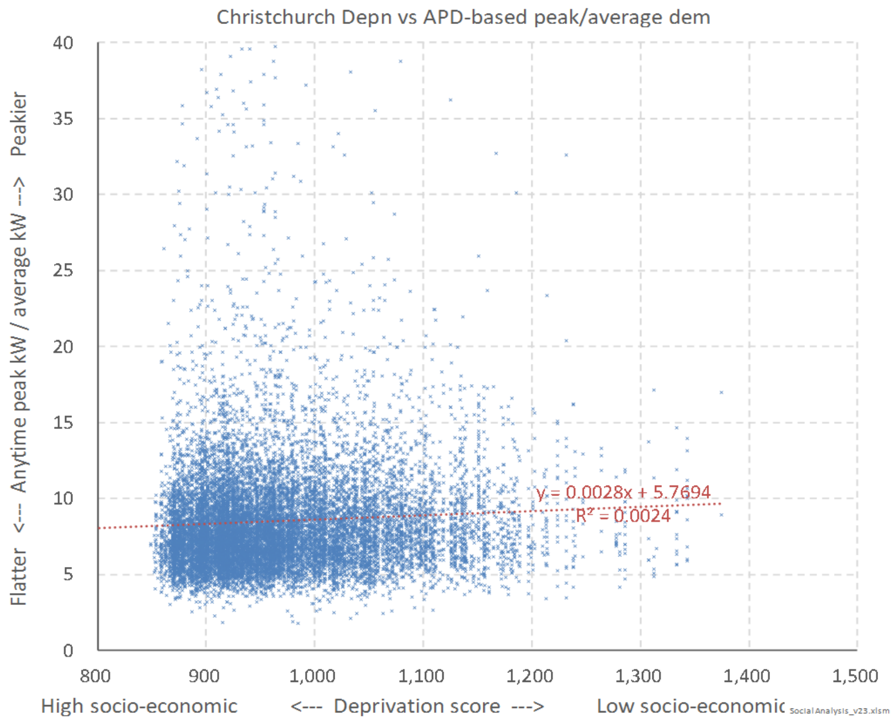
The next factor which will drive the nature and scale of altered tariff bill impact on a consumer is how 'peaky' their consumption is. In general, consumers whose demand profile is peakier than average will face higher bills from a move to a peakier tariff structure (i.e. one that recovers a greater amount of revenue from consumers' consumption at peak times), and vice versa for consumers whose demand profile is flatter than average.

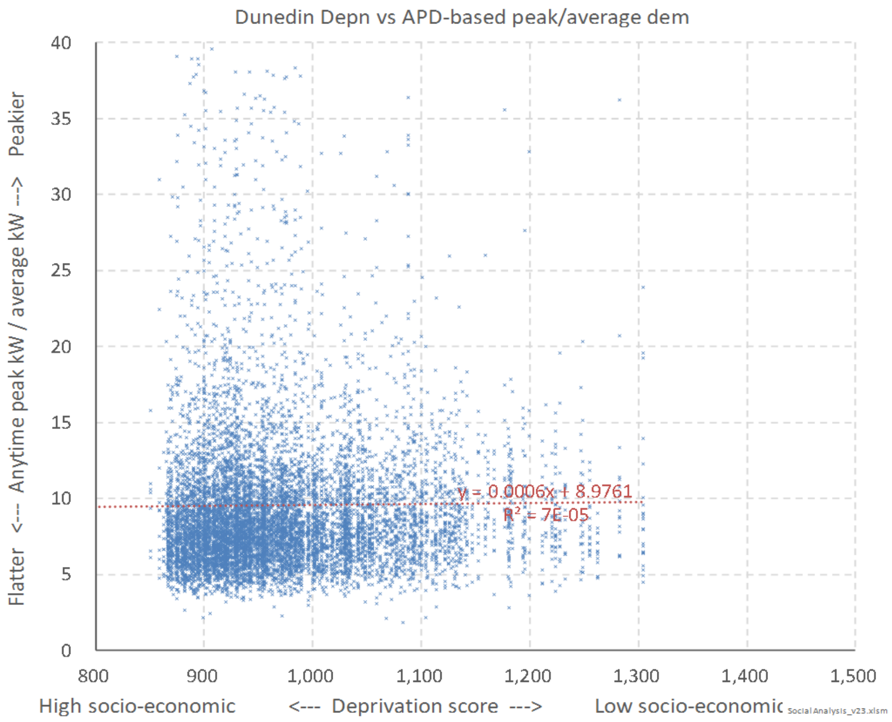
One measure of the peakiness of demand is the ratio of the customer's individual measured peak demand over the course of the year (known as Anytime Peak Demand, APD) versus their average level of demand. For example, a consumer who consumes 7,000 kWh during the year has an average demand of 7,000 kWh ÷ 8,760 hrs = 0.8 kW. If their measured APD was 7 kW, their ratio of APD/Avg demand would be 7 ÷ 0.8 = 8.75.

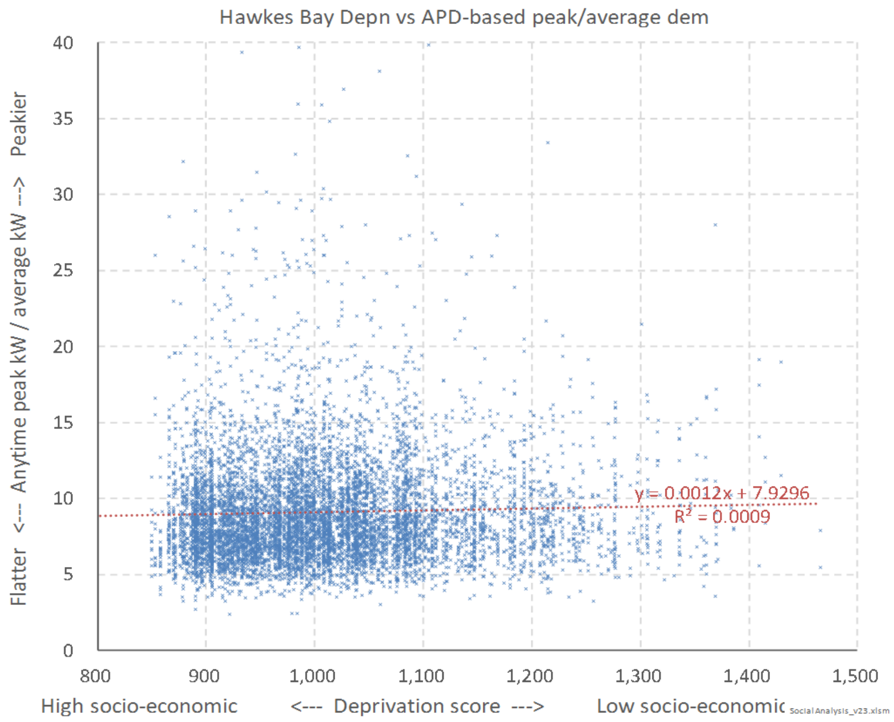
The following graphs demonstrate that, lower socio-economic consumers appear to be peakier on average. However, this relationship is not very strong, with a wide variation of peakiness across the different socio-economic segments.

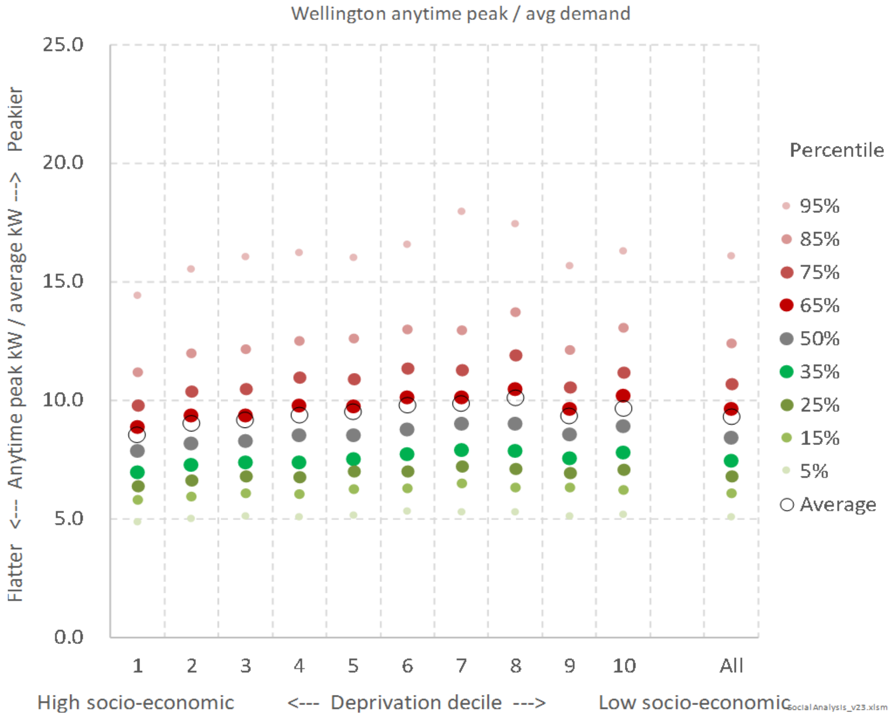


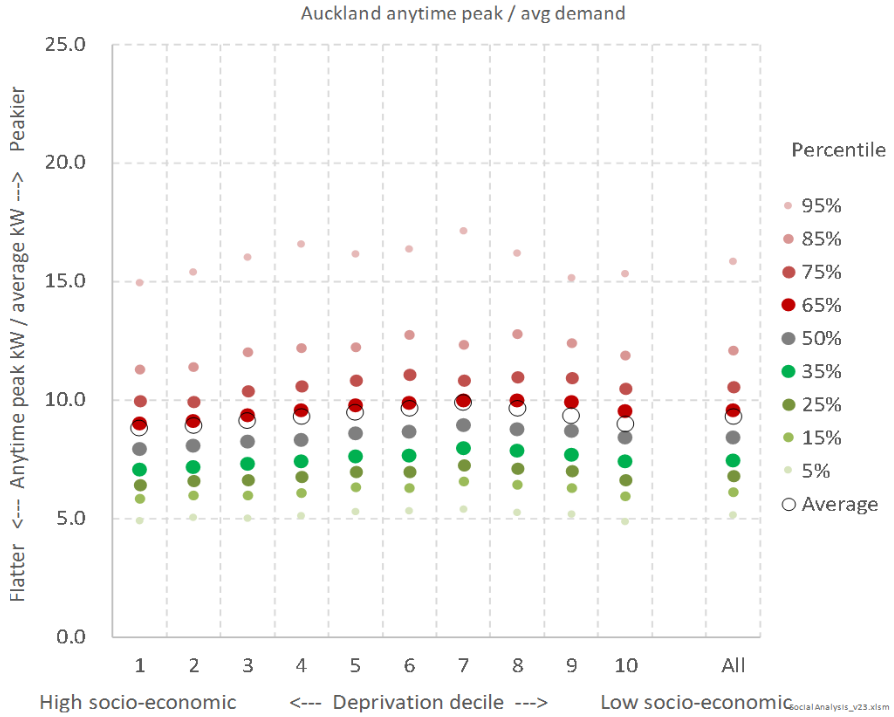

Auckland Depn vs APD-based peak/average dem
Flatter <--- Anytime peak kW / average kW ---> Peakier
y = 0.0017x + 7.6368
R² = 0.001
High socio-economic
<--- Deprivation score --->
Low socio-economic
Social Analysis_v23.xlsm

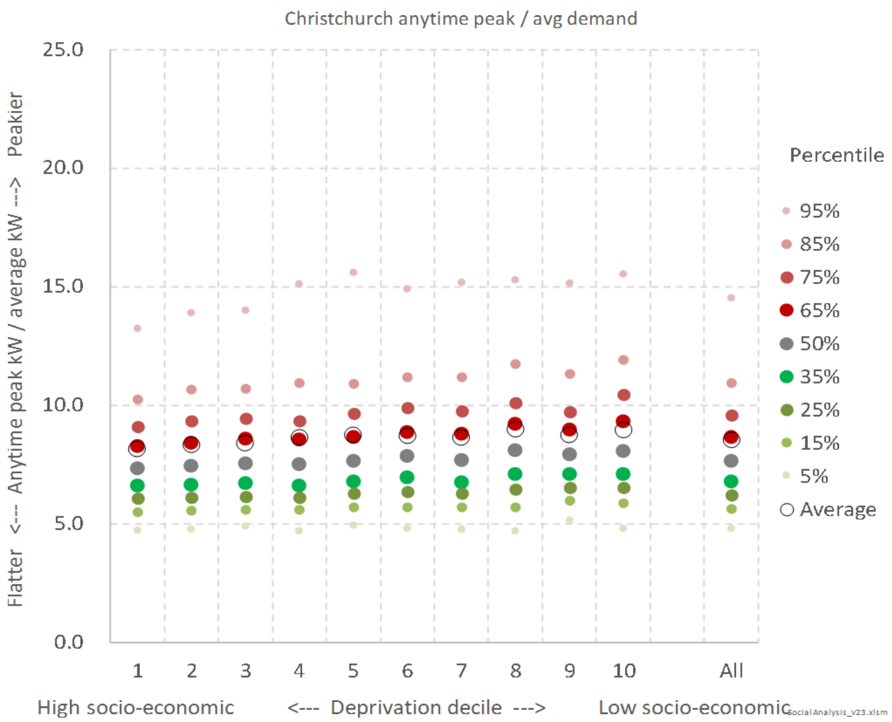

Christchurch Depn vs APD-based peak/average dem
Flatter <--- Anytime peak kW / average kW ---> Peakier
y = 0.0028x + 5.7694
R² = 0.0024
High socio-economic
<--- Deprivation score --->
Low socio-economic
Social Analysis_v23.xlsm

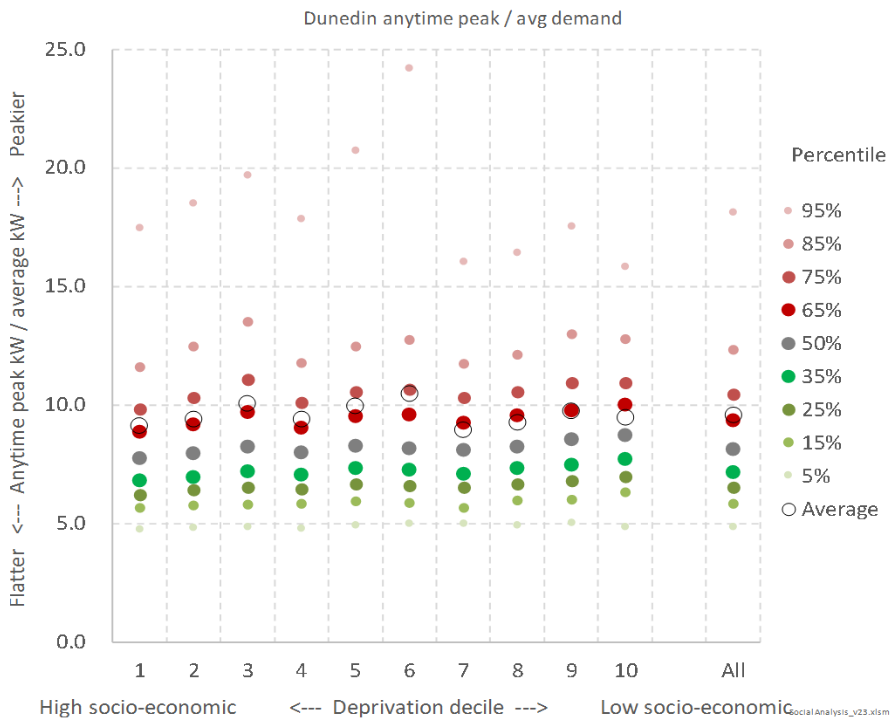

Dunedin Depn vs APD-based peak/average dem
Flatter <--- Anytime peak kW / average kW ---> Peakier
y = 0.0006x + 8.9761
R² = 7E-05
High socio-economic <--- Deprivation score ---> Low socio-economic

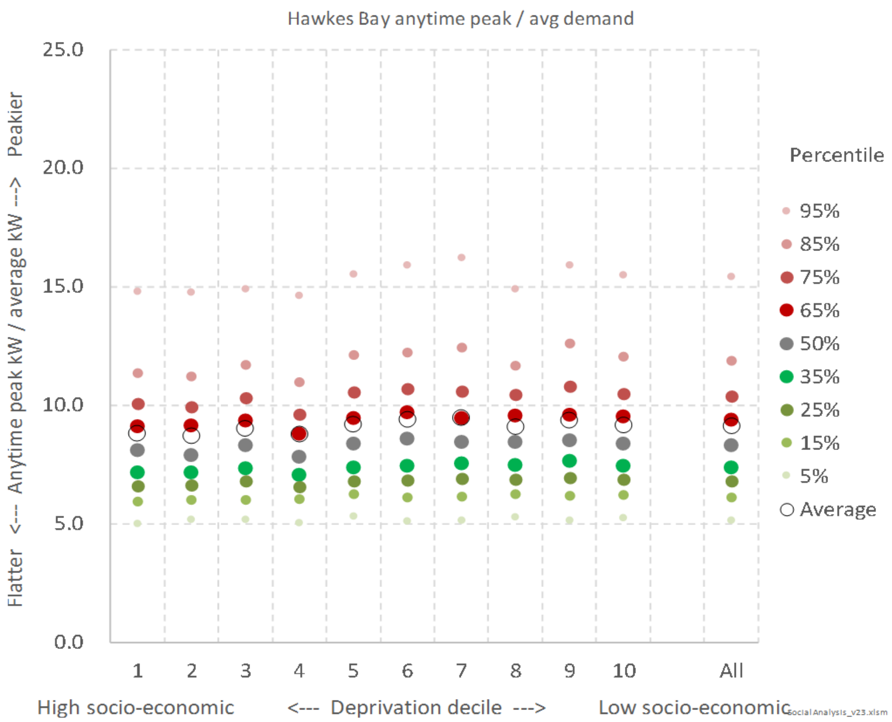

Hawkes Bay Depn vs APD-based peak/average dem
Flatter <--- Anytime peak kW / average kW ---> Peakier
y = 0.0012x + 7.9296
R² = 0.0009
High socio-economic <--- Deprivation score ---> Low socio-economic

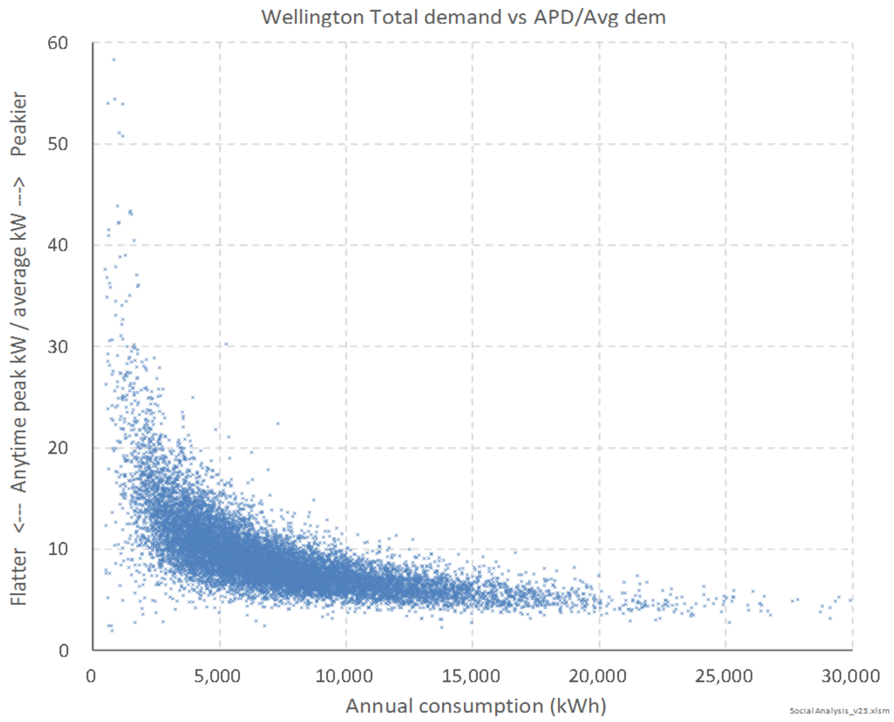

Wellington anytime peak / avg demand
25.0
20.0
15.0
10.0
5.0
0.0
Flatter <--- Anytime peak kW / average kW ---> Peakier
1 2 3 4 5 6 7 8 9 10 All
High socio-economic <--- Deprivation decile ---> Low socio-economic
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average


Auckland anytime peak / avg demand
25.0
20.0
15.0
10.0
5.0
0.0
Flatter <--- Anytime peak kW / average kW ---> Peakier
1 2 3 4 5 6 7 8 9 10 All
High socio-economic <--- Deprivation decile ---> Low socio-economic
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average


Christchurch anytime peak / avg demand
Flatter <--- Anytime peak kW / average kW ---> Peakier
25.0
20.0
15.0
10.0
5.0
0.0
1
2
3
4
5
6
7
8
9
10
All
High socio-economic
<--- Deprivation decile --->
Low socio-economic
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average

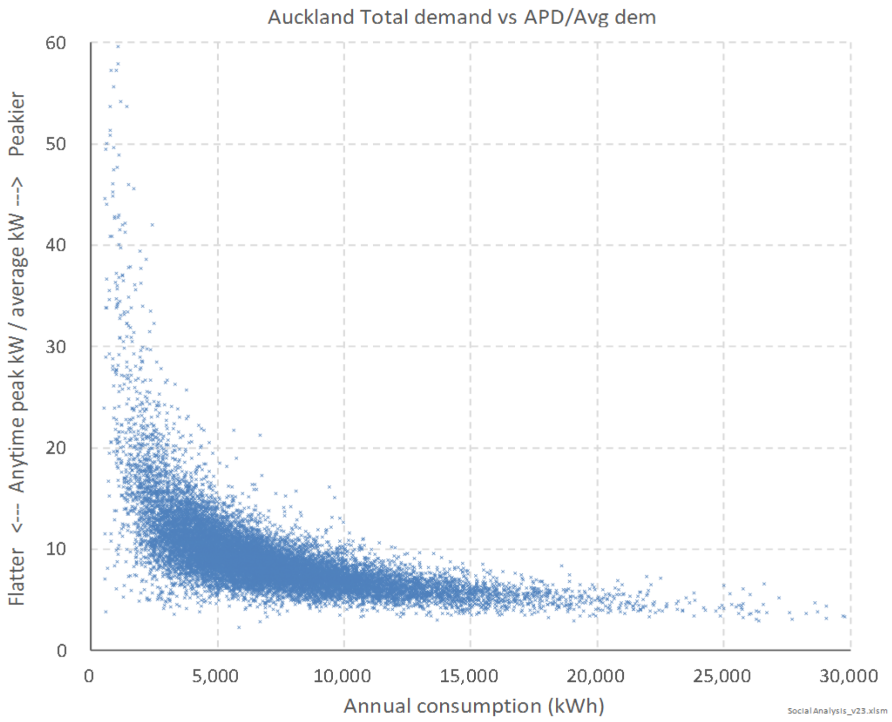

Dunedin anytime peak / avg demand
Flatter <--- Anytime peak kW / average kW ---> Peakier
25.0
20.0
15.0
10.0
5.0
0.0
1
2
3
4
5
6
7
8
9
10
All
High socio-economic
<--- Deprivation decile --->
Low socio-economic
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average

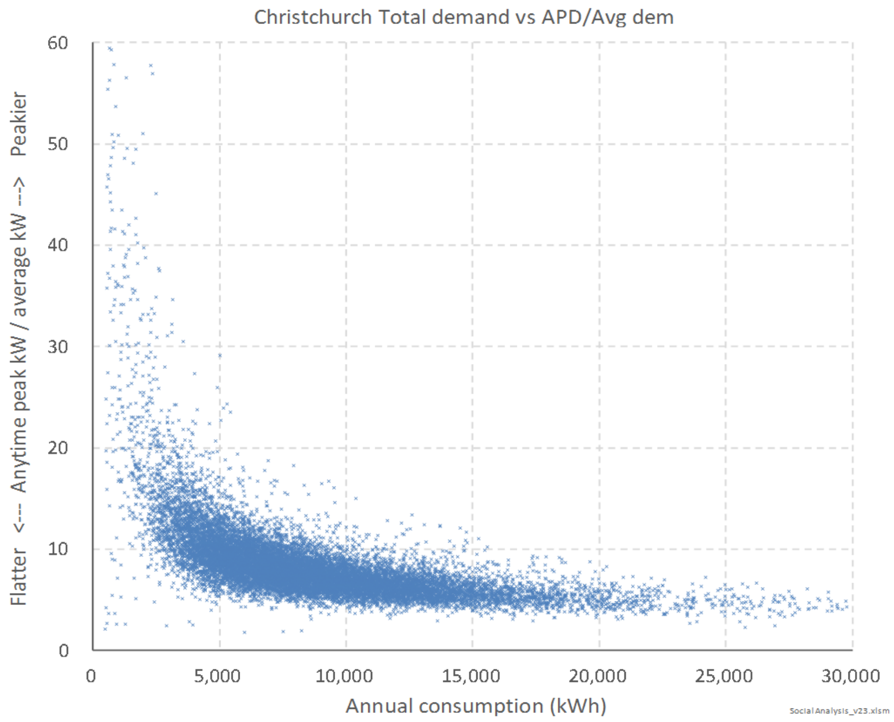


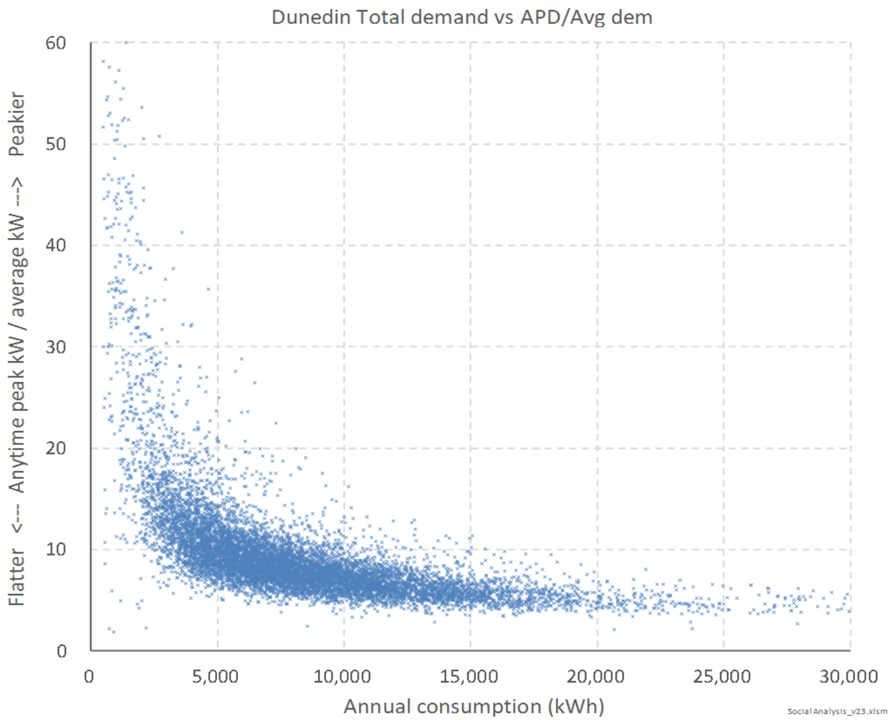


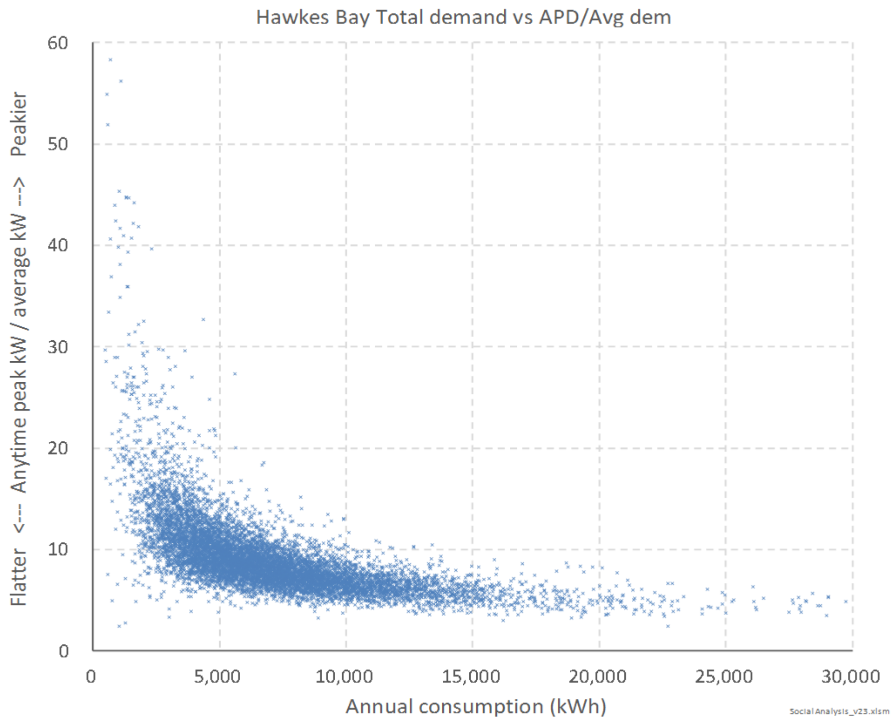
This observed relationship, such as it is, is likely to be more a function of low income consumers tending to have lower total demand. Or, put another way, it is hard for consumers who consume a lot of power (which tends to be higher socio-economic consumers) to also be peaky.

This is shown in the following graph of the correlation between consumers' total demand and their ratio of anytime peak to average demand.


Auckland Total demand vs APD/Avg dem
Flatter <--- Anytime peak kW / average kW ---> Peakier
0
10
20
30
40
50
60
0
5,000
10,000
15,000
20,000
25,000
30,000
Annual consumption (kWh)
Social Analysis_v23.xlsm


Christchurch Total demand vs APD/Avg dem
Flatter <--- Anytime peak kW / average kW ---> Peakier
0
10
20
30
40
50
60
0
5,000
10,000
15,000
20,000
25,000
30,000
Annual consumption (kWh)
Social Analysis_v23.xlsm





The key tariff implication of the above relationship between APD and socio-economic measure is that a move to a tariff structure which charges based on a measure of a consumer's *anytime* peak (e.g. APD or booked capacity pricing) will tend to result in relative increases for lower socio-economic consumers.

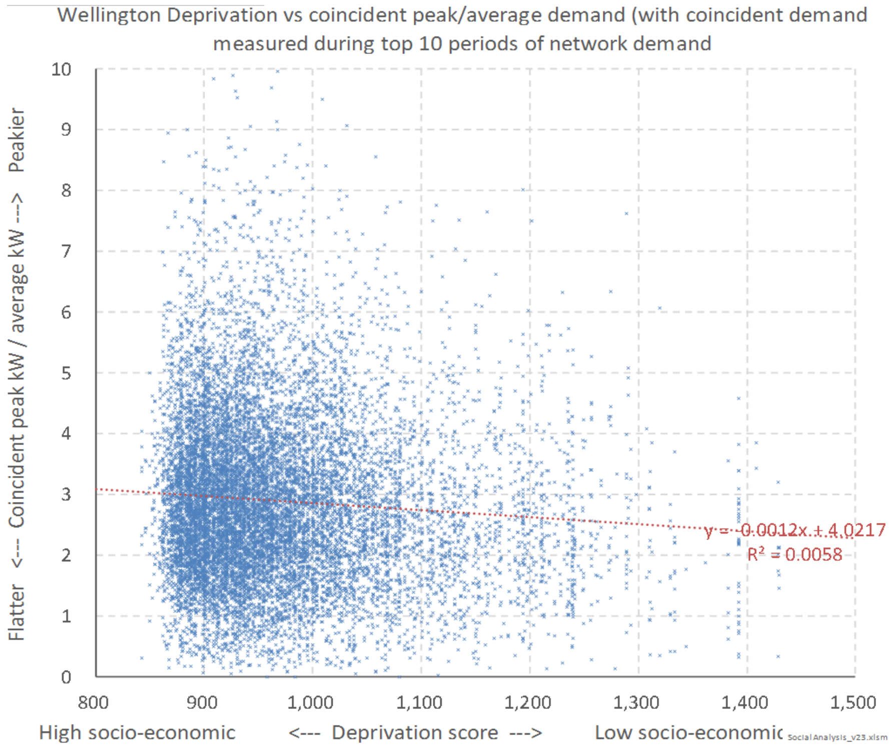
Relationship between deprivation and consumers' contribution to <u>network</u> peak demand

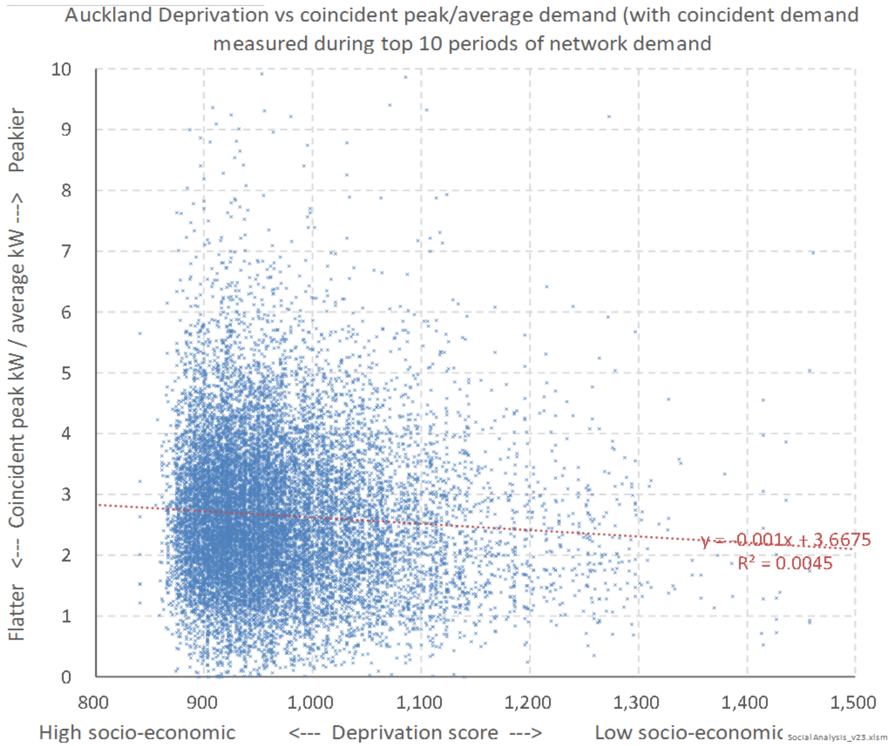
The arguably more appropriate measure of the peakiness of a consumer for charging purposes is to measure their demand during those periods when the *network* is experiencing peak demand. This 'coincident peak demand' (CPD) is a measure of the extent to which a consumer is contributing to the highest periods of system peak demand which are the biggest driver of network expenditure.

The following graphs show the peakiness of consumers as measured by the ratio of their coincident peak kW demand to their average kW demand (with coincident peak demand being their measured demand during the top 10 periods of network peak demand – as assessed by summing the half-hourly demand across the thousands of ICPs for each network)

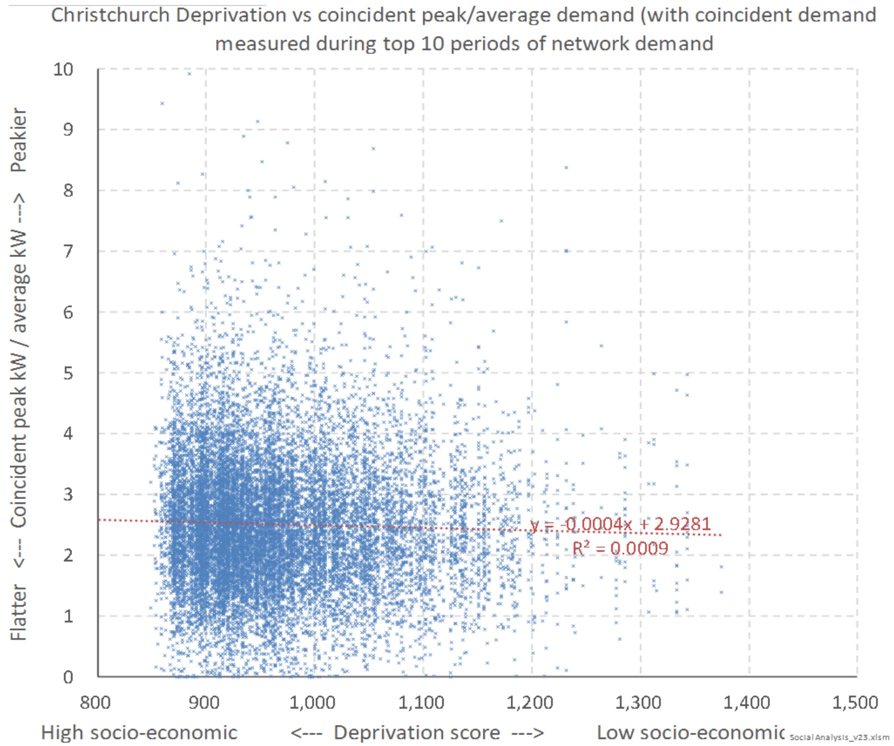
These graphs show that consumers in the lowest socio-economic decile tend to consume proportionately <u>less</u> of their power during system peak periods compared to other consumers. However:

- there appears to be variation between networks as to the extent of this correlation (with some networks exhibiting little correlation); and
- within each socio-demographic decile there is significant variation as to consumers' relative contribution to system peak

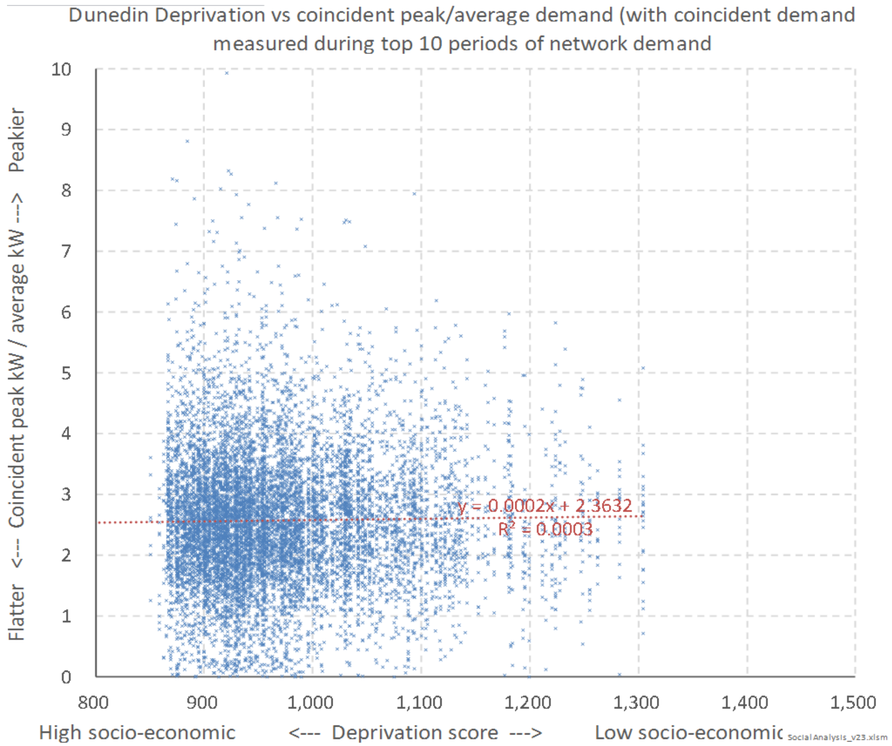




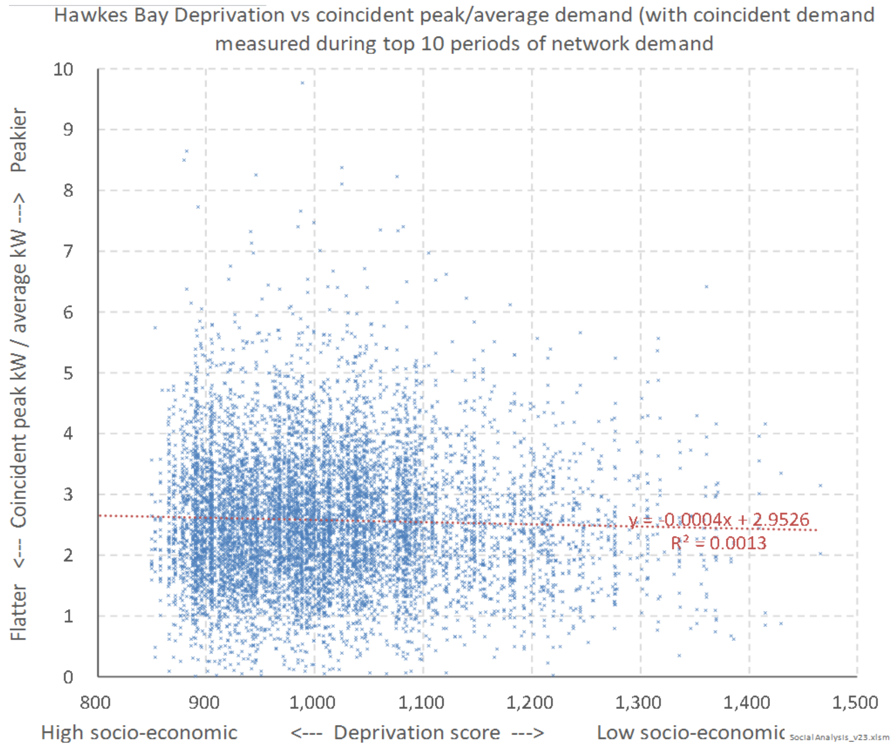
Auckland Deprivation vs coincident peak/average demand (with coincident demand measured during top 10 periods of network demand
Flatter <--- Coincident peak kW / average kW ---> Peakier
0
1
2
3
4
5
6
7
8
9
10
800
900
1,000
1,100
1,200
1,300
1,400
1,500
High socio-economic
<--- Deprivation score --->
Low socio-economic
y = -0.001x + 3.6675
R² = 0.0045



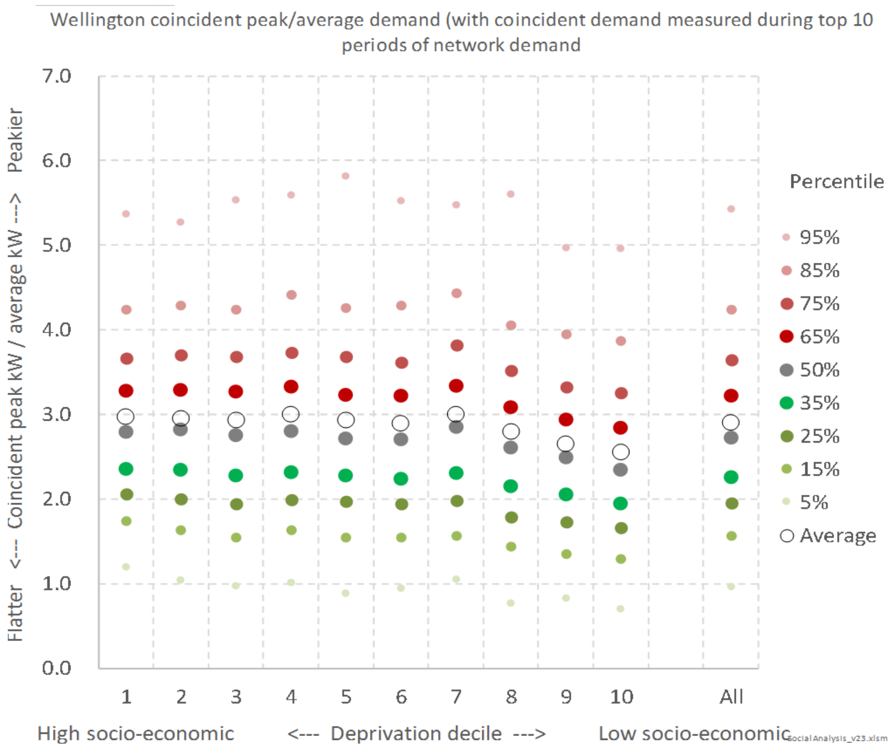
Christchurch Deprivation vs coincident peak/average demand (with coincident demand measured during top 10 periods of network demand
Flatter <--- Coincident peak kW / average kW ---> Peakier
0
1
2
3
4
5
6
7
8
9
10
800
900
1,000
1,100
1,200
1,300
1,400
1,500
High socio-economic
<--- Deprivation score --->
Low socio-economic
y = -0.0004x + 2.9281
R² = 0.0009



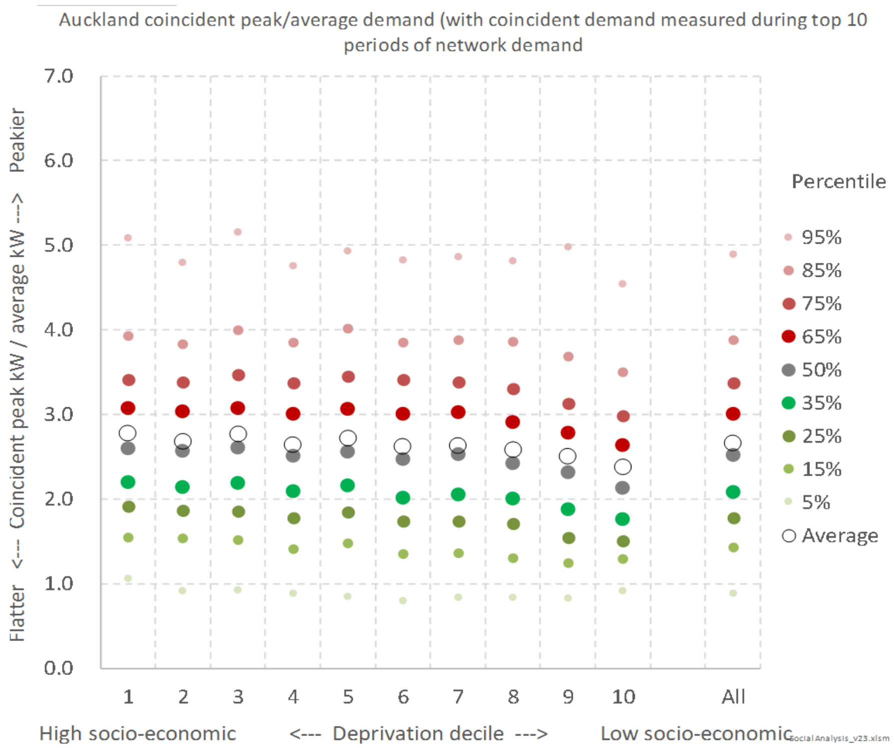
Dunedin Deprivation vs coincident peak/average demand (with coincident demand measured during top 10 periods of network demand
Flatter <--- Coincident peak kW / average kW ---> Peakier
10
9
8
7
6
5
4
3
2
1
0
800
900
1,000
1,100
1,200
1,300
1,400
1,500
High socio-economic <--- Deprivation score ---> Low socio-economic
y = 0.0002x + 2.3632
R^2 = 0.0003



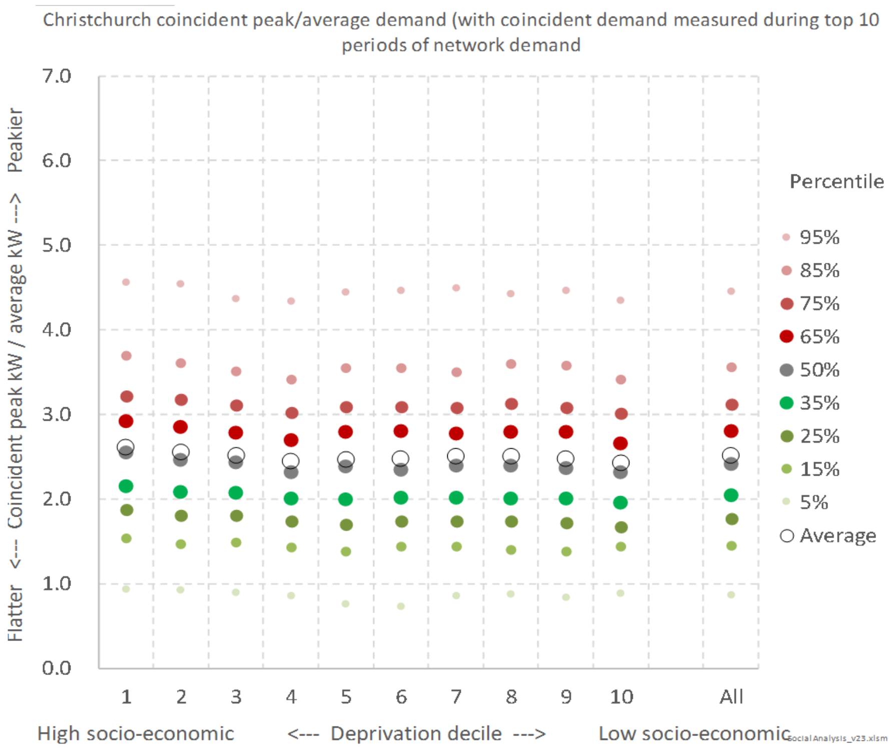
Hawkes Bay Deprivation vs coincident peak/average demand (with coincident demand measured during top 10 periods of network demand
Flatter <--- Coincident peak kW / average kW ---> Peakier
10
9
8
7
6
5
4
3
2
1
0
800
900
1,000
1,100
1,200
1,300
1,400
1,500
High socio-economic <--- Deprivation score ---> Low socio-economic
y = -0.0004x + 2.9526
R^2 = 0.0013



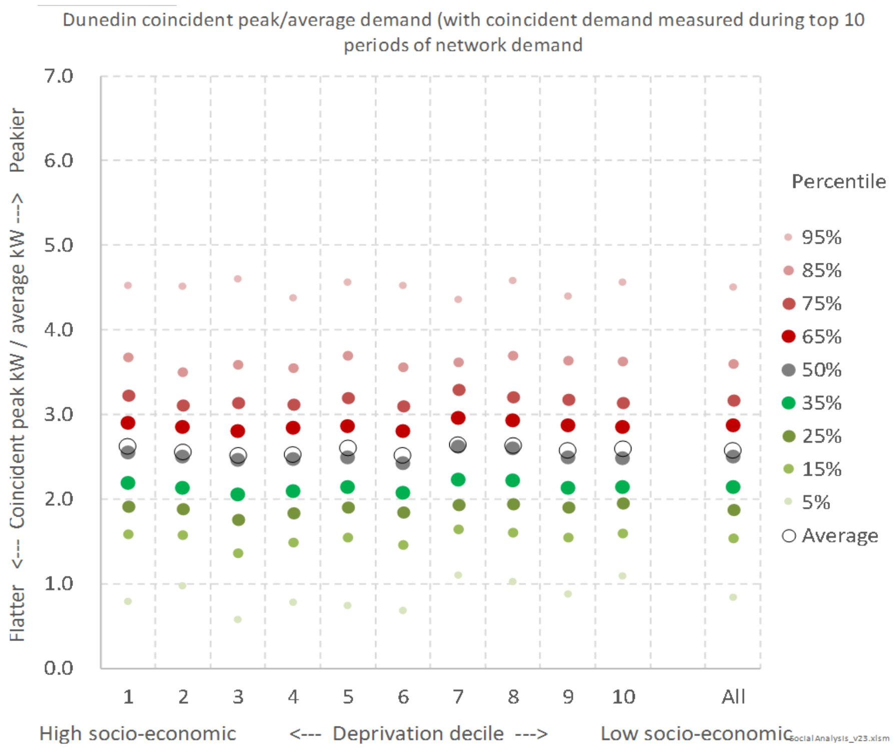
Wellington coincident peak/average demand (with coincident demand measured during top 10 periods of network demand
Flatter <--- Coincident peak kW / average kW ---> Peakier
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1
2
3
4
5
6
7
8
9
10
All
High socio-economic
<--- Deprivation decile --->
Low socio-economic
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average



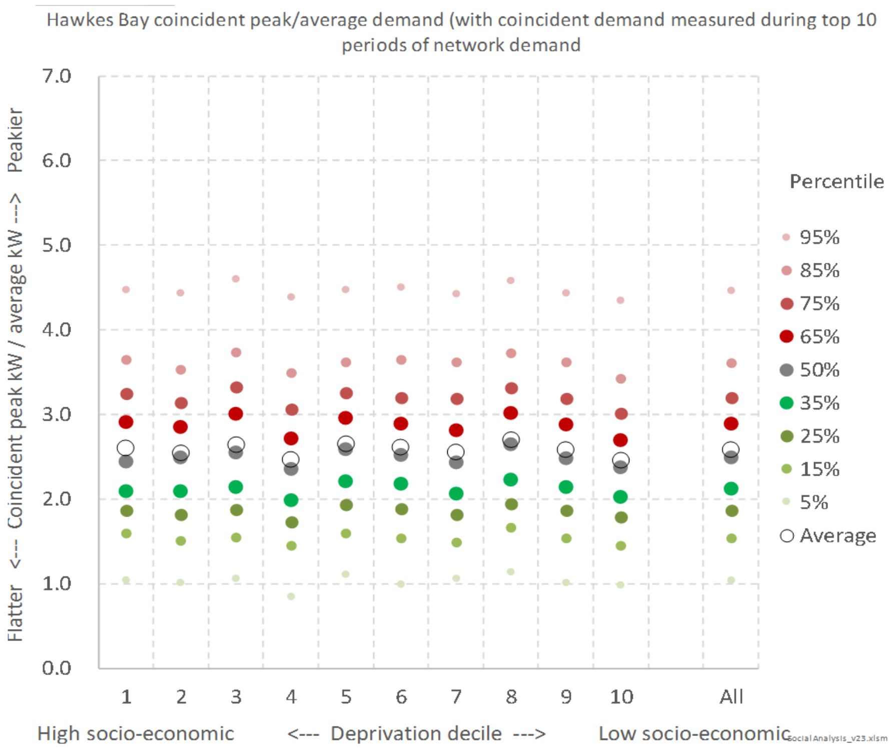
Auckland coincident peak/average demand (with coincident demand measured during top 10 periods of network demand
Flatter <--- Coincident peak kW / average kW ---> Peakier
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1
2
3
4
5
6
7
8
9
10
All
High socio-economic
<--- Deprivation decile --->
Low socio-economic
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average



Christchurch coincident peak/average demand (with coincident demand measured during top 10 periods of network demand
Flatter <--- Coincident peak kW / average kW ---> Peakier
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1
2
3
4
5
6
7
8
9
10
All
High socio-economic
<--- Deprivation decile --->
Low socio-economic
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average



Dunedin coincident peak/average demand (with coincident demand measured during top 10 periods of network demand
Flatter <--- Coincident peak kW / average kW ---> Peakier
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1
2
3
4
5
6
7
8
9
10
All
High socio-economic
<--- Deprivation decile --->
Low socio-economic
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average



This relationship (such as it exists) between social deprivation and customers' contribution to system peak demand may be a function of consumers in the lowest deciles being more likely to follow different daily patterns to average. For example, they may be more likely to work at different times (e.g. early morning / late-night shift work), and they are more likely to be unemployed.

The key tariff implication of this relationship, is that tariff structures which are based on coincident peak demand could generally result in lower bills for consumers in the lowest deciles, and vice versa for flat tariff structures.

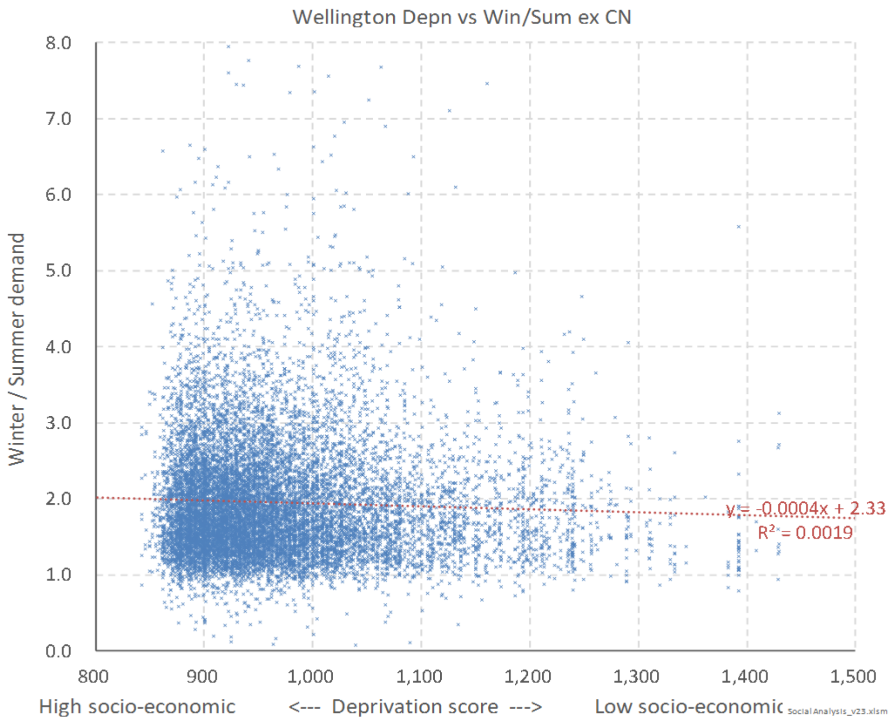
Relationship between deprivation and summer/winter consumption patterns

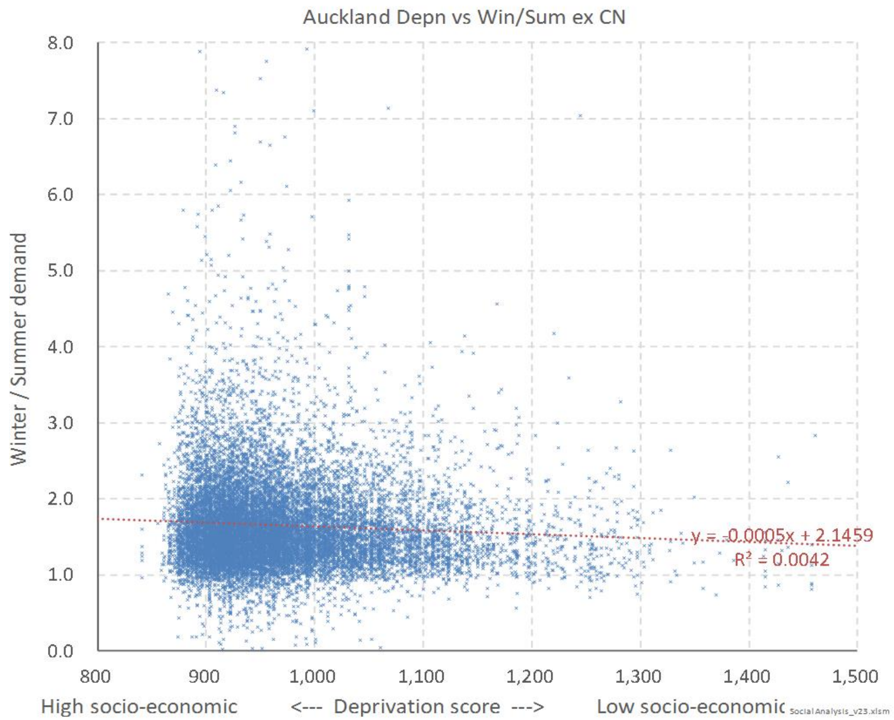
The last measure of pattern of consumption which is relevant to consider is the ratio between summer and winter demand. This is indicative of whether consumers use electricity to heat their home.

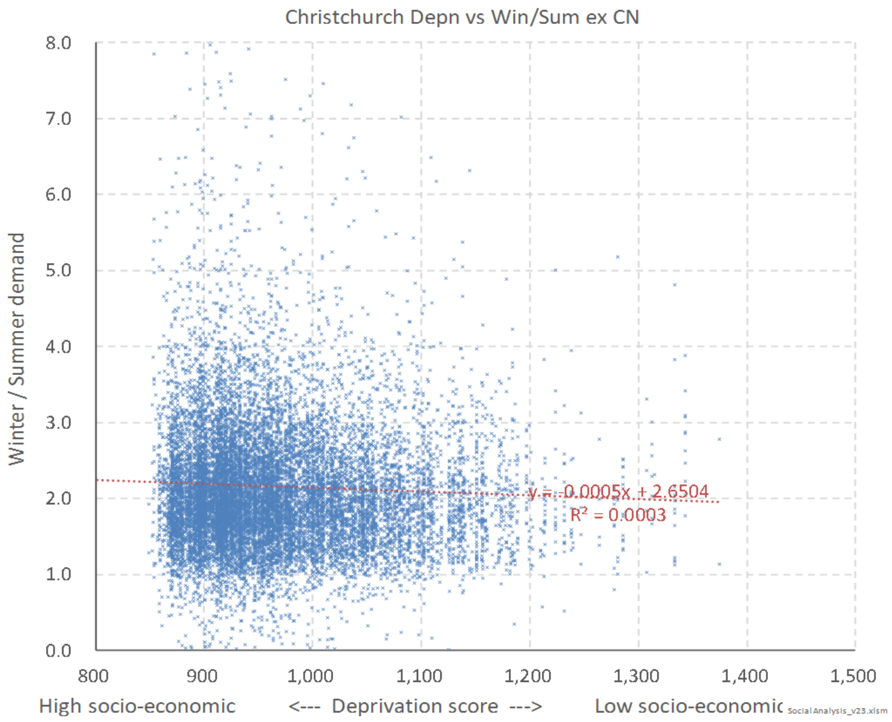
The measure that was chosen to reflect this was the ratio of total consumption for the four months classed as 'winter' (Jun-Sep) compared with total consumption for the four months classed as 'summer' (Dec-Mar).

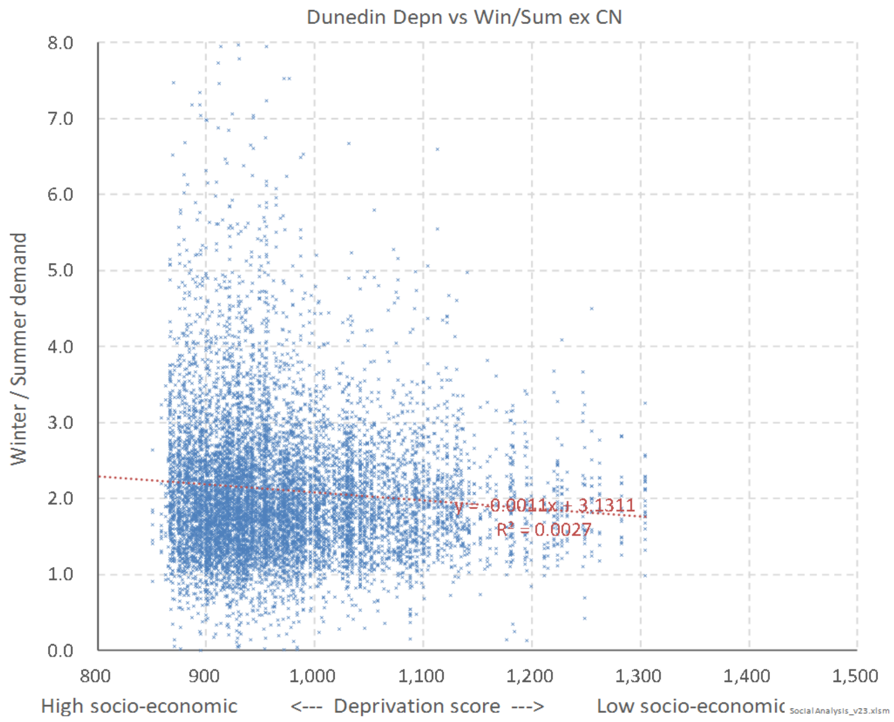
As is shown in the following graphs, on average residential consumers consume twice as much in winter months as they do in summer months. However, there is considerable variation between consumers with some consuming three to four times more in winter than in summer, whereas others only consuming a little bit more in winter than in summer.

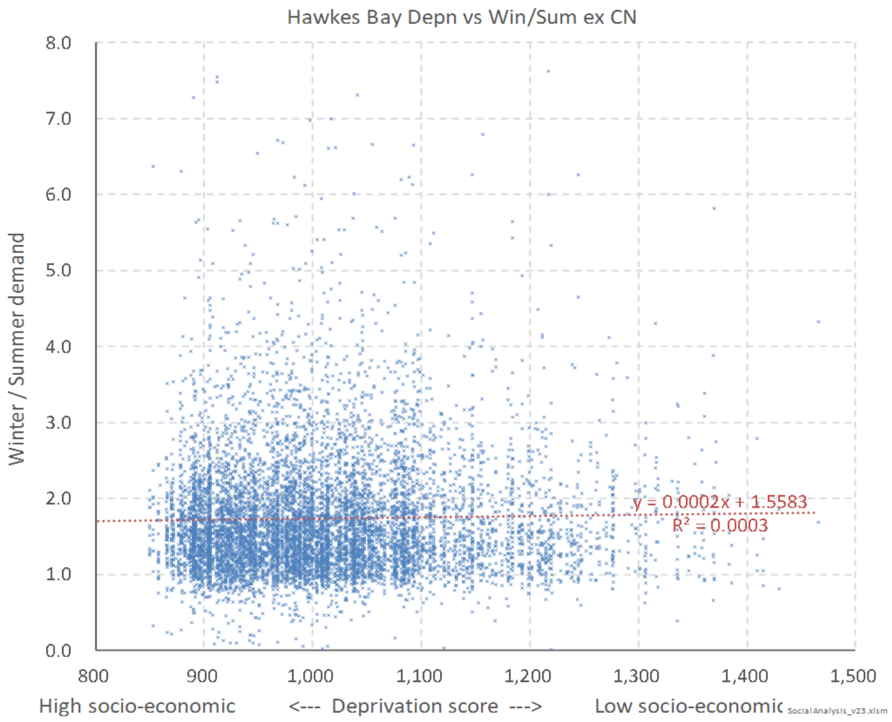
With regards to any correlation with deprivation, it appears there is no strong correlation – although possibly those in the lowest decile have a slightly lower winter/summer ratio.

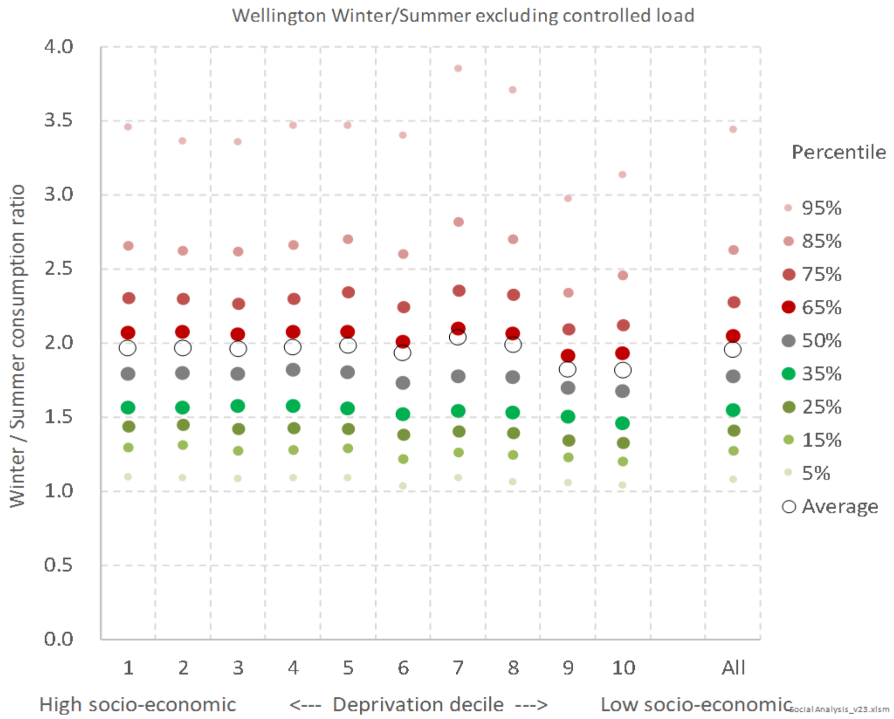

Wellington Depn vs Win/Sum ex CN
Winter / Summer demand
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
800
900
1,000
1,100
1,200
1,300
1,400
1,500
High socio-economic
<--- Deprivation score --->
Low socio-economic
y = -0.0004x + 2.33
R² = 0.0019

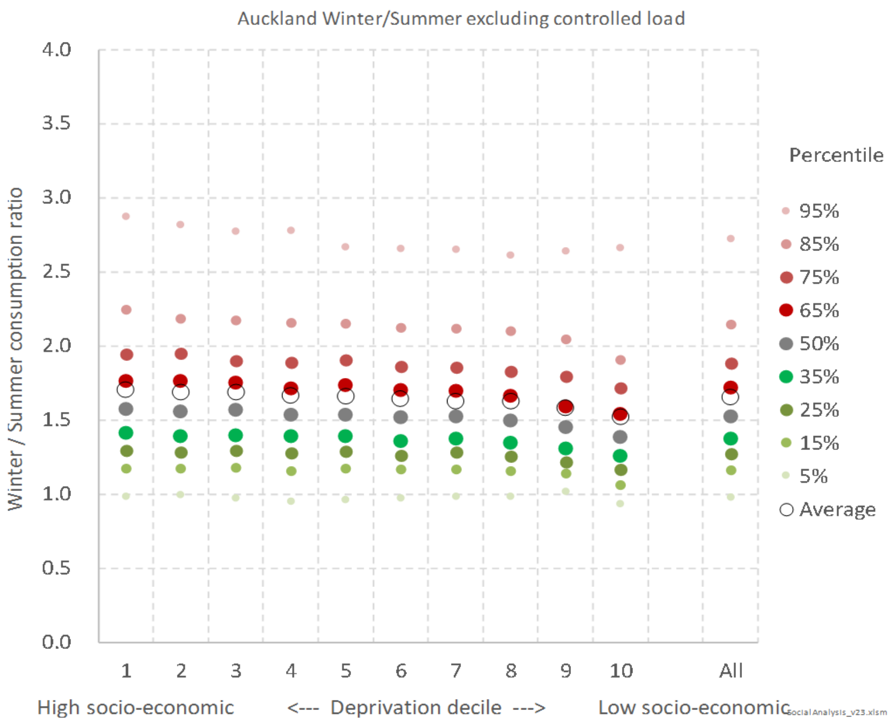

Auckland Depn vs Win/Sum ex CN
Winter / Summer demand
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
800
900
1,000
1,100
1,200
1,300
1,400
1,500
High socio-economic
<--- Deprivation score --->
Low socio-economic
y = -0.0005x + 2.1459
R² = 0.0042


Christchurch Depn vs Win/Sum ex CN
Winter / Summer demand
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
800
900
1,000
1,100
1,200
1,300
1,400
1,500
High socio-economic
<--- Deprivation score --->
Low socio-economic
y = -0.0005x + 2.6504
R² = 0.0003
Social Analysis_v23.xlsm

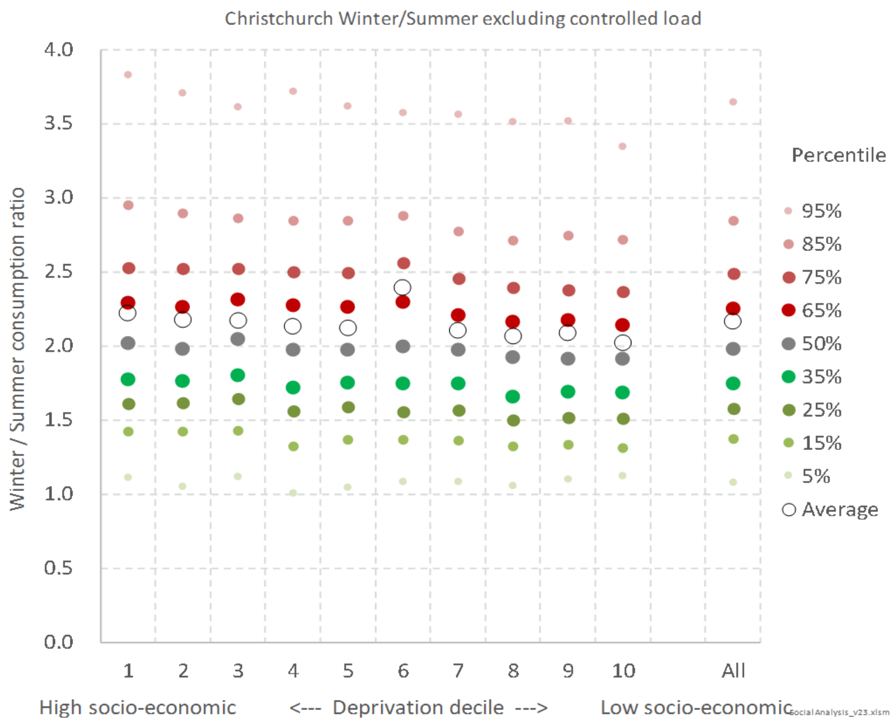

Dunedin Depn vs Win/Sum ex CN
Winter / Summer demand
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
800
900
1,000
1,100
1,200
1,300
1,400
1,500
High socio-economic
<--- Deprivation score --->
Low socio-economic
y = -0.0011x + 3.1311
R² = 0.0027
Social Analysis_v23.xlsm


Hawkes Bay Depn vs Win/Sum ex CN
Winter / Summer demand
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
800
900
1,000
1,100
1,200
1,300
1,400
1,500
y = 0.0002x + 1.5583
R² = 0.0003
High socio-economic
<--- Deprivation score --->
Low socio-economic

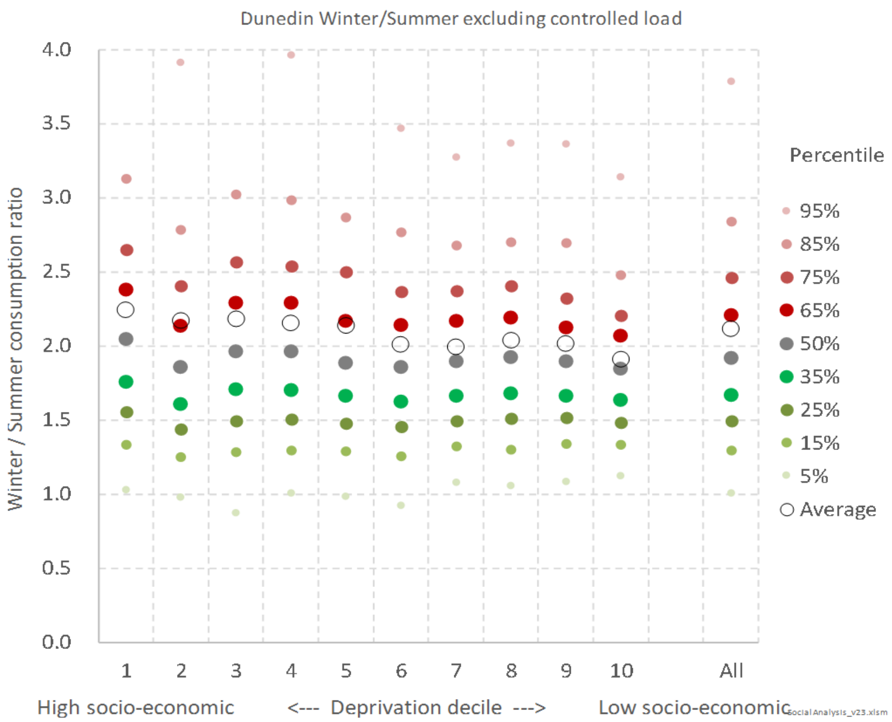

Wellington Winter/Summer excluding controlled load
Winter / Summer consumption ratio
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1
2
3
4
5
6
7
8
9
10
All
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average
High socio-economic
<--- Deprivation decile --->
Low socio-economic

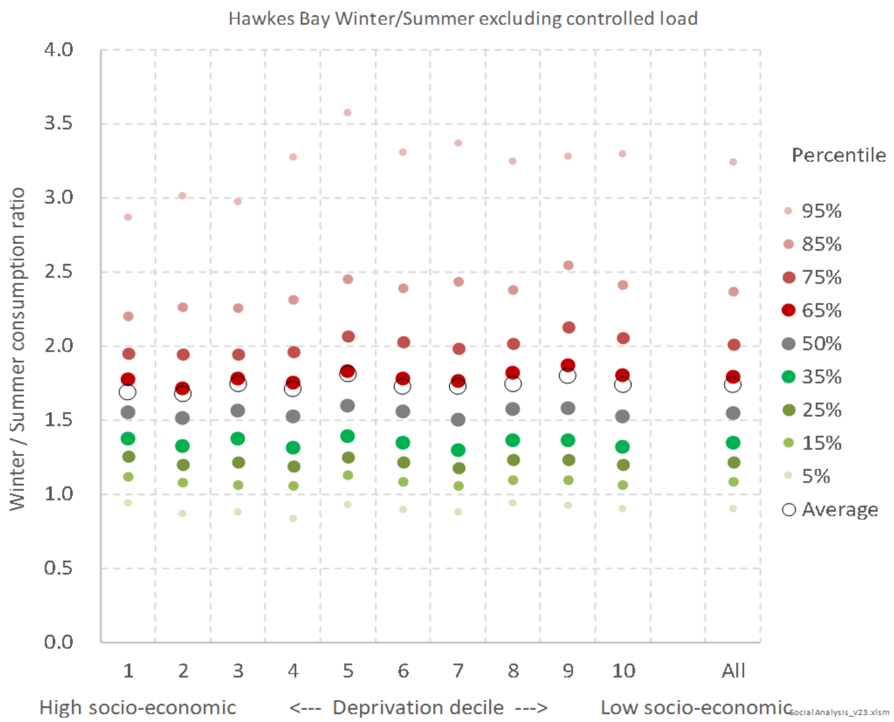


Auckland Winter/Summer excluding controlled load
Winter / Summer consumption ratio
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1 2 3 4 5 6 7 8 9 10 All
High socio-economic <--- Deprivation decile ---> Low socio-economic
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average



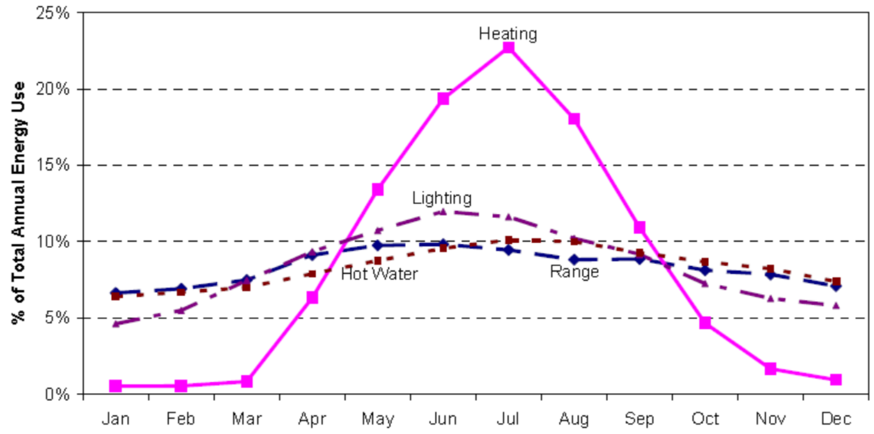
Christchurch Winter/Summer excluding controlled load
Winter / Summer consumption ratio
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1 2 3 4 5 6 7 8 9 10 All
High socio-economic <--- Deprivation decile ---> Low socio-economic
Percentile
95%
85%
75%
65%
50%
35%
25%
15%
5%
Average





This variation between consumers is likely indicative of different types of fuel used for heating, with those households with electric space heating (rather than gas or wood) having the largest variation between winter and summer. Likewise, those with electric water heating (rather than gas or solar) will also have higher winter electricity consumption, given analysis in the HEEP study (show in Figure 37 below) which showed higher winter consumption of hot water – although not to the same extent as space heating.

Figure 37: HEEP analysis of within-year demand for residential energy

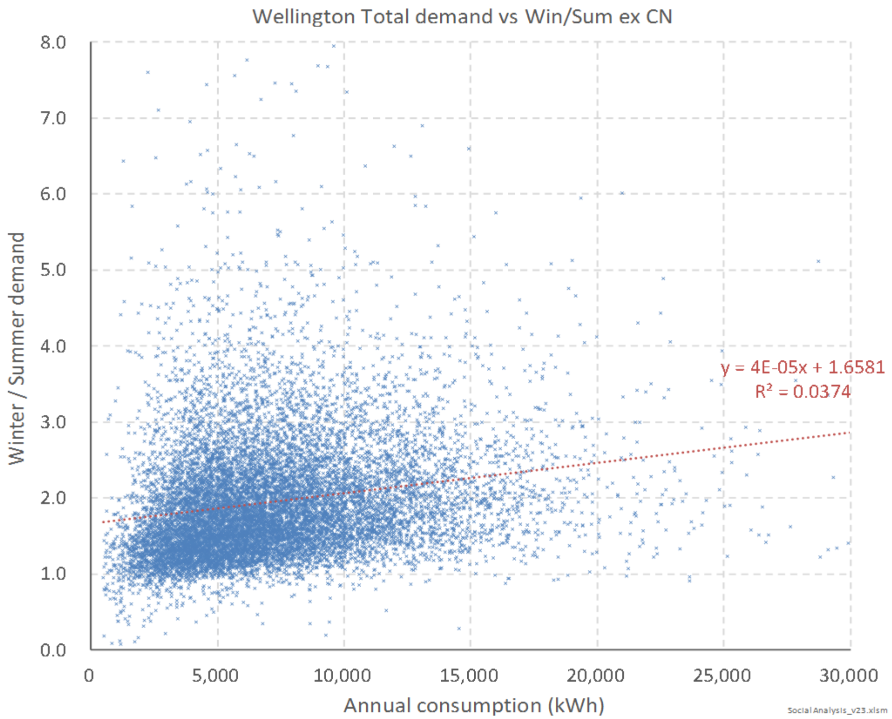


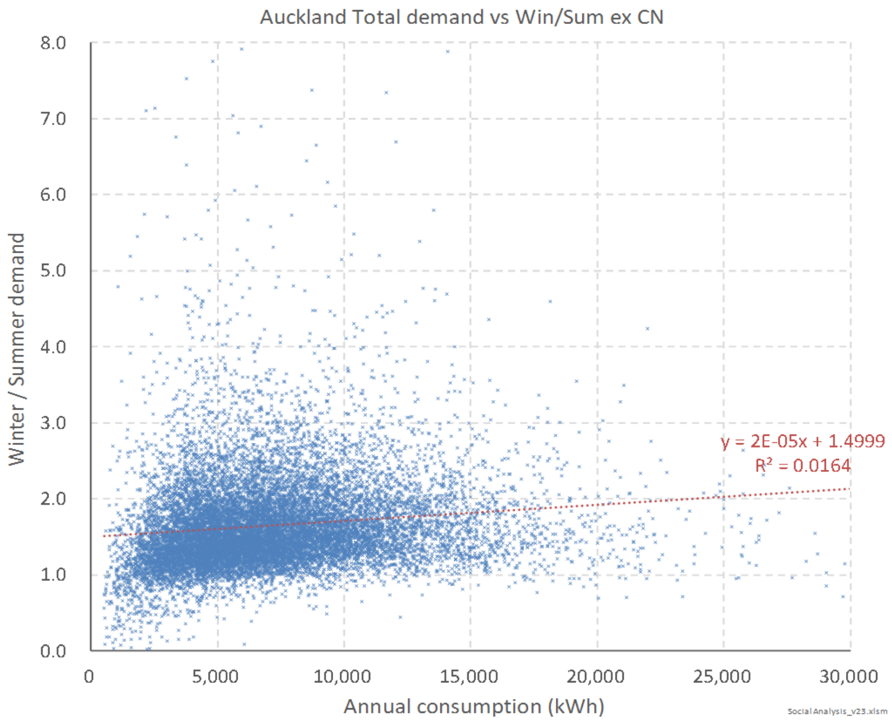
Source: "Household Energy End-use Project (HEEP) Year 10 report", BRANZ, 2006

The efficiency of appliances will also have a bearing on the seasonal variation in demand. Consumers with heat pump heaters will have lower winter consumption than those with resistance electric heaters to deliver the same level of heating. Likewise, having efficient lights will reduce the extent of lighting-related increases in winter consumption.

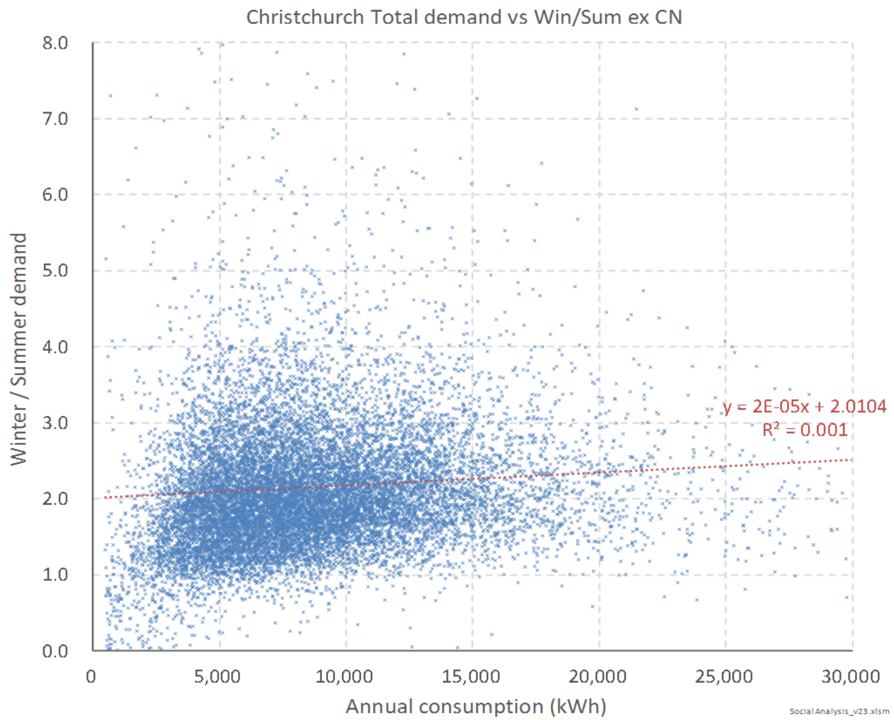
As previously mentioned, there is no strong correlation between winter/summer demand ratios and social deprivation, although those in the lowest deciles appear to have a slightly lower winter/summer ratio.

It is not clear why this is. It may be because, in general, larger consumers have a higher winter/summer ratio as shown below. Thus, given that wealthier consumers tend to live in larger homes, their heating requirements as a proportion of their overall energy requirements may be larger.

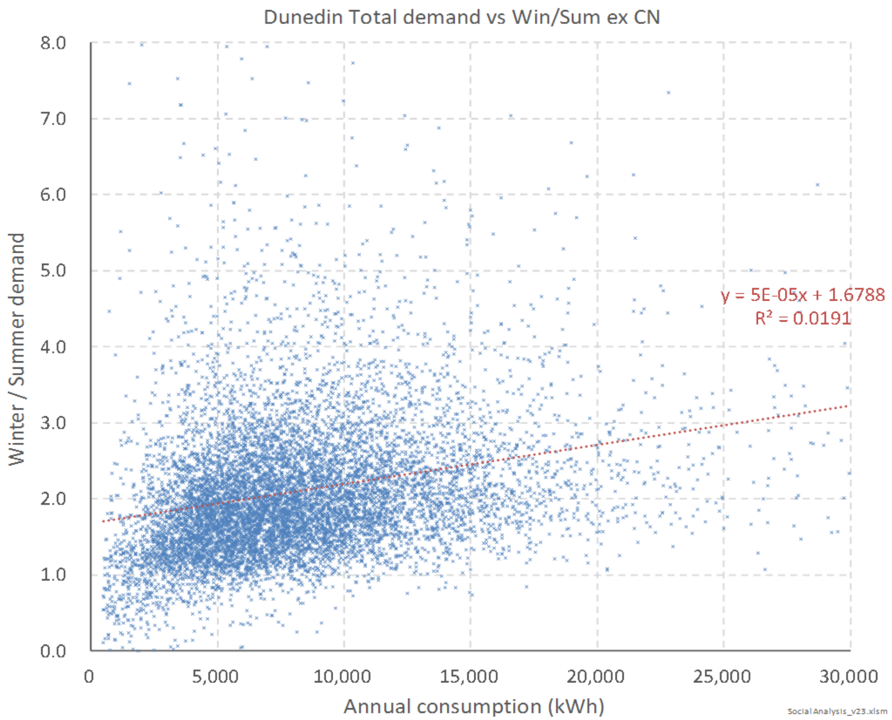


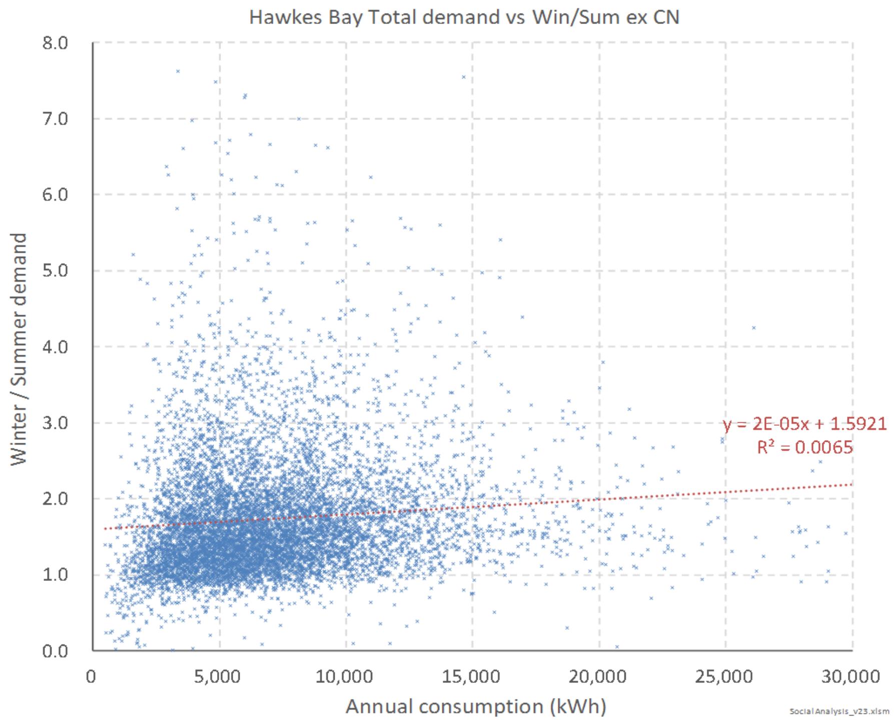


Auckland Total demand vs Win/Sum ex CN
Winter / Summer demand
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
5,000
10,000
15,000
20,000
25,000
30,000
Annual consumption (kWh)
y = 2E-05x + 1.4999
R² = 0.0164
Social Analysis_v23.xlsm



Christchurch Total demand vs Win/Sum ex CN
Winter / Summer demand
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
5,000
10,000
15,000
20,000
25,000
30,000
Annual consumption (kWh)
y = 2E-05x + 2.0104
R² = 0.001
Social Analysis_v23.xlsm



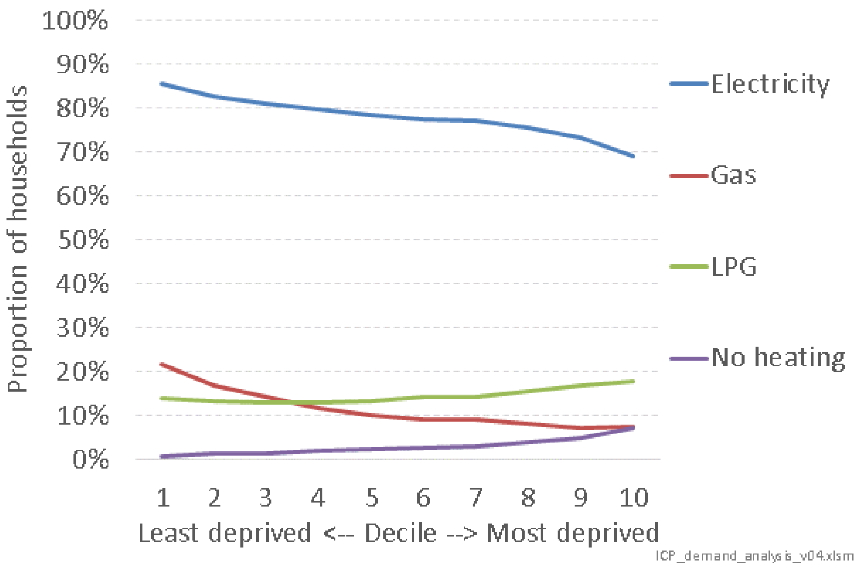


There may also be an income effect driving the relationship between winter/summer ratios and socio-economic decile. Thus, it is known that consumers in the lowest deciles tend to under-heat their homes as they are unable to afford

- the fuel bills and/or
- the capital cost of a high efficiency appliance or insulation measure.

This is illustrated in Figure 38 below which shows that the proportion of households in the most deprived decile that were reported as having no space heating was nine-times greater than those in the most affluent decile.

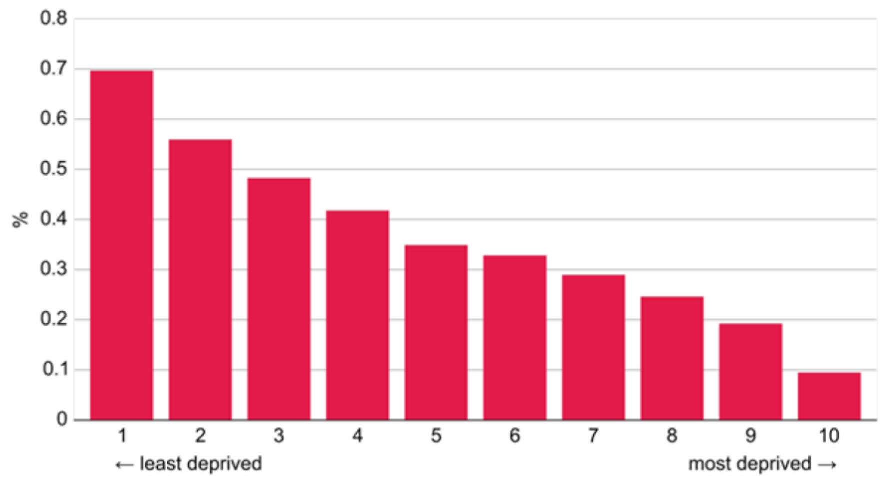
Figure 38: 2013 Census reported proportion of households with different types of heating



Relationship between deprivation and propensity to respond to altered prices

Analysis published by the Electricity Authority, and repeated in Figure 39 below, shows that the least deprived (decile 1) consumers are approximately ten times more likely to install solar panels than the most deprived (decile 10) consumers.

Figure 39: Uptake of solar panels by deprivation index



Source: Electricity Authority

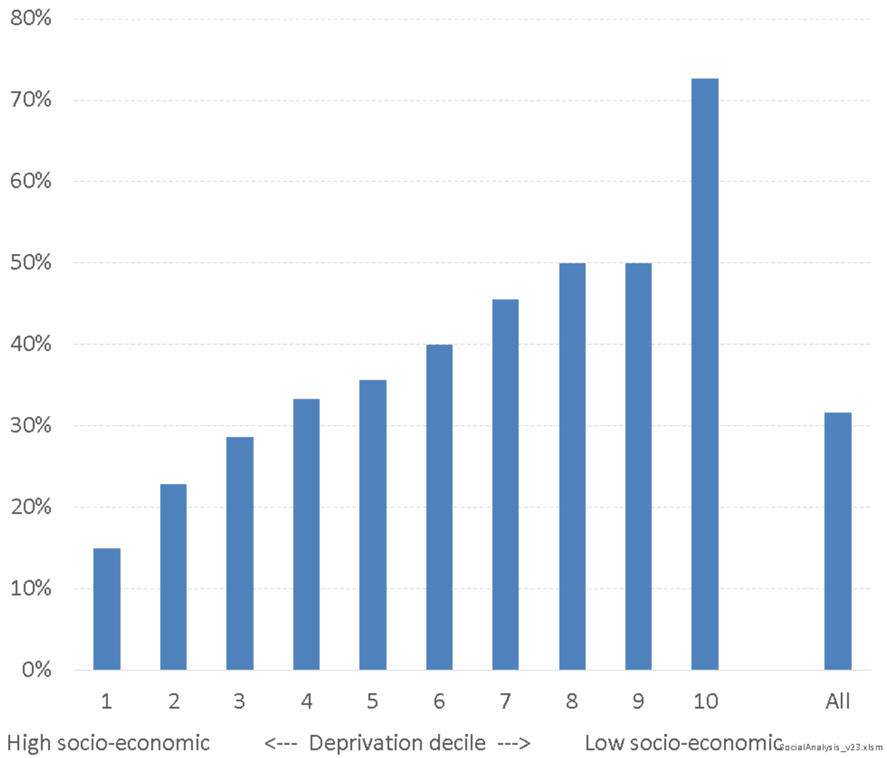
This is not just because the most affluent consumers are better able to afford the initial capital outlay for solar PV.

Just as, if not more, importantly it is because the most deprived consumers are much more likely to live in rented accommodation– noting that the installation of energy technologies with high upfront cost in rental properties suffer significant ‘tenant / landlord’ barriers.

This is borne out by experience in Australia which shows there is a significant correlation between solar uptake and home ownership.

This linkage between deprivation and renting is shown in Figure 40 below

Figure 40 – Relationship between deprivation and likelihood of living in rental accommodation - Wellington



Thus, 73% of Wellington households in decile 10 meshblocks reported as living in rental accommodation, compared to only 16% for decile 1 and the average for the whole of Wellington of 36%.

These results for Wellington are typical for the rest of the country – noting that the national average for the proportion of renters is approximately 35% (up from approximately 30% ten years earlier).

This results of the propensity of low-income consumers to take up solar PV are also likely to extend to other energy technologies which:

- Have a capital premium; and/or
- Which are required to be installed in a property. As well as insulation and efficient heating systems, this aspect of being 'installed' in a property extends to a significant degree to efficient lighting, and much whiteware (e.g. 'smart' fridges, dishwashers, and the like.)

Appendix D. Modelling results for all networks

Change in power bills from 50% solar uptake with existing price structures

Figure 41: Wellington

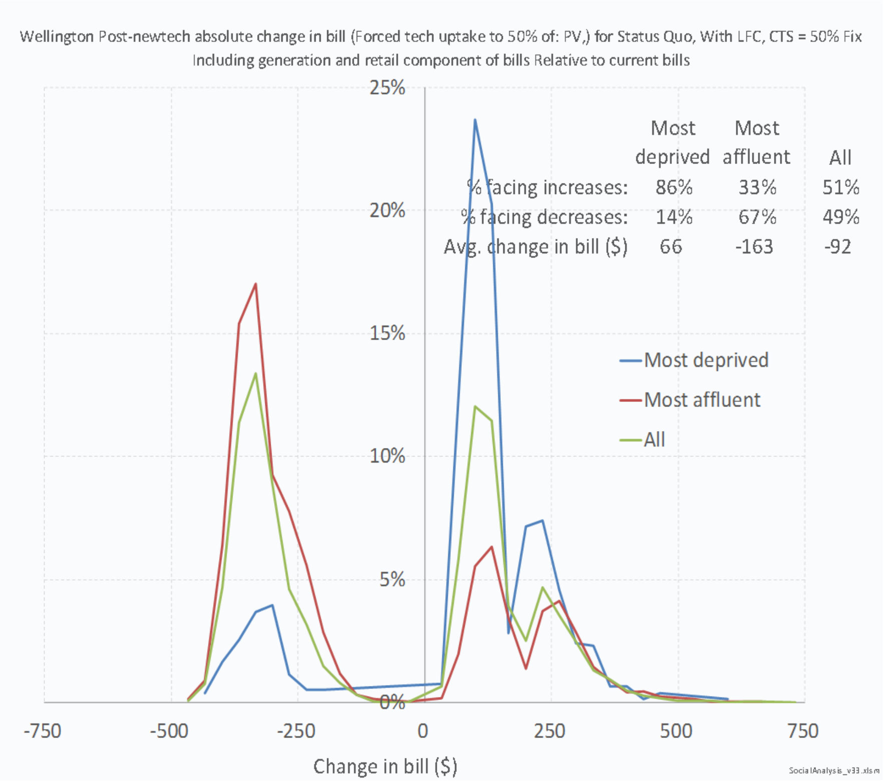


Figure 42: Auckland

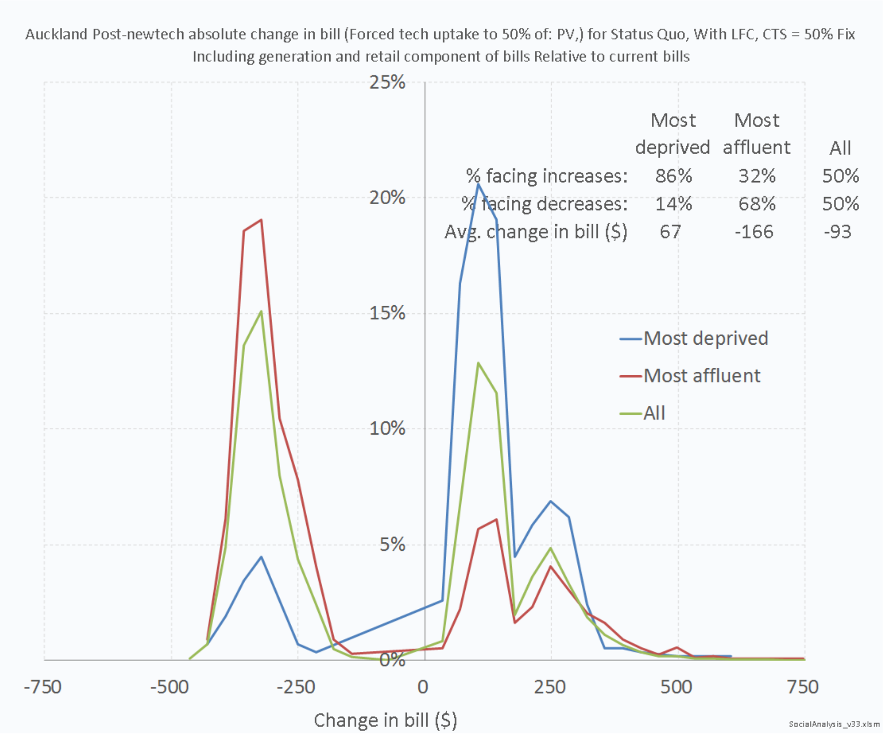


Figure 43: Christchurch

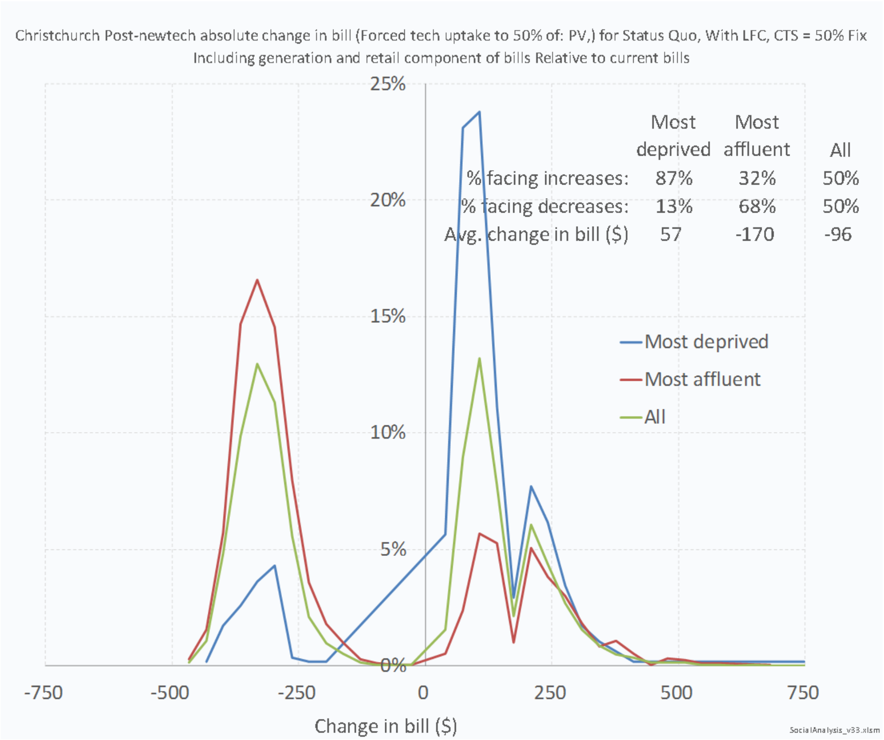


Figure 44: Dunedin

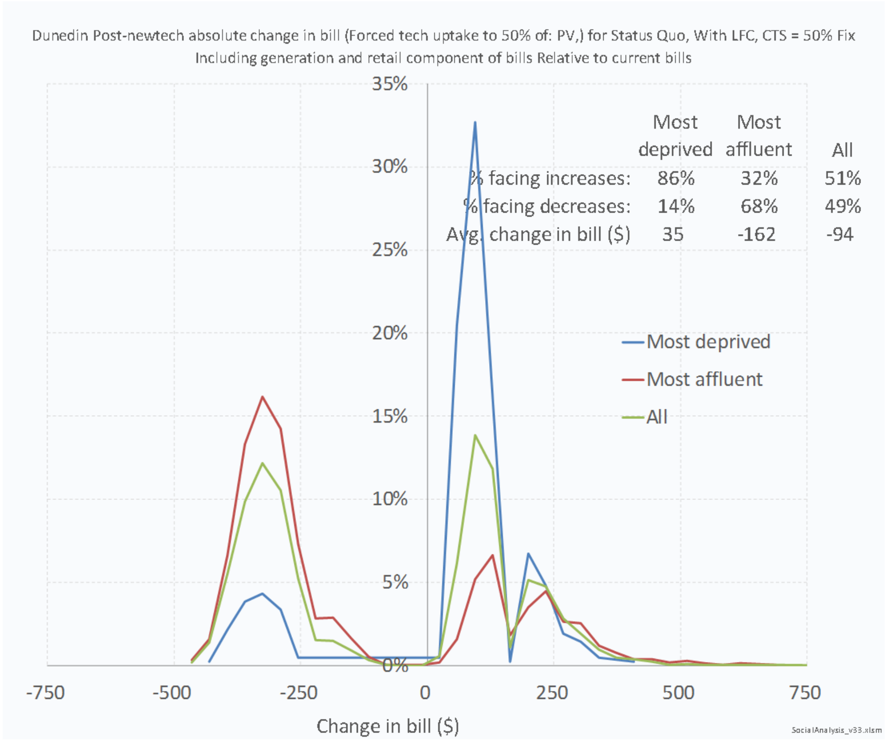
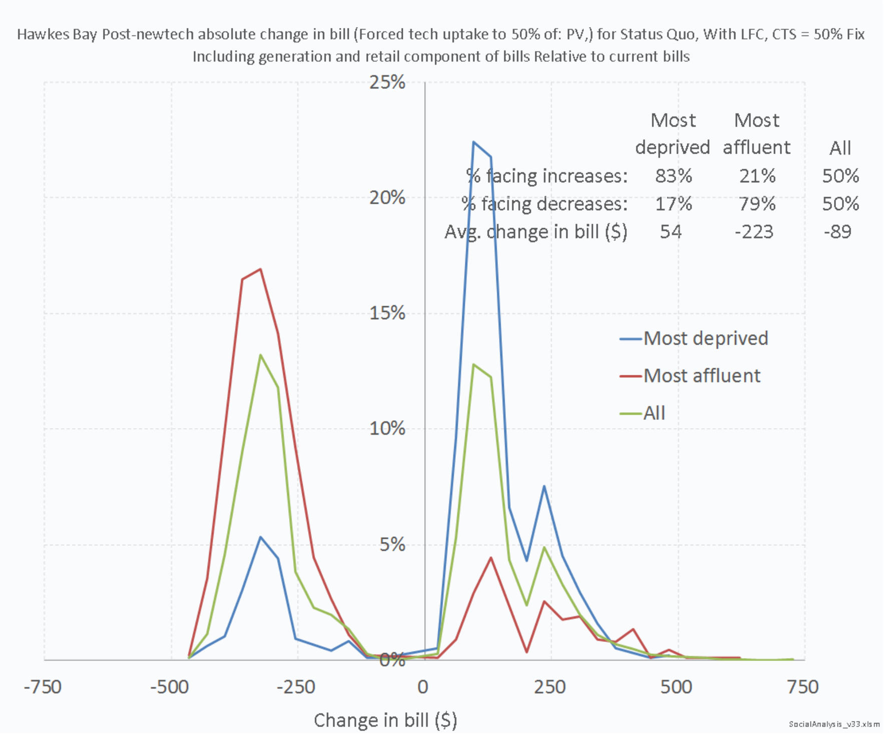


Figure 45: Hawkes Bay



Change in overall energy costs from 50% solar uptake with existing price structures

Figure 46: Wellington

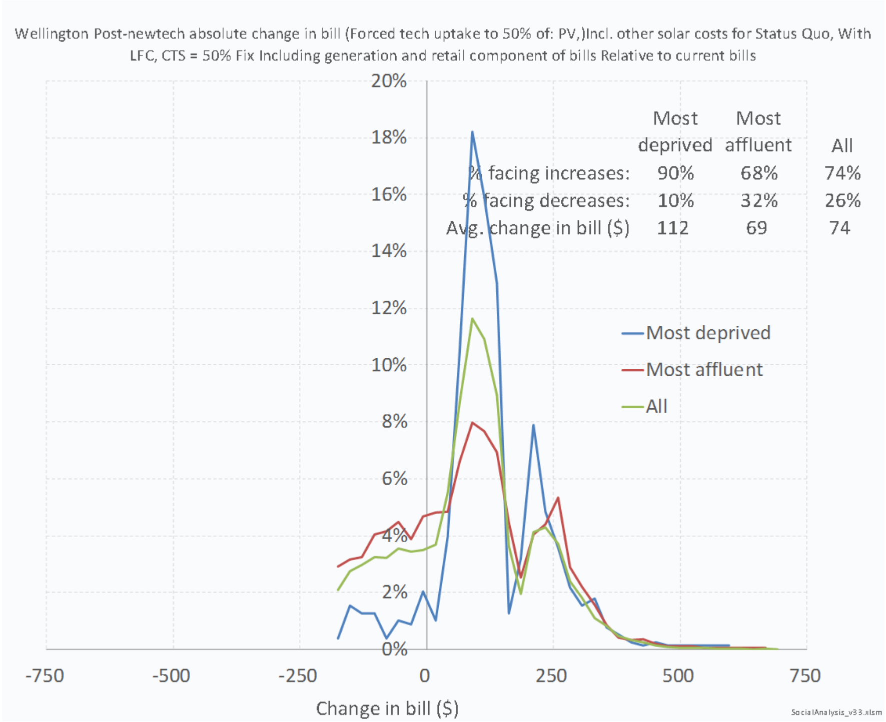


Figure 47: Auckland

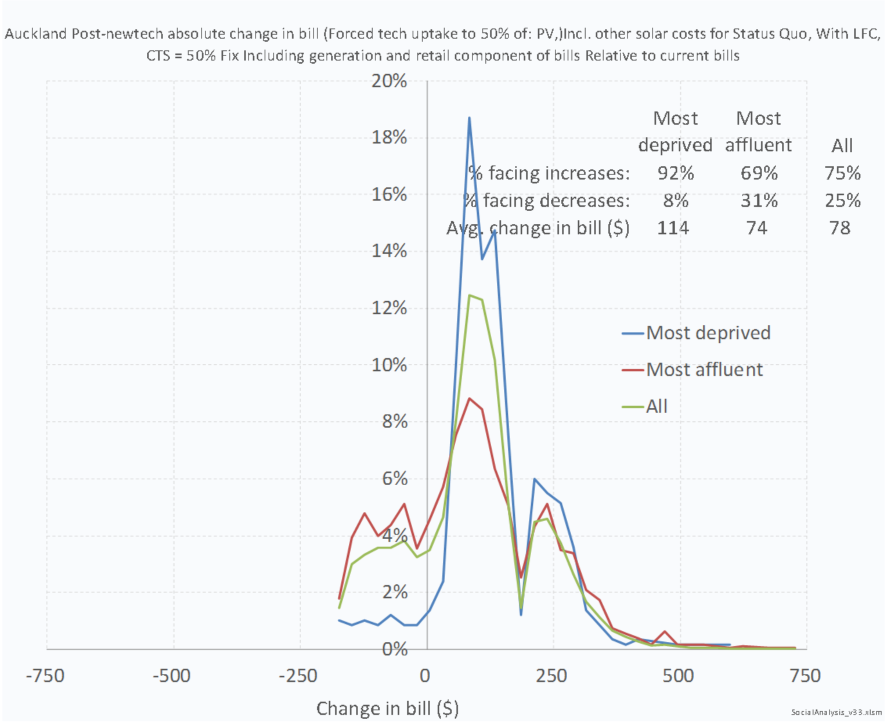


Figure 48: Christchurch

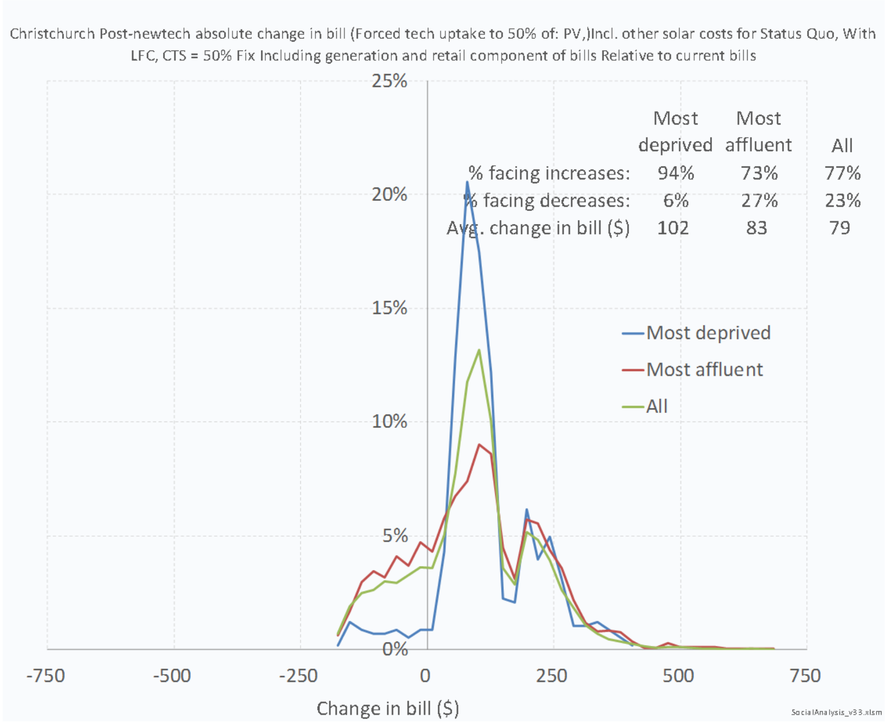


Figure 49: Dunedin

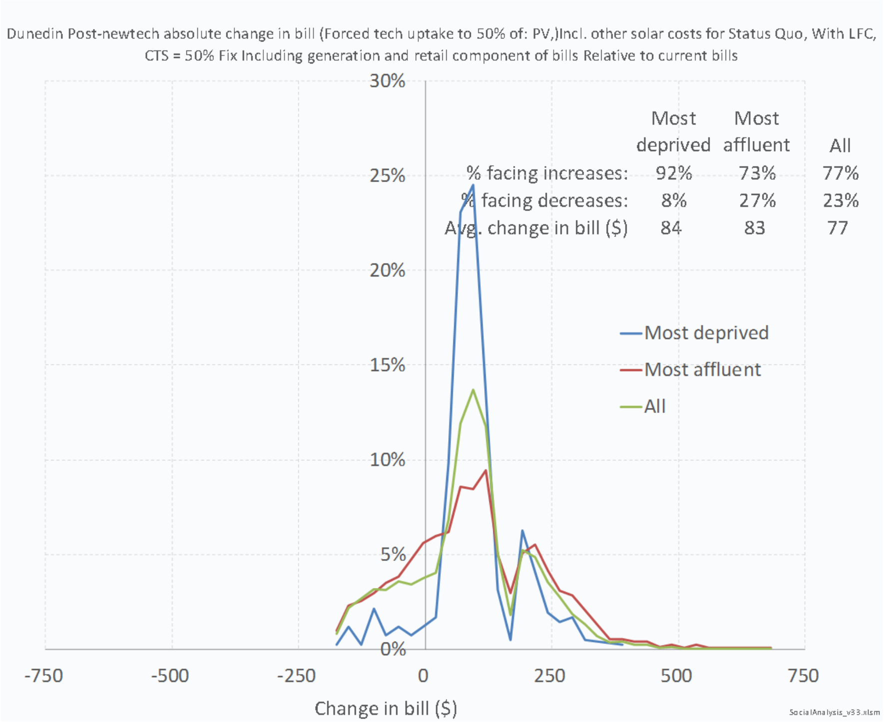
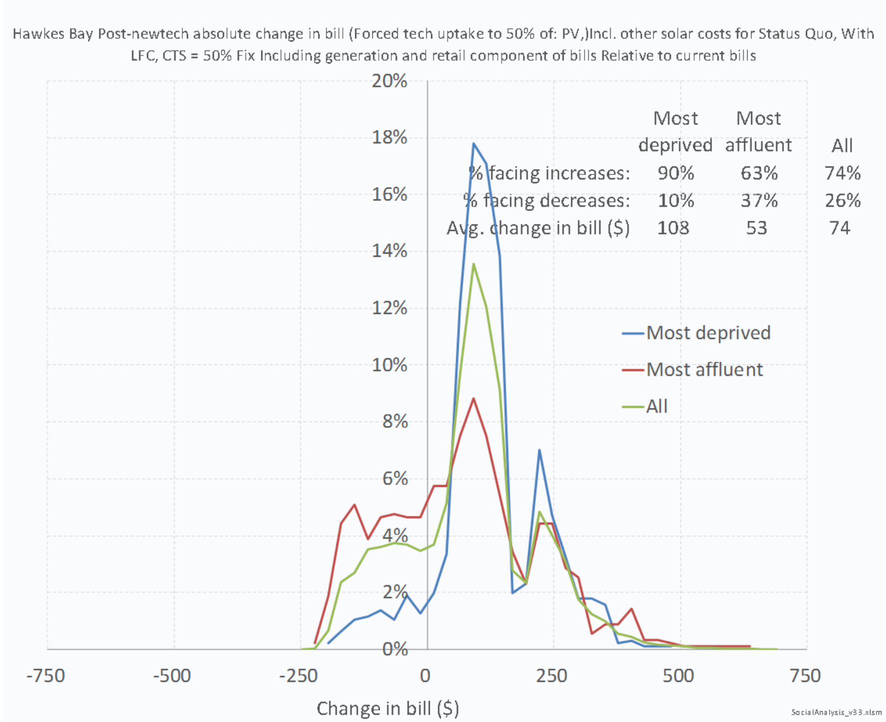


Figure 50: Hawkes Bay



Change in bill relative to today due to 50% EV uptake with continuation of current flat + LFC tariff structures

Figure 51: Wellington

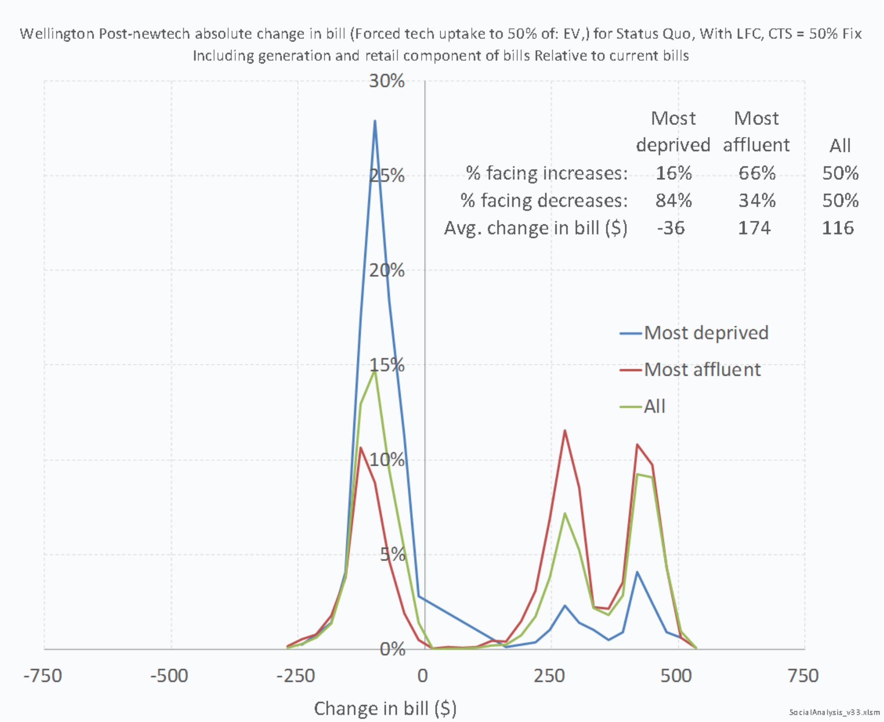


Figure 52: Auckland

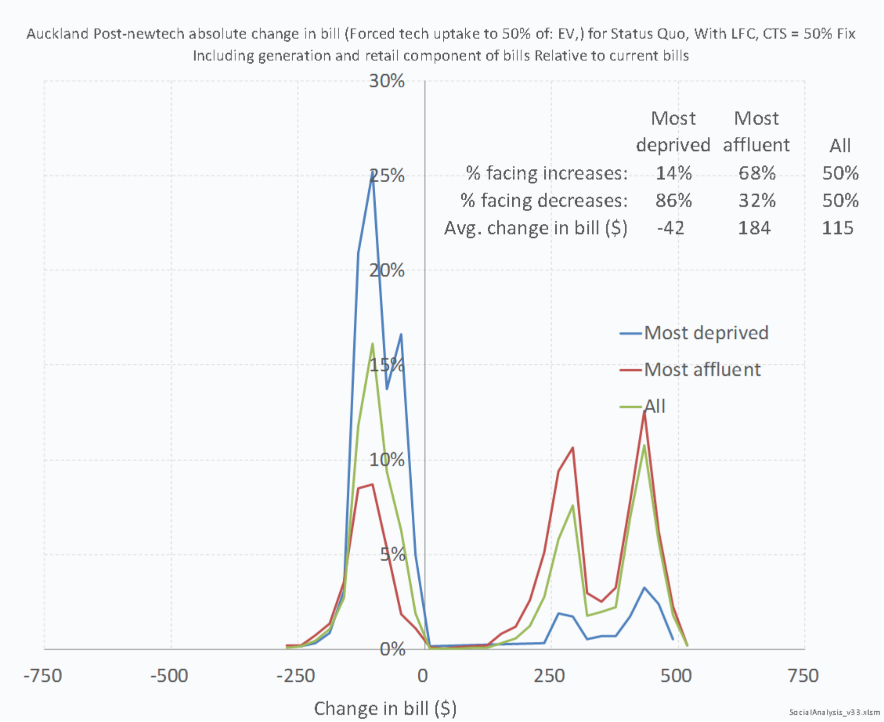


Figure 53: Christchurch

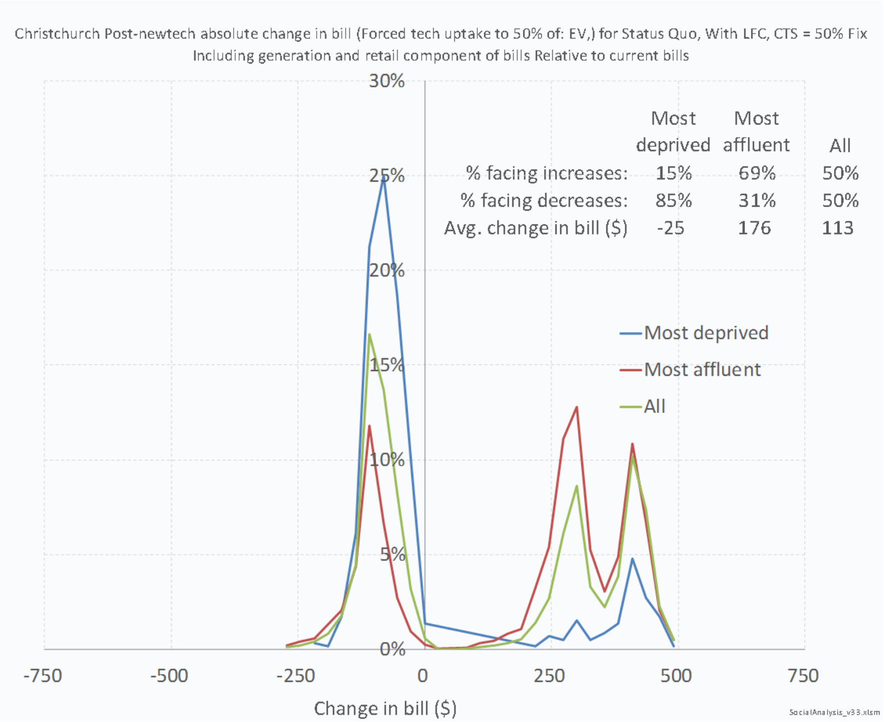


Figure 54: Dunedin

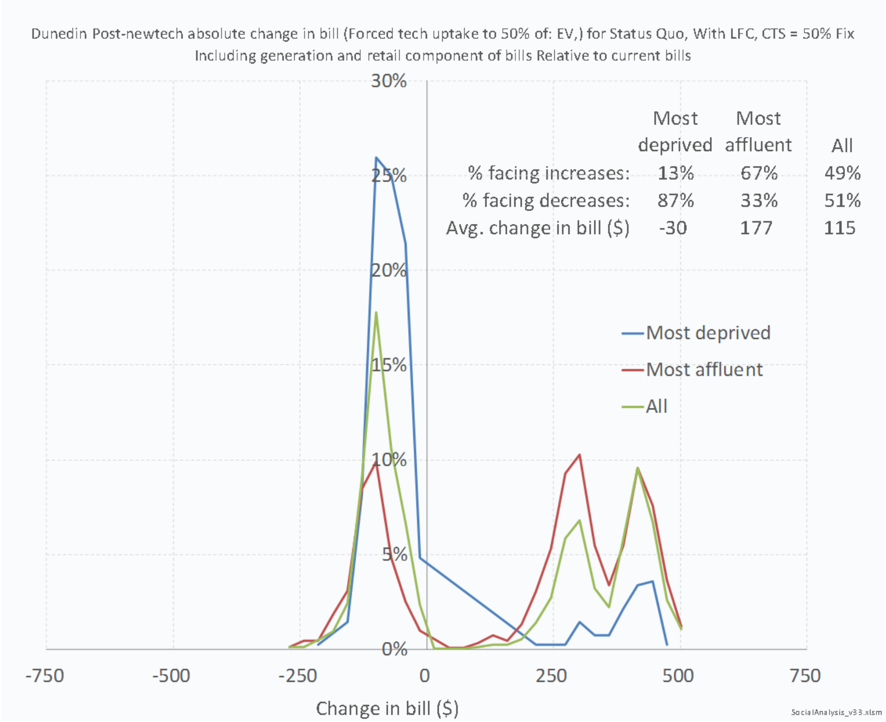
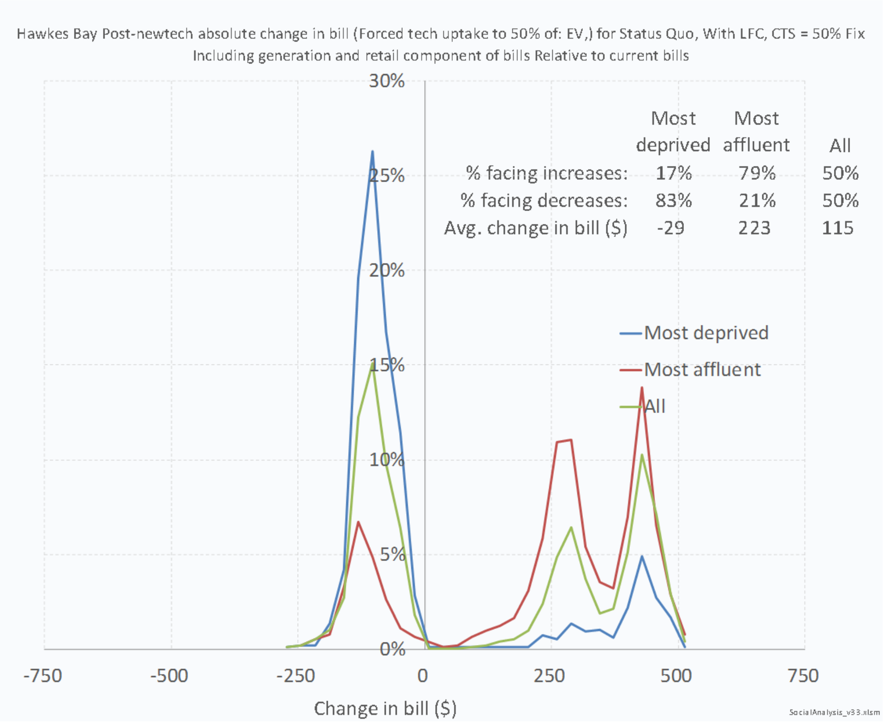


Figure 55: Hawkes Bay



Change in bills for non-adopters due to uptake of solar PV and EVs by other customers in a situation where tariffs continue as flat + LFC

Figure 56: Wellington

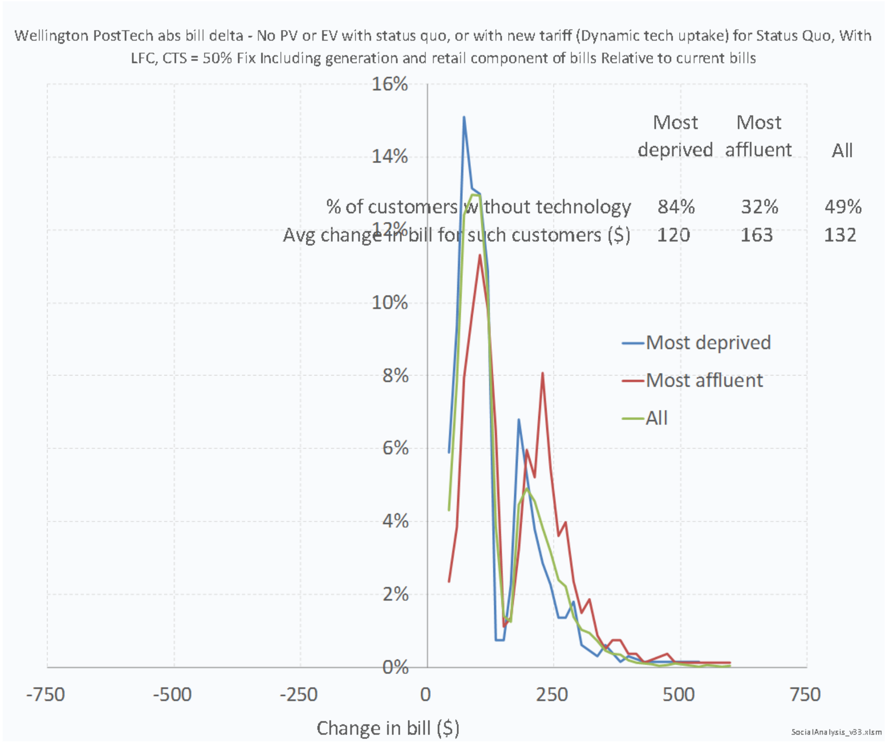


Figure 57: Auckland

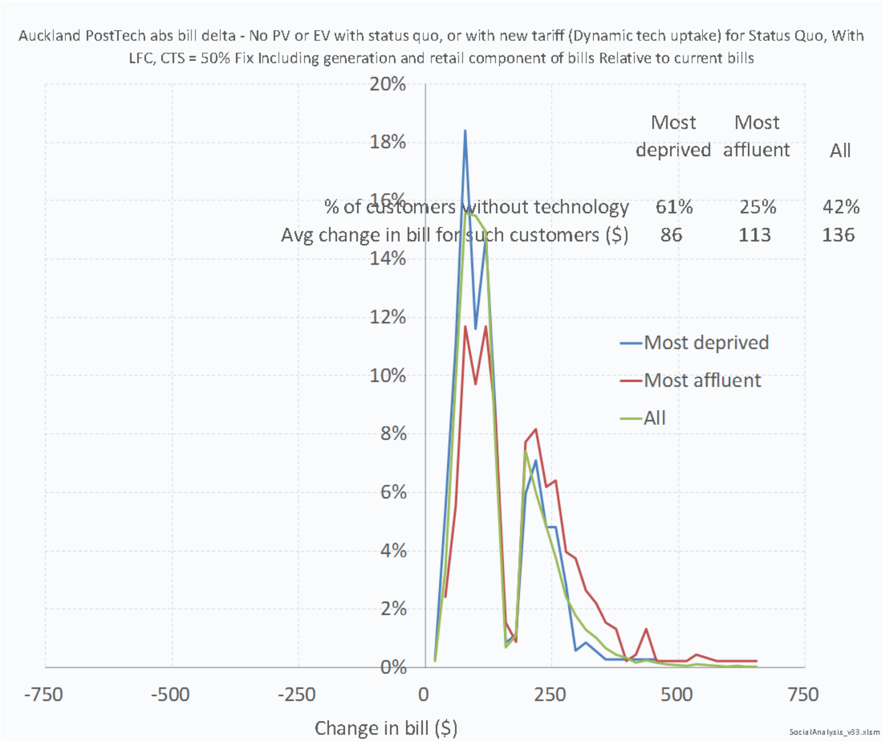


Figure 58: Christchurch

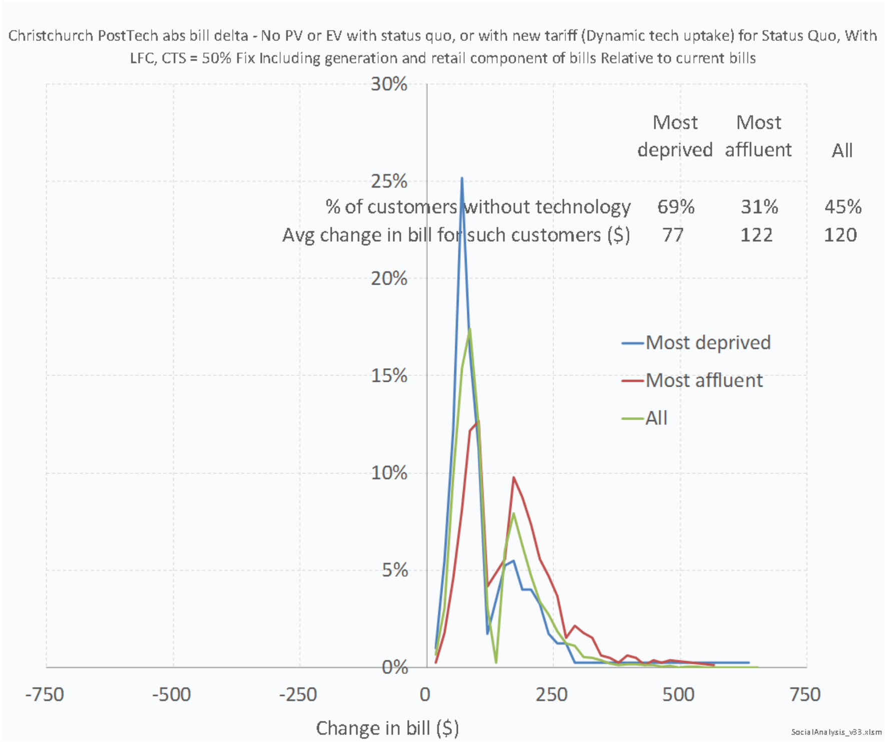


Figure 59: Dunedin

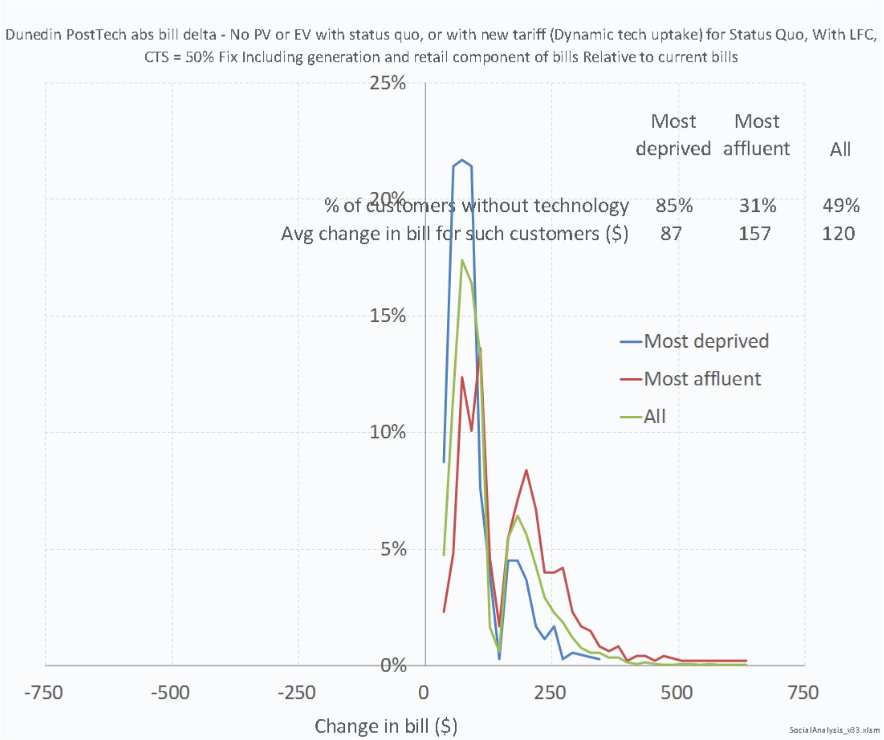
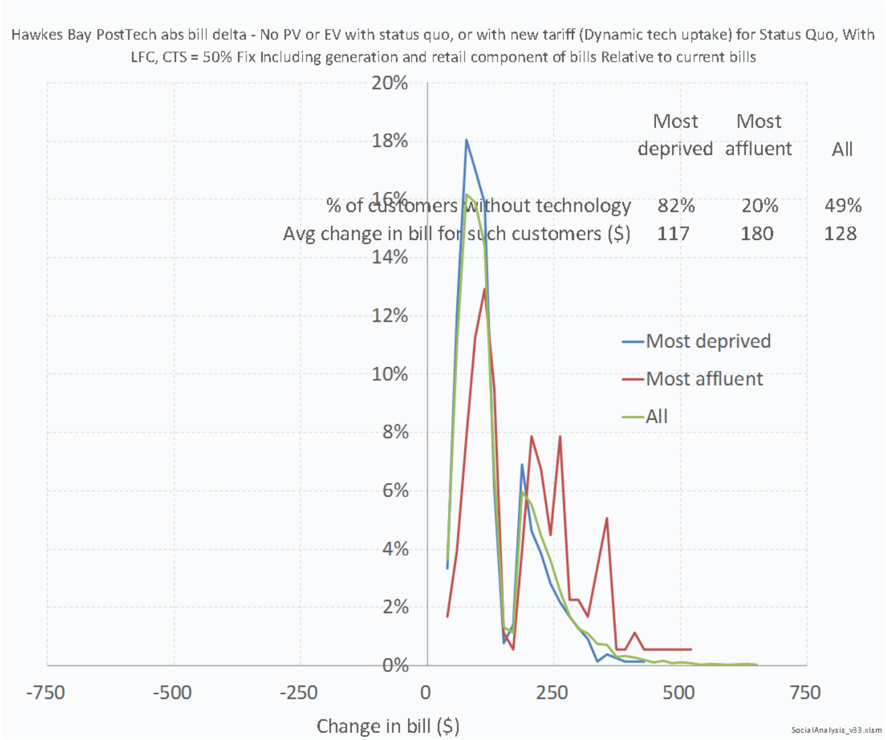
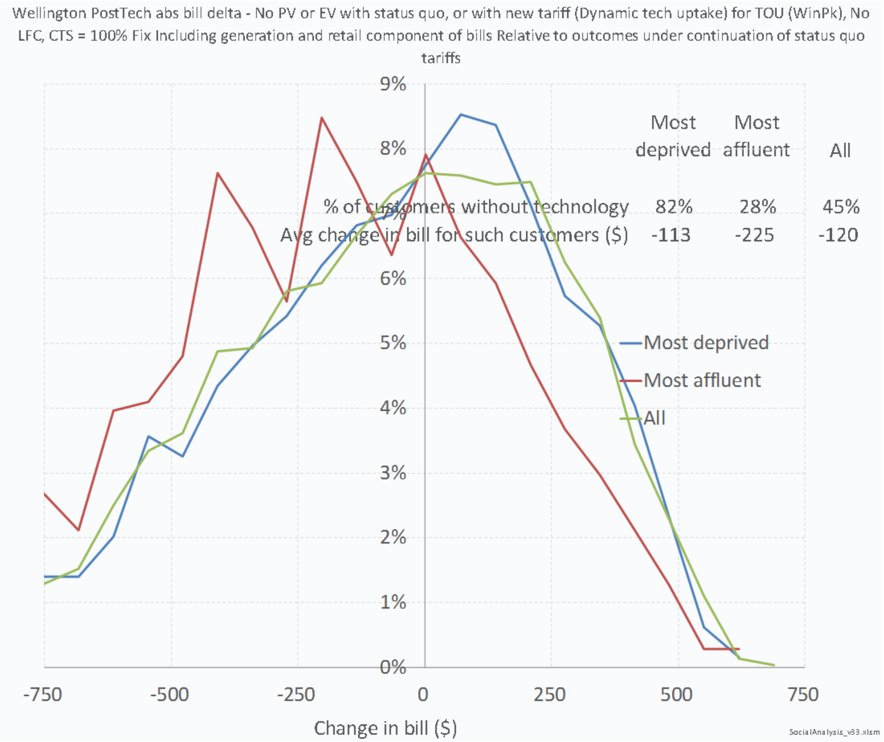


Figure 60: Hawkes Bay



Long-term impact of fully cost-reflective price structures

Figure 61: Wellington



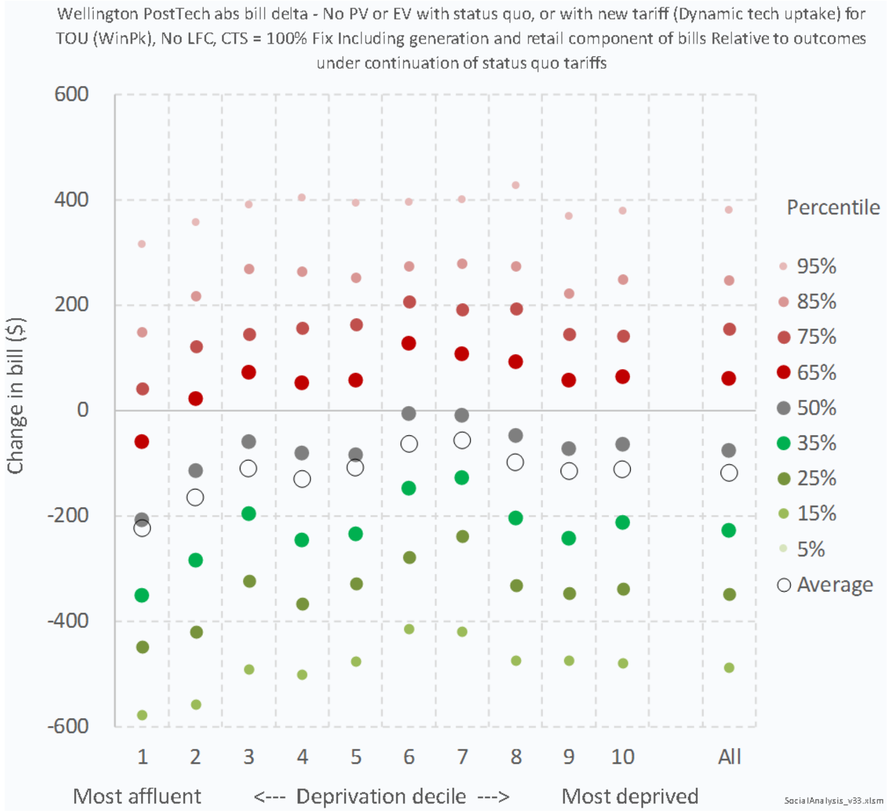
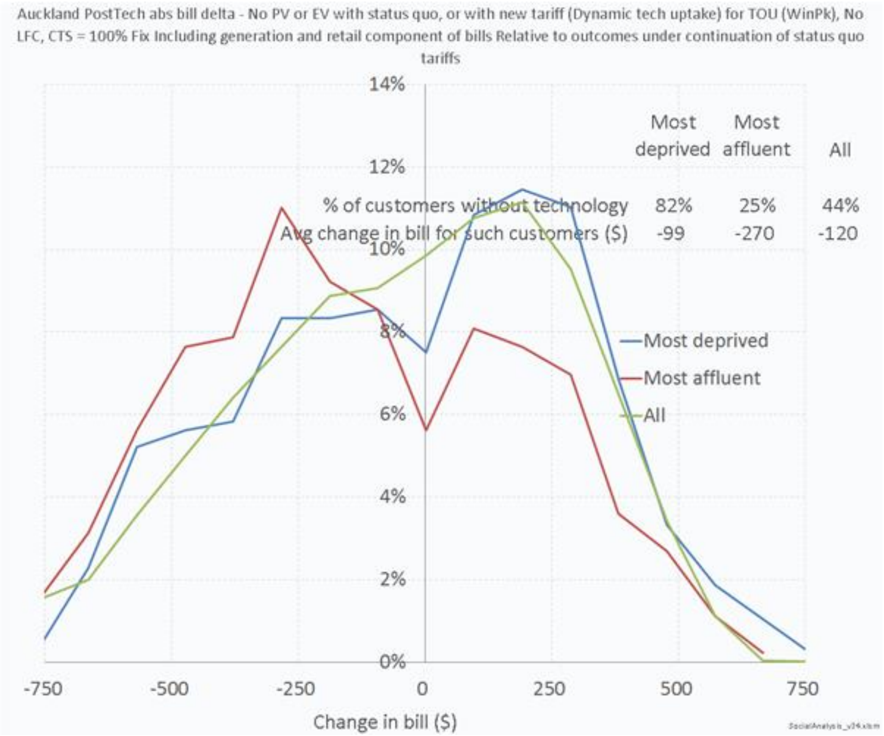


Figure 62: Auckland



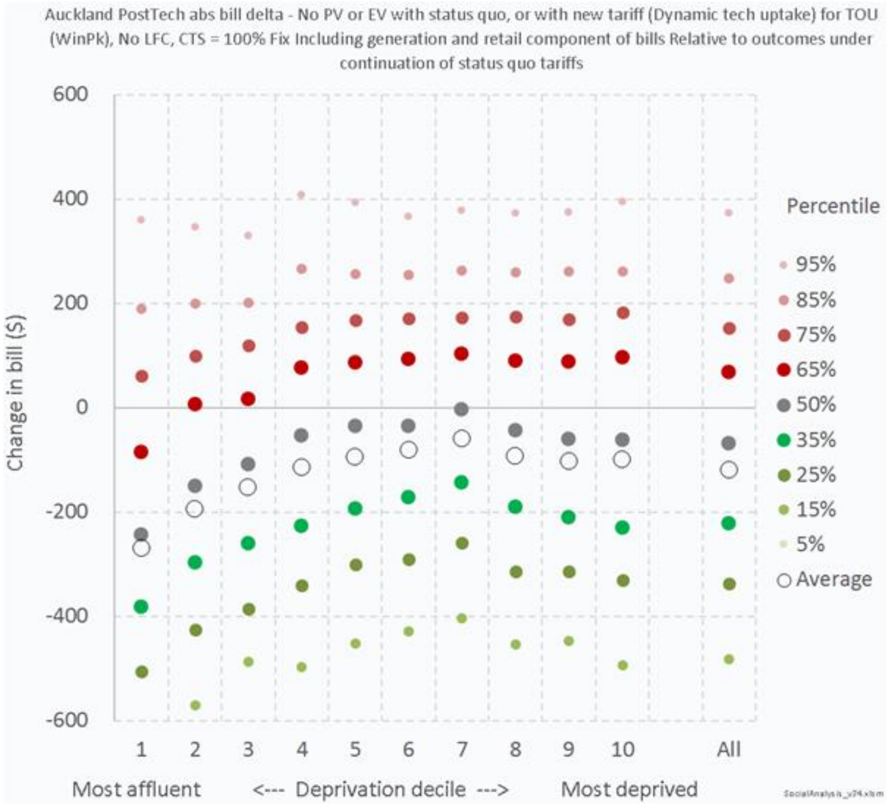
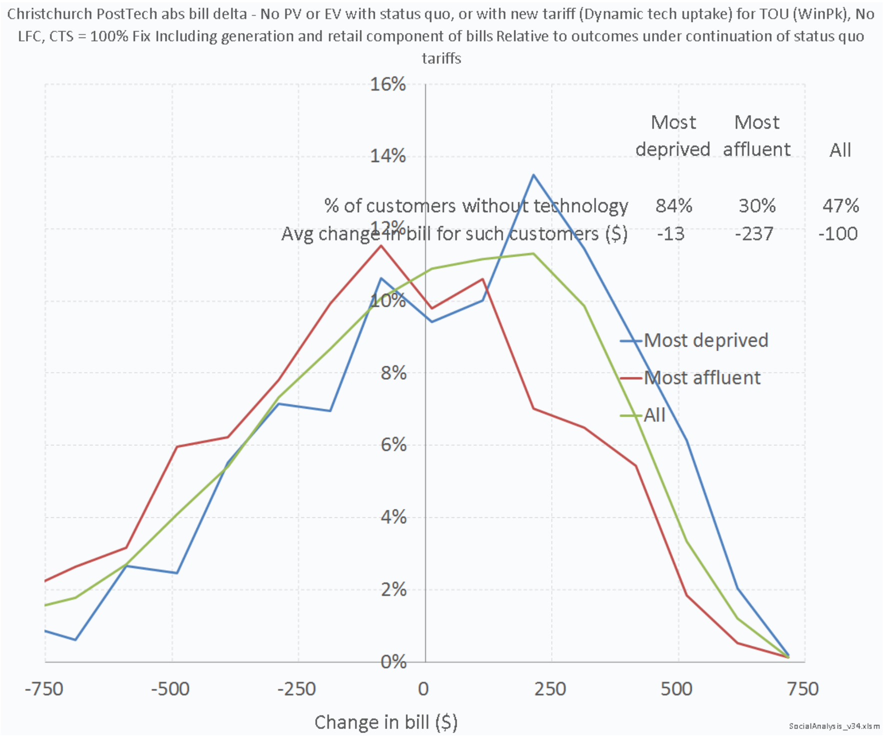


Figure 63: Christchurch



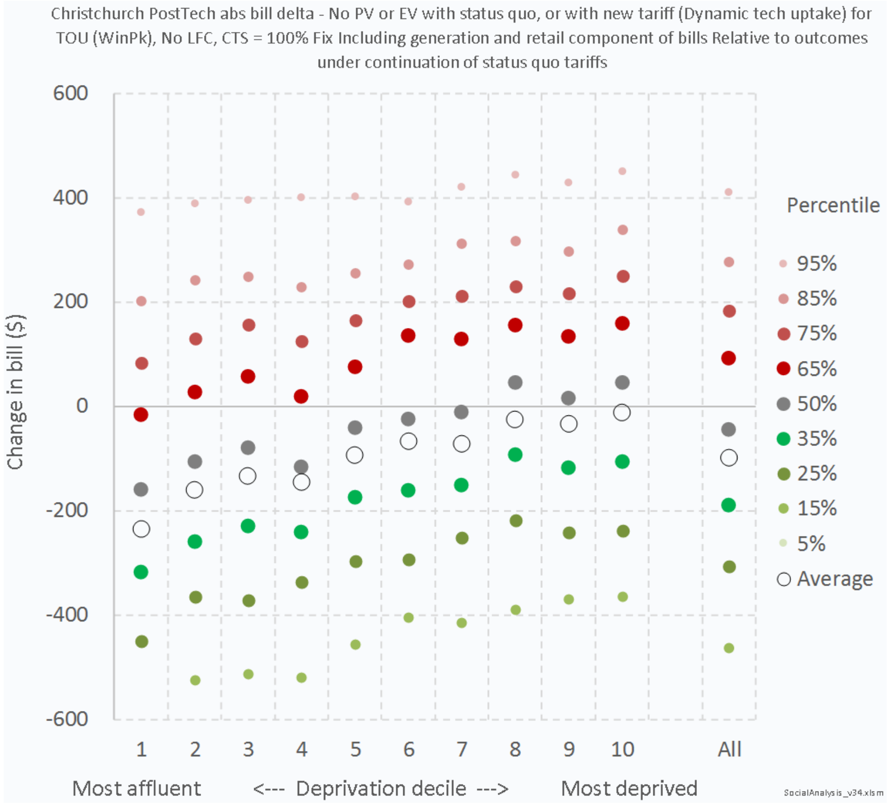
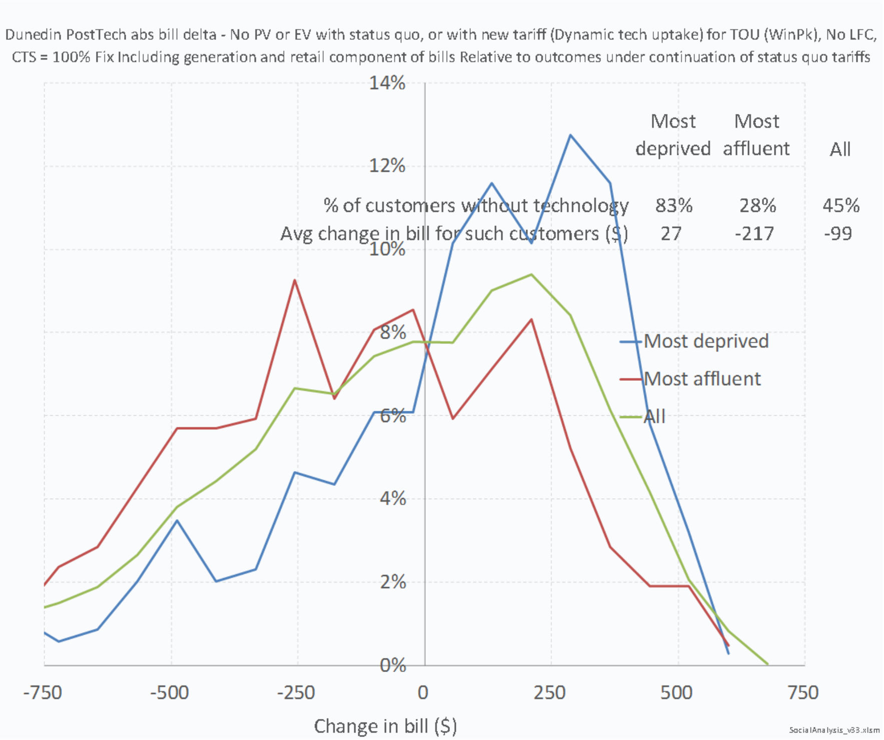


Figure 64: Dunedin



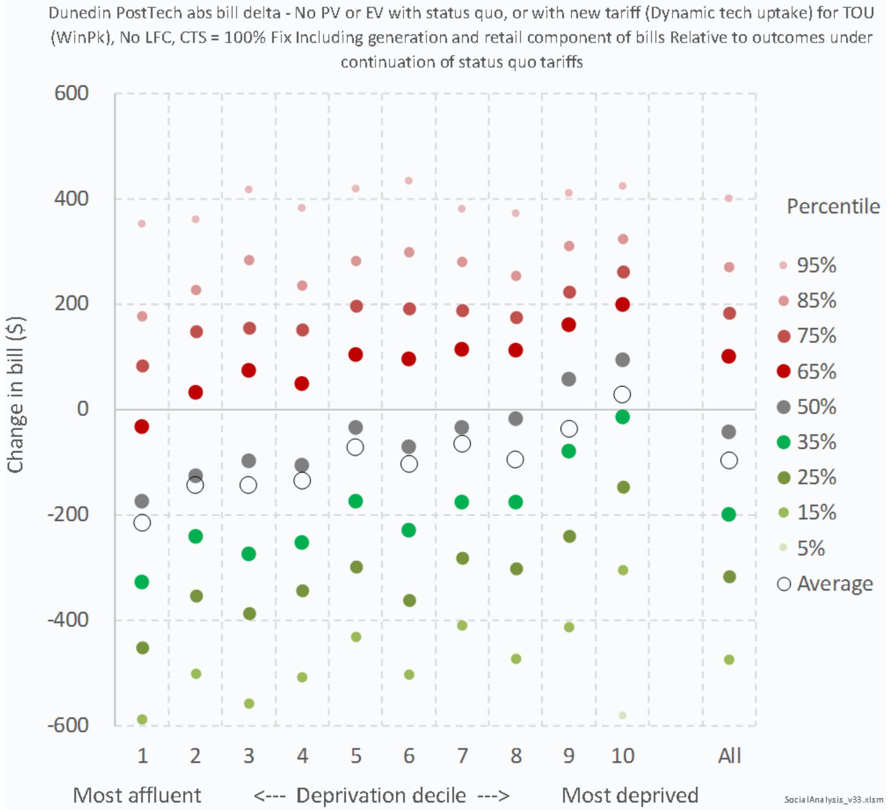
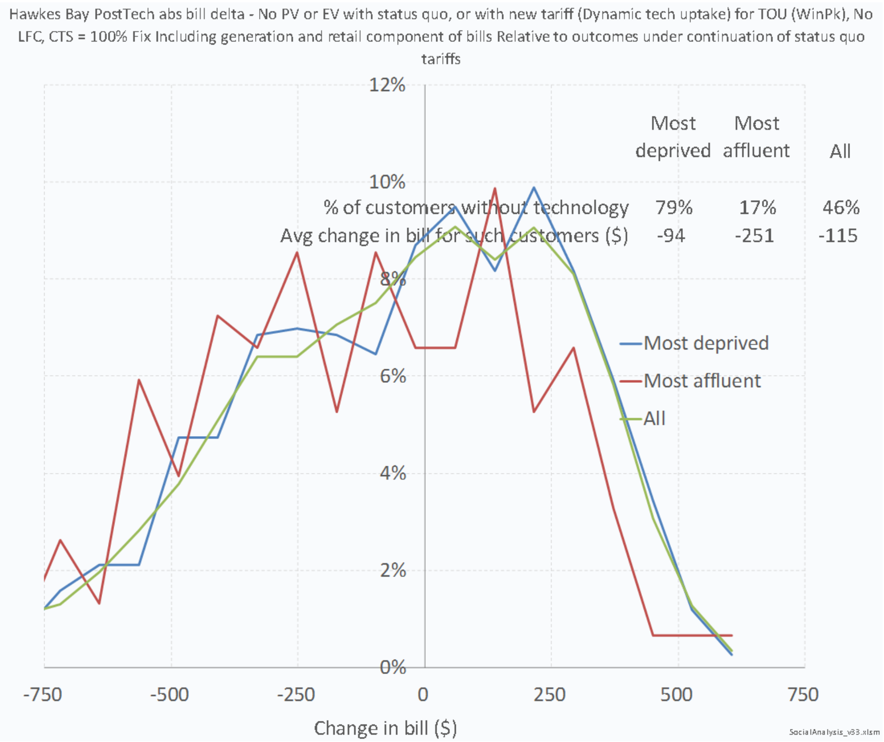
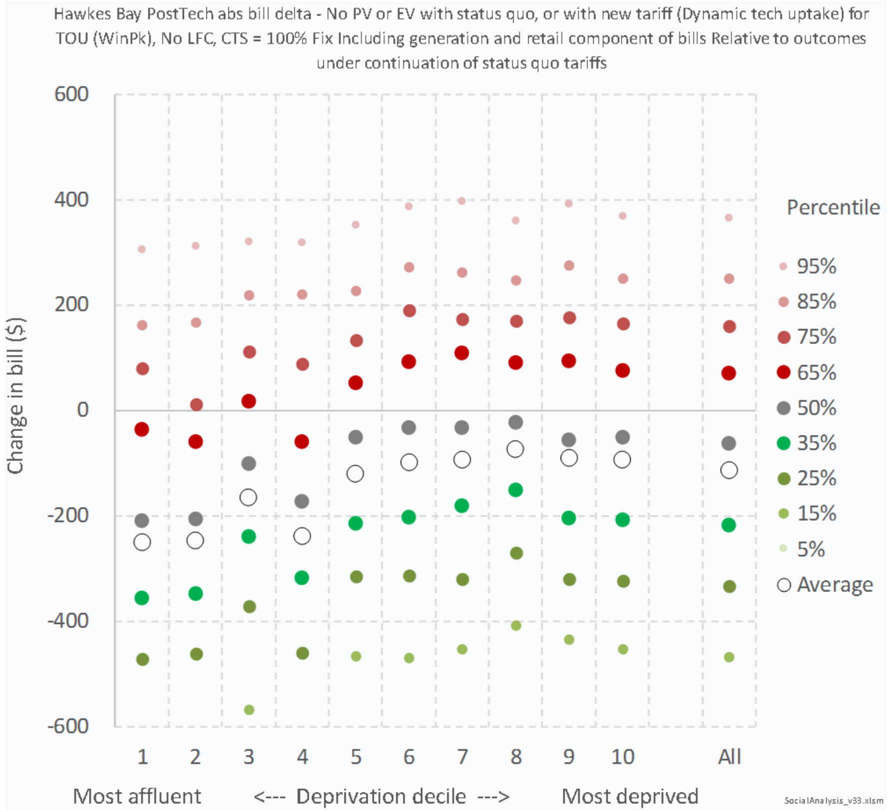


Figure 65: Hawkes Bay





Initial impact of fully cost-reflective prices

Figure 66: Wellington

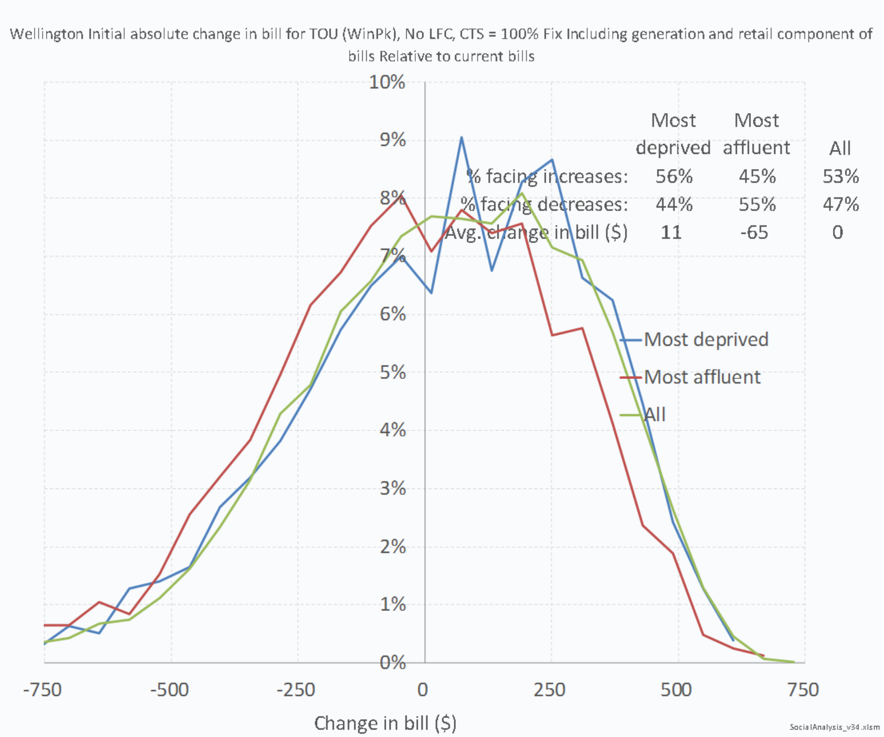


Figure 67: Auckland

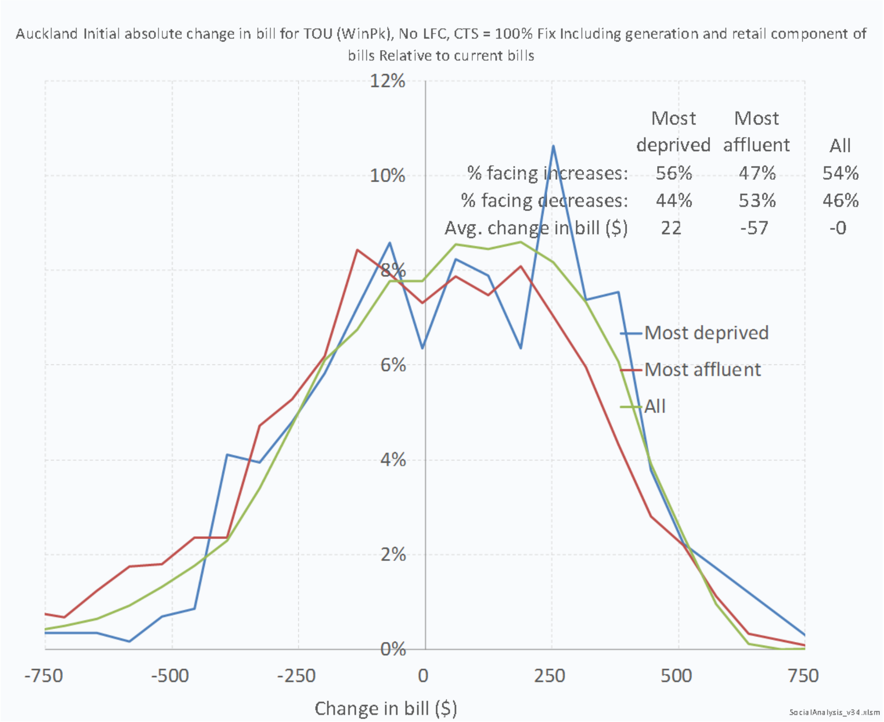


Figure 68: Christchurch

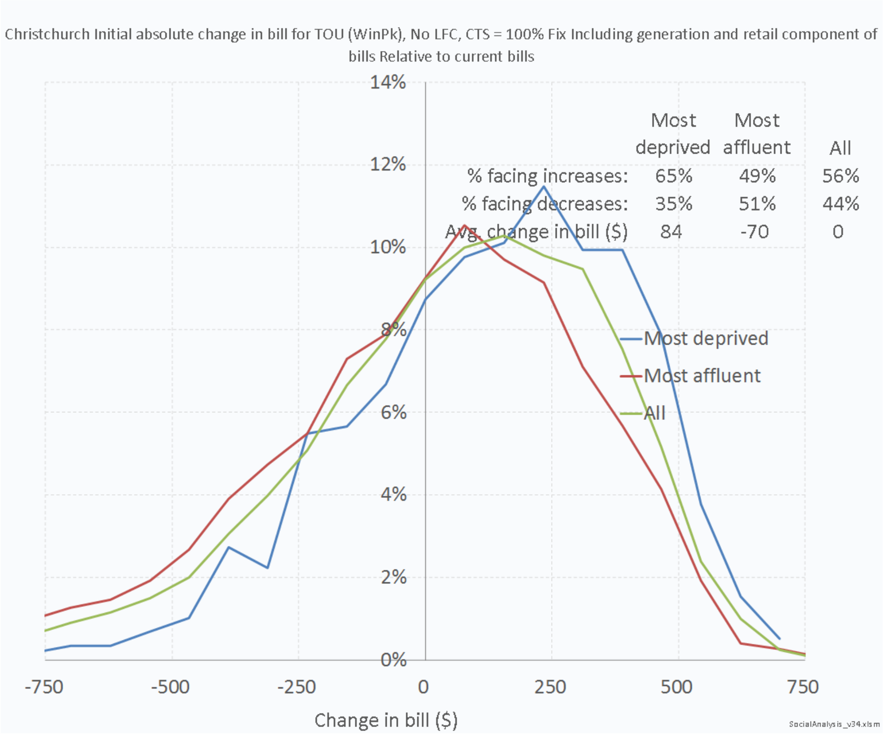


Figure 69: Dunedin

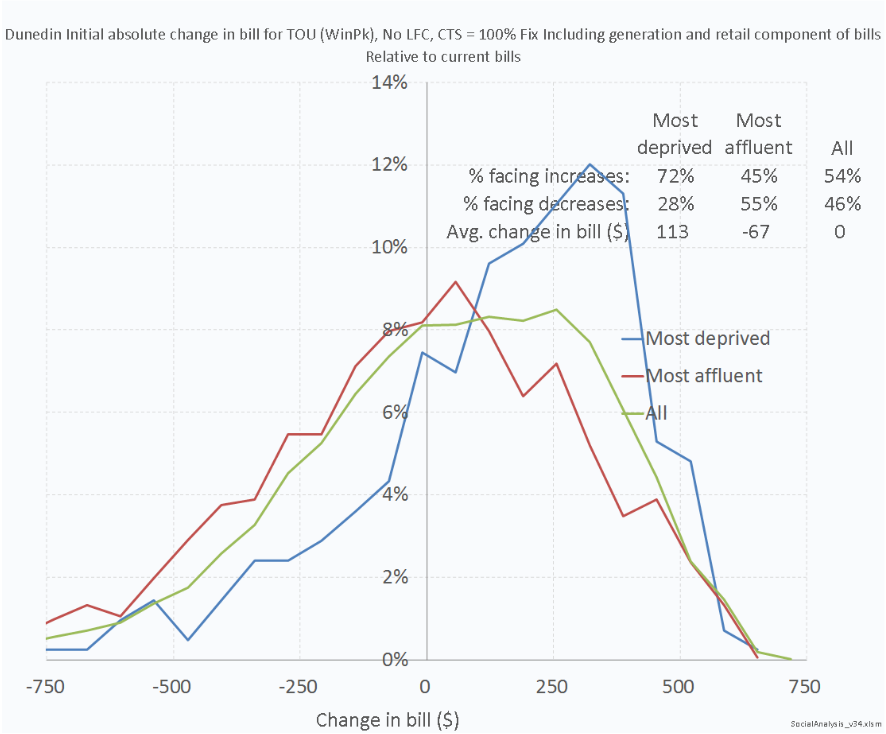
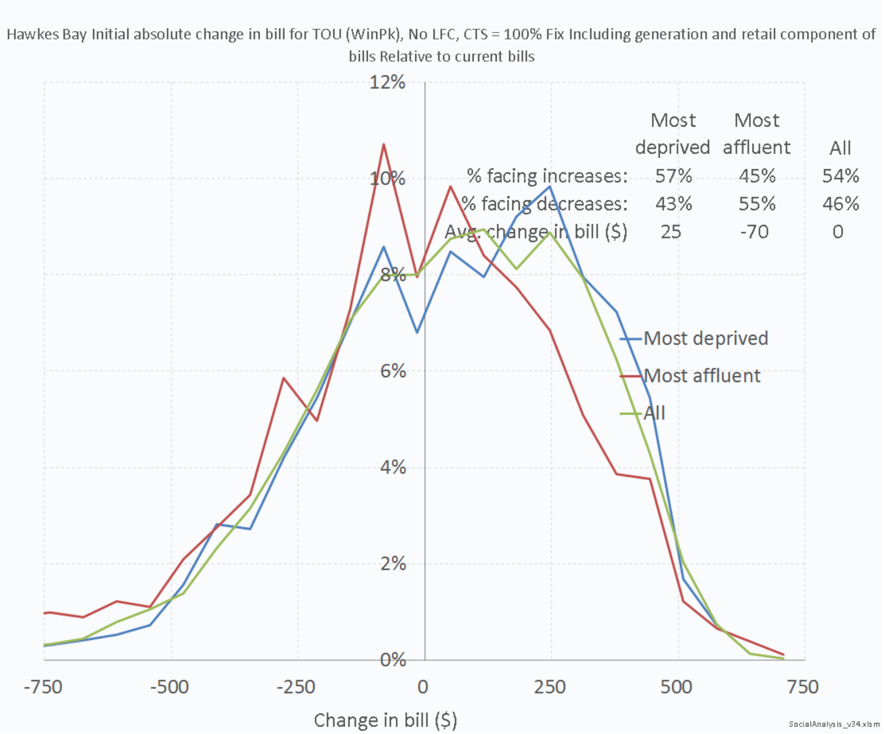


Figure 70: Hawkes Bay



Long-term impact – partially cost-reflective prices

Figure 71: Wellington

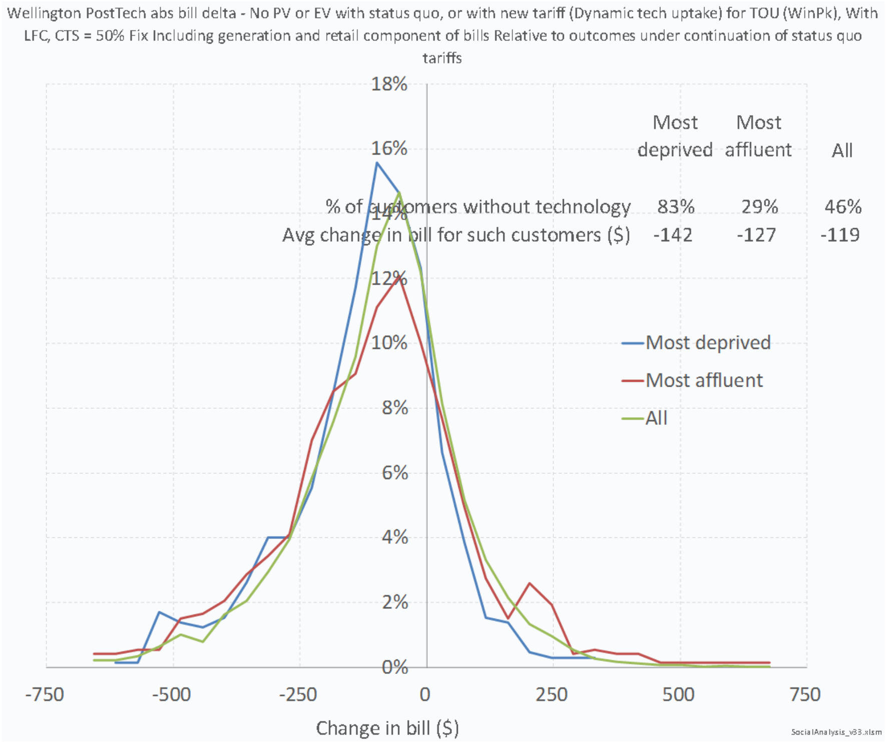


Figure 72: Auckland

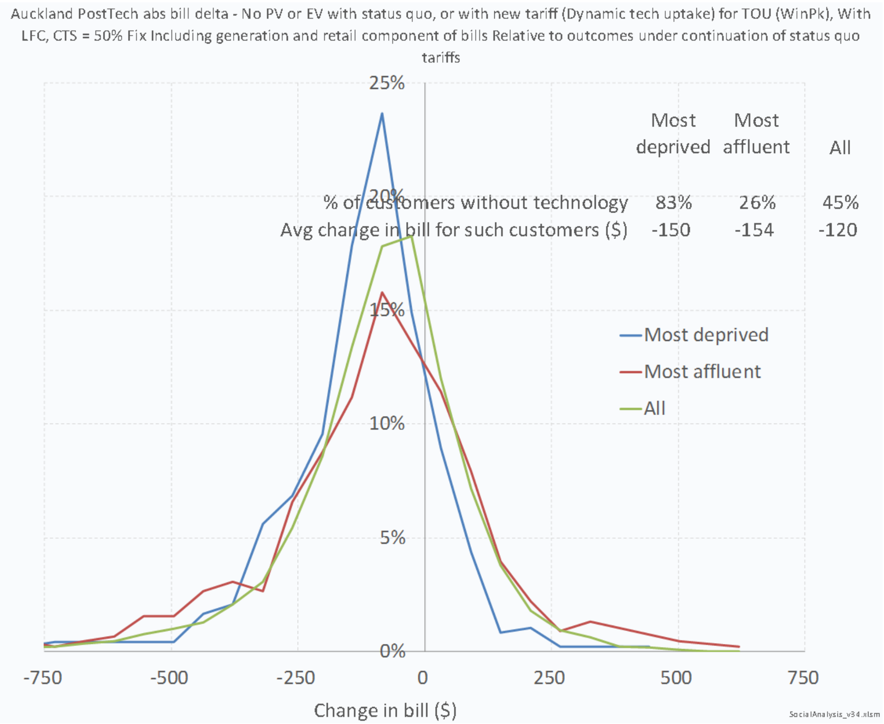


Figure 73: Christchurch

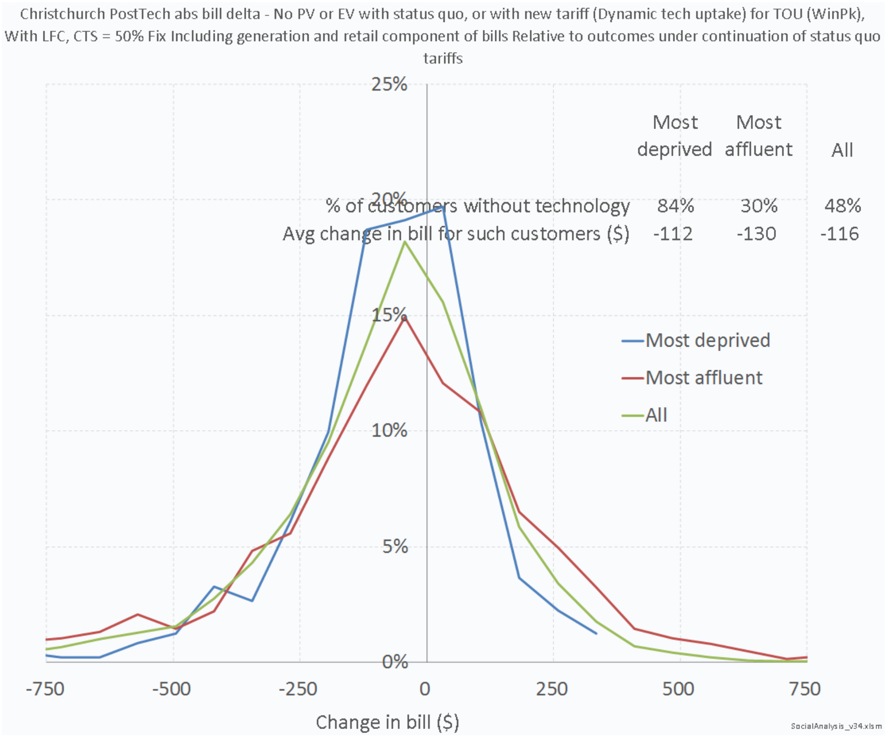


Figure 74: Dunedin

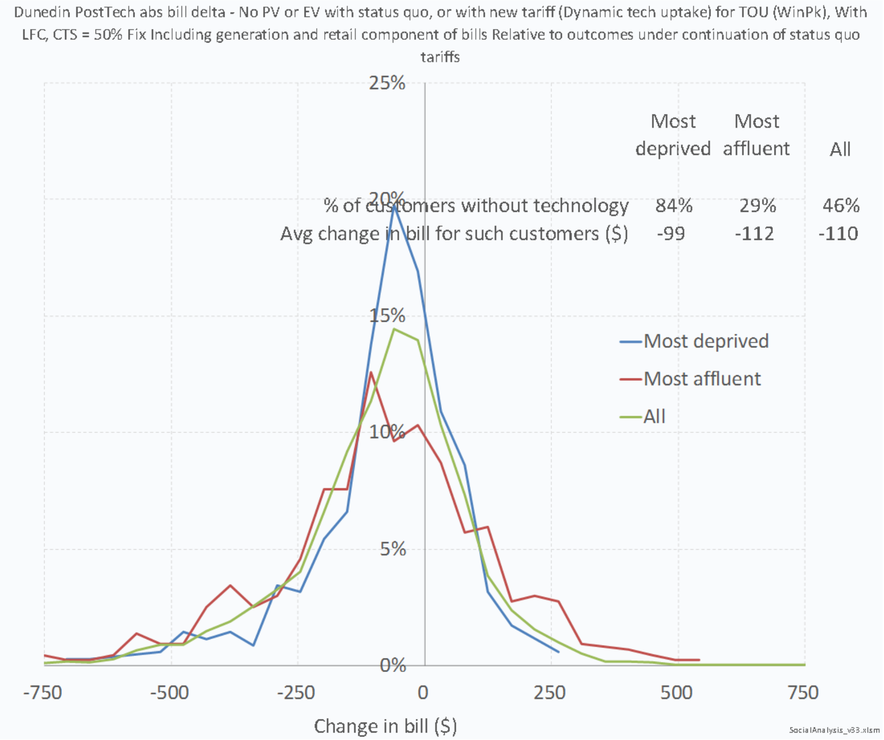
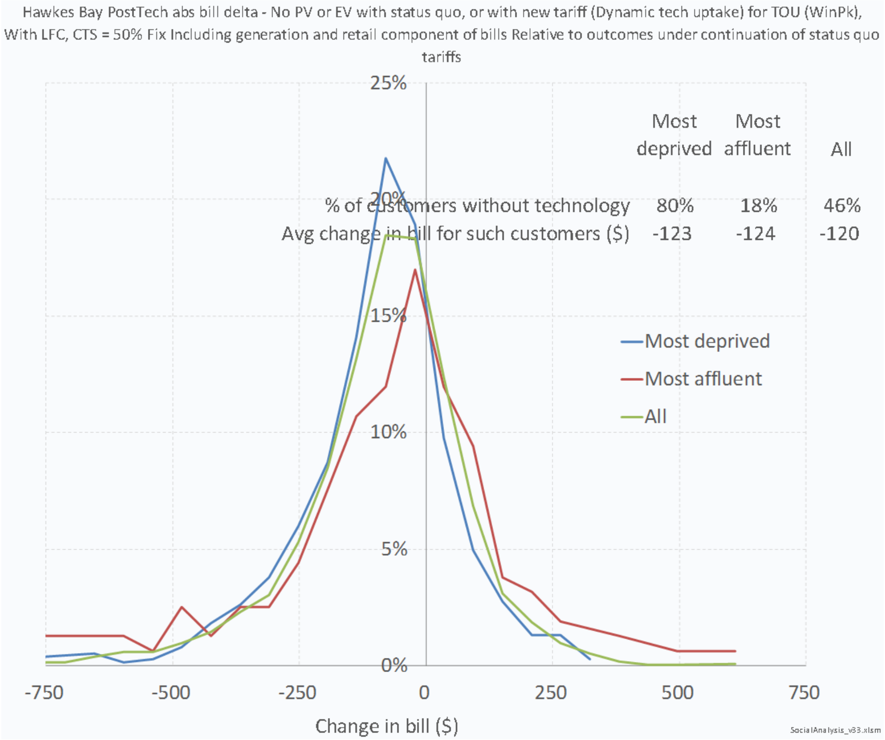
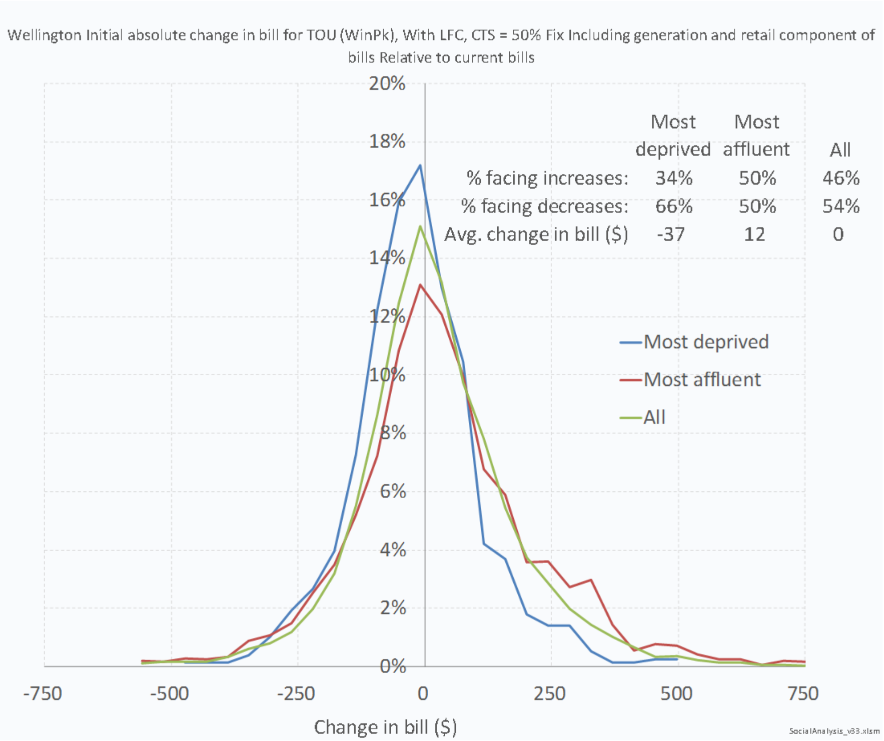


Figure 75: Hawkes Bay



Initial impact – partially cost-reflective prices

Figure 76: Wellington



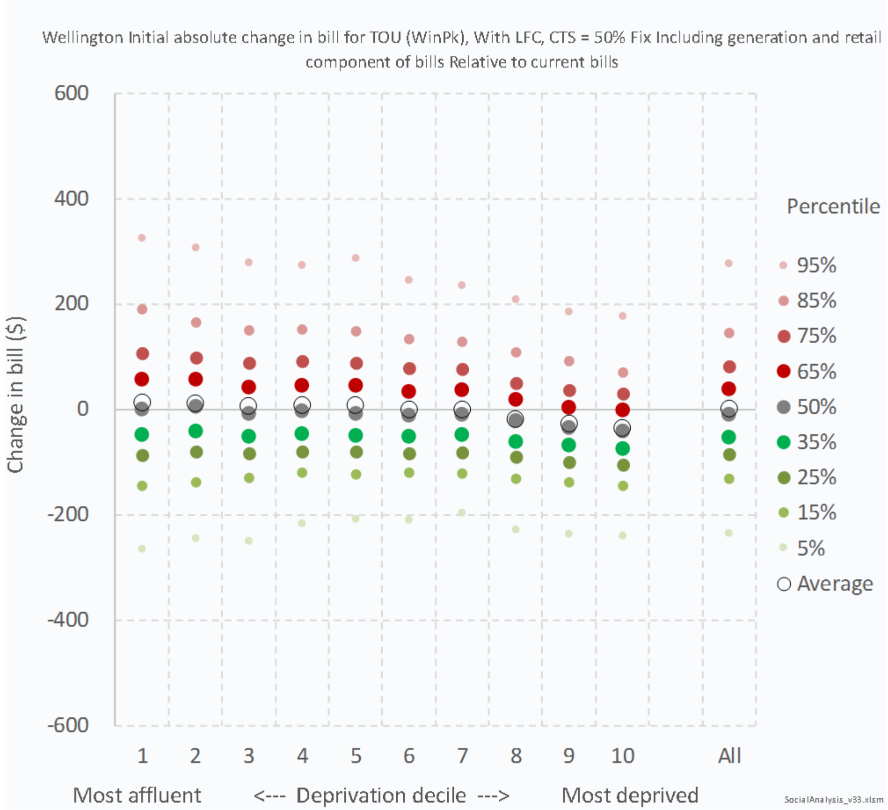
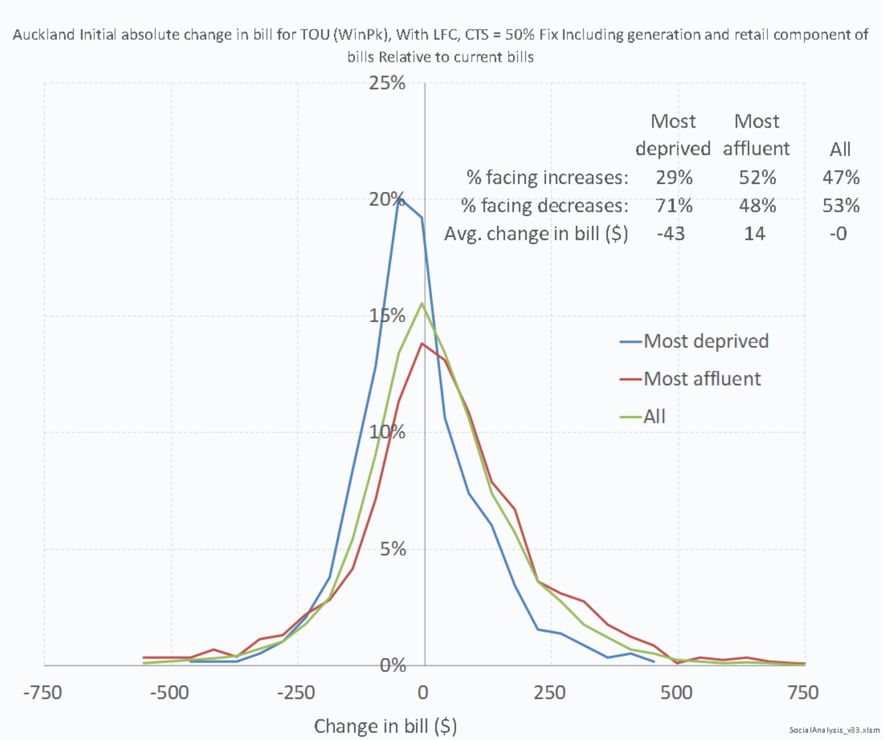


Figure 77: Auckland



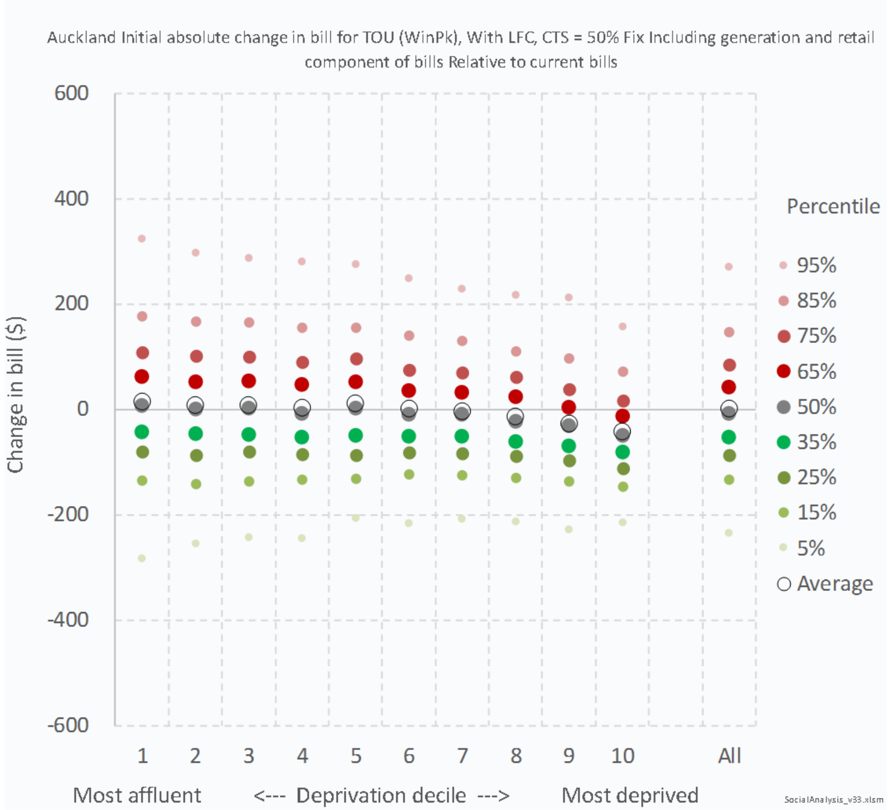
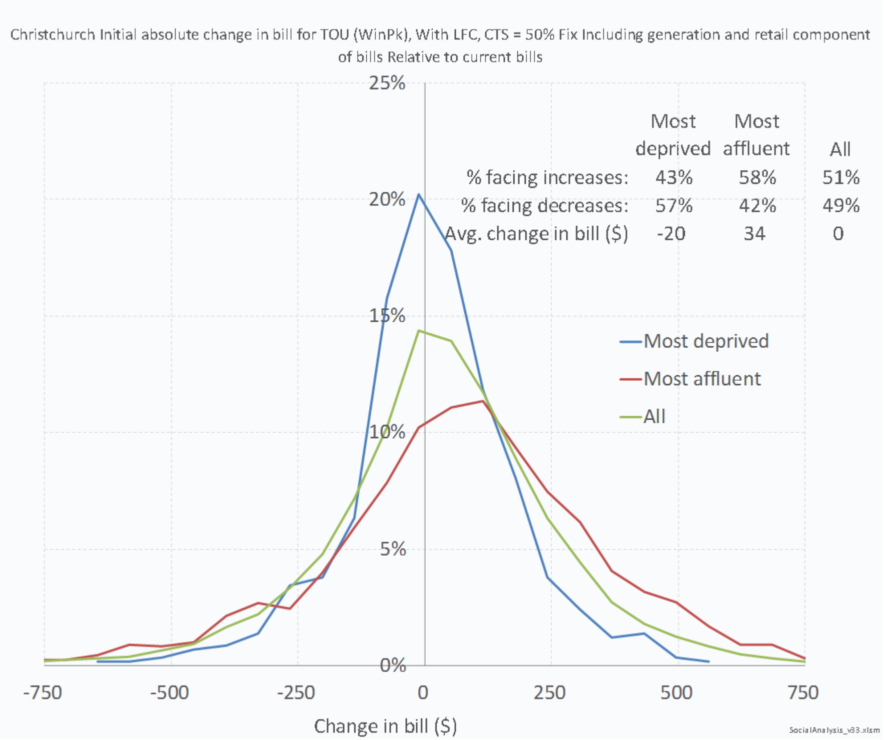


Figure 78: Christchurch



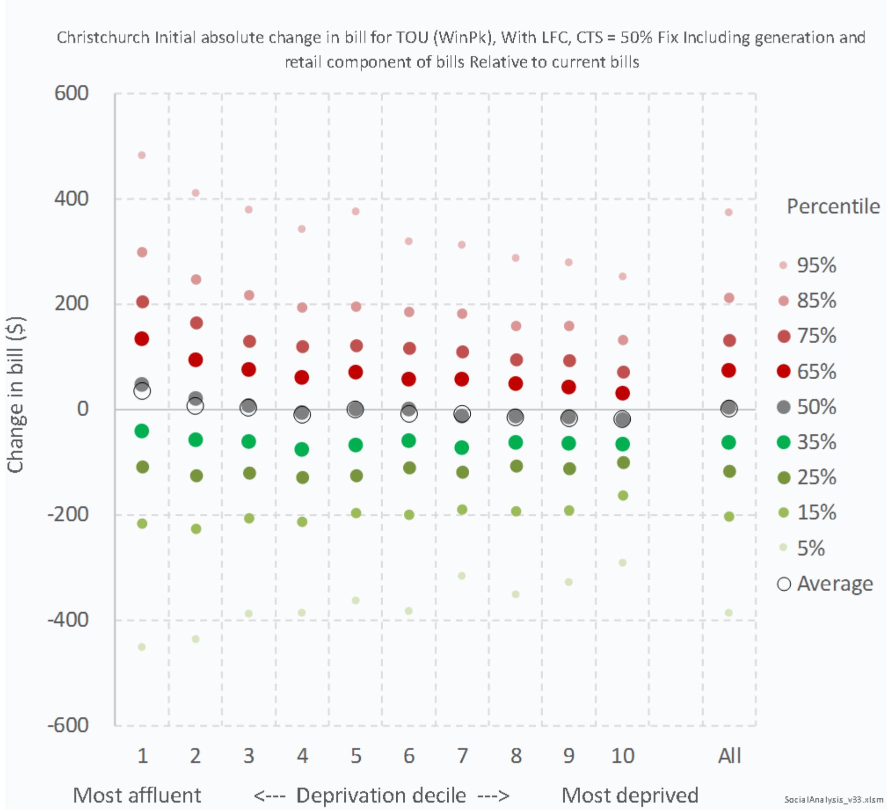


Figure 79: Dunedin

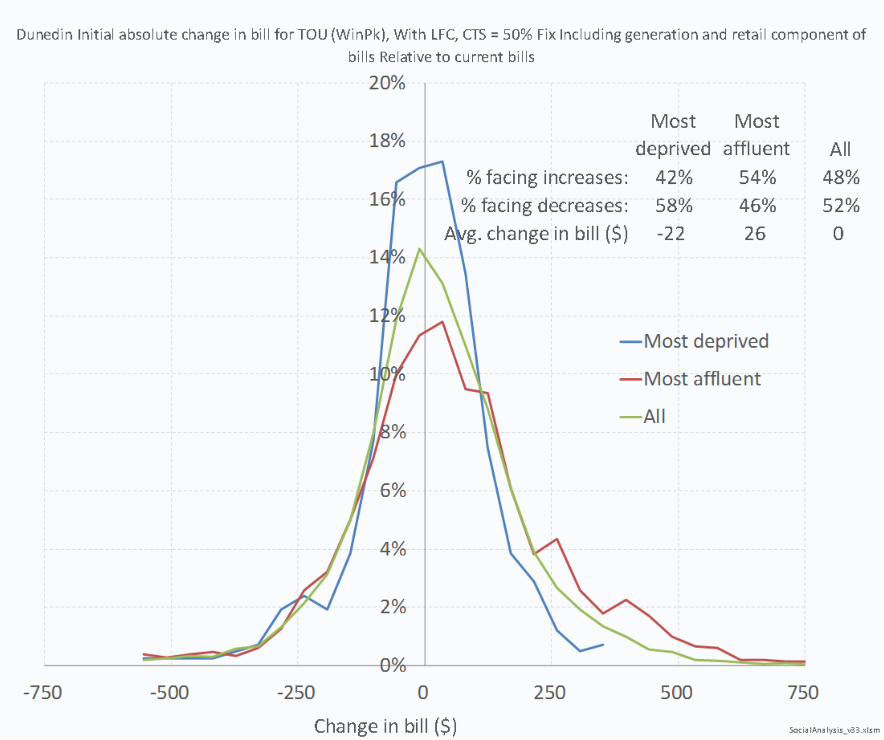
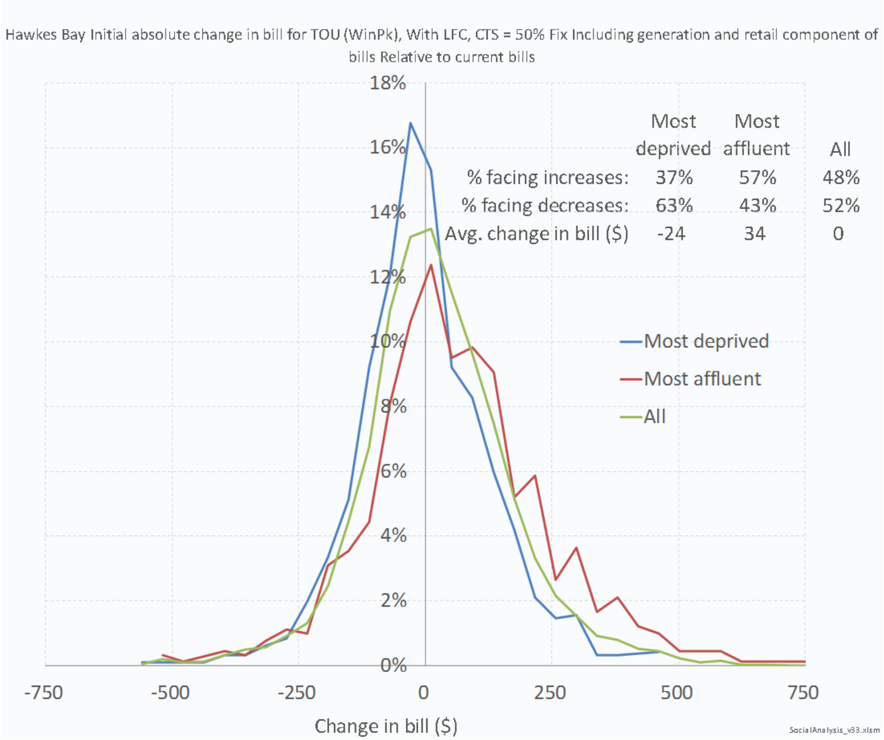
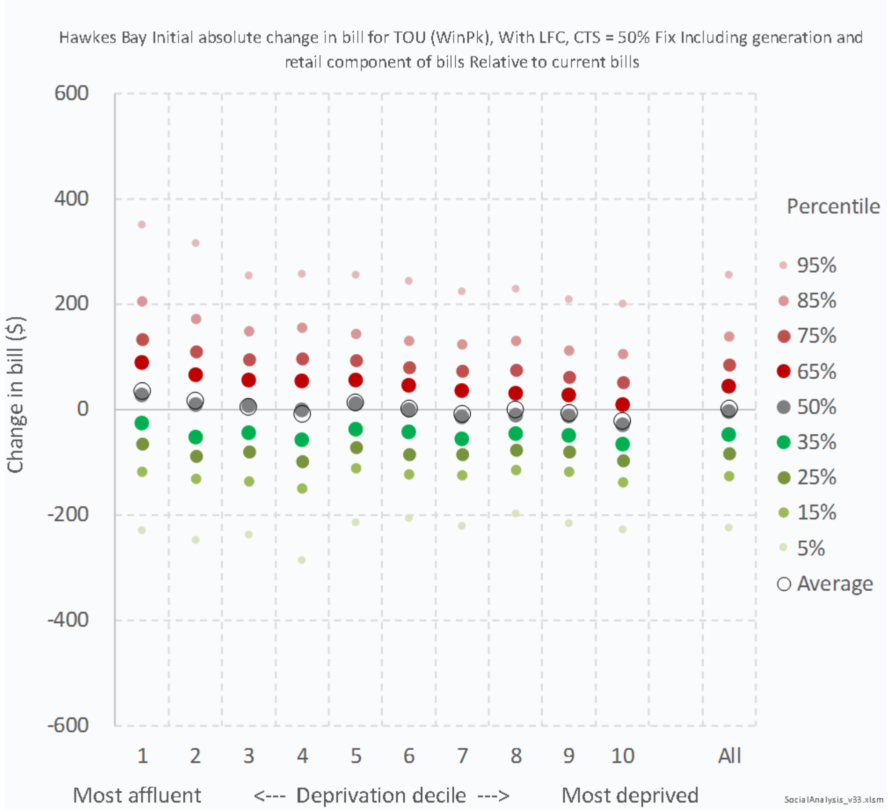


Figure 80: Hawkes Bay





Long-term impact of fully cost-reflective pricing – adopters and non-adopters

Figure 81: Wellington

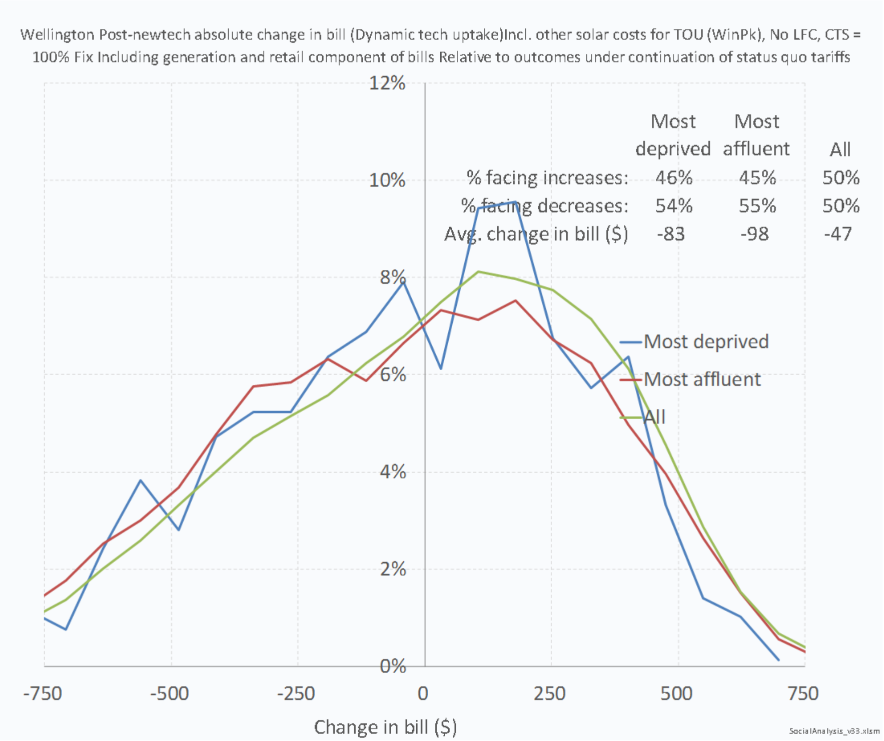


Figure 82: Auckland

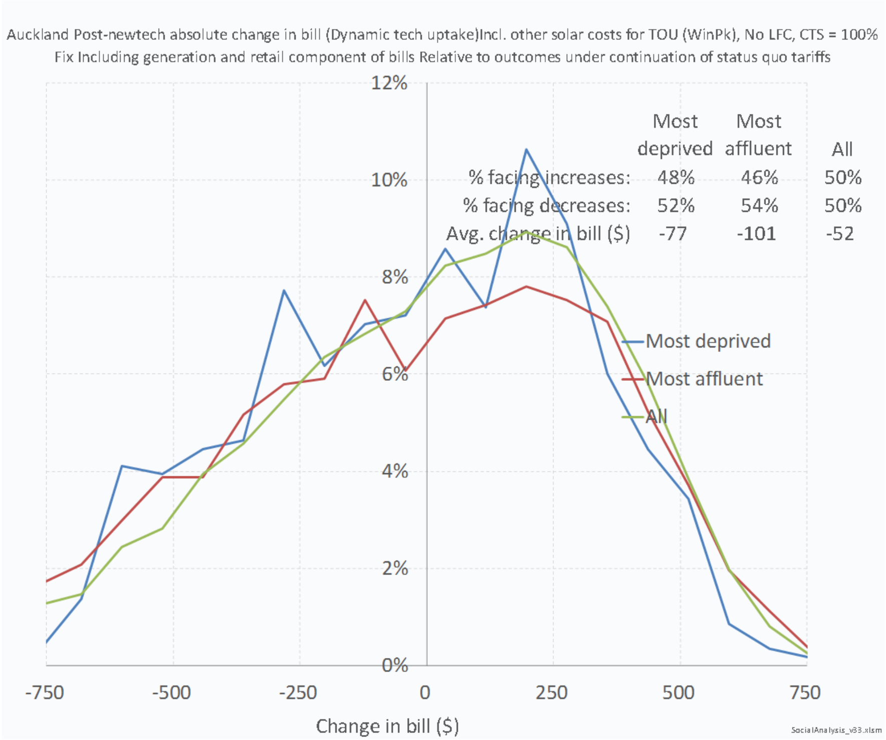


Figure 83: Christchurch

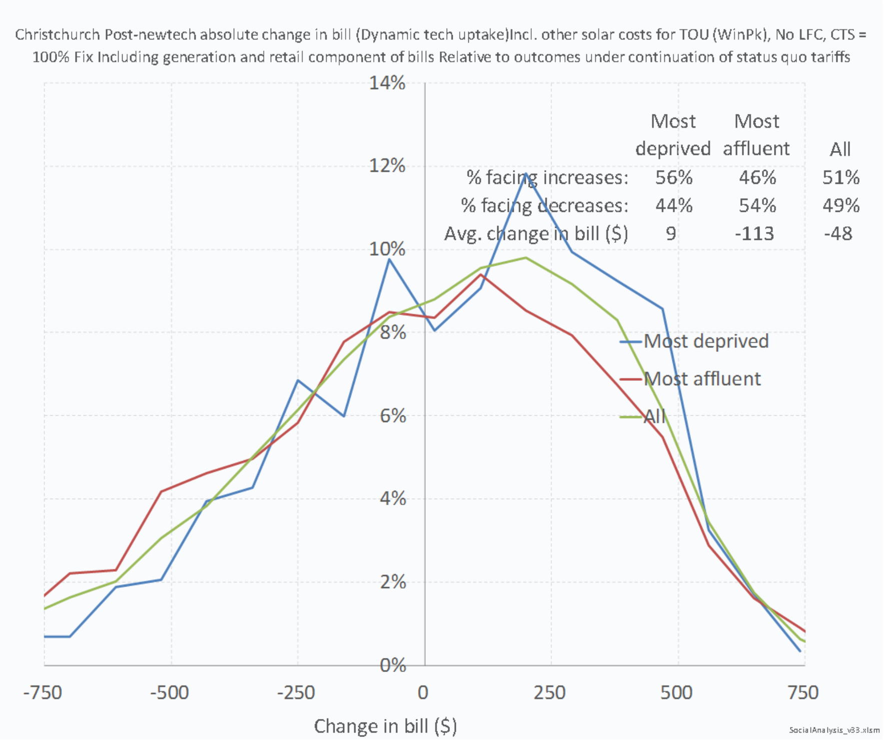


Figure 84: Dunedin

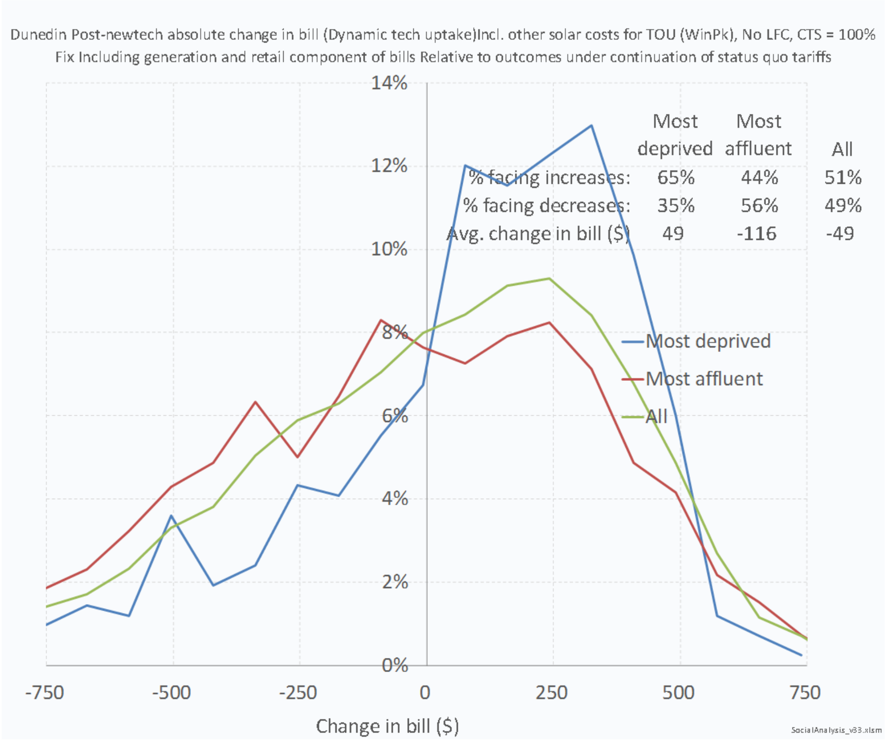
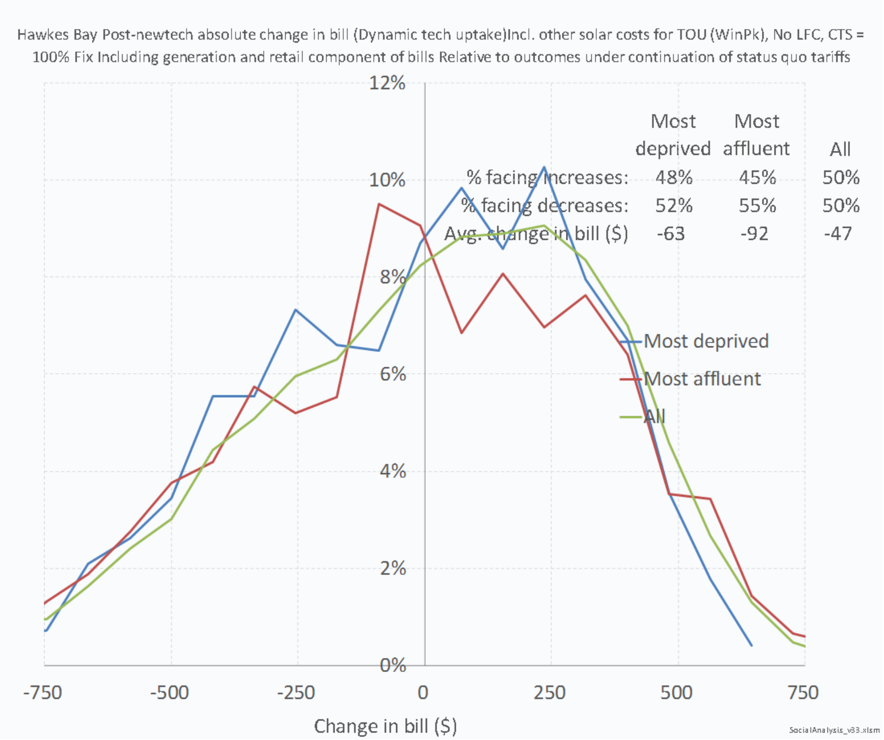


Figure 85: Hawkes Bay



Long-term impact of partially cost-reflective pricing – adopters and non-adopters

Figure 86: Wellington

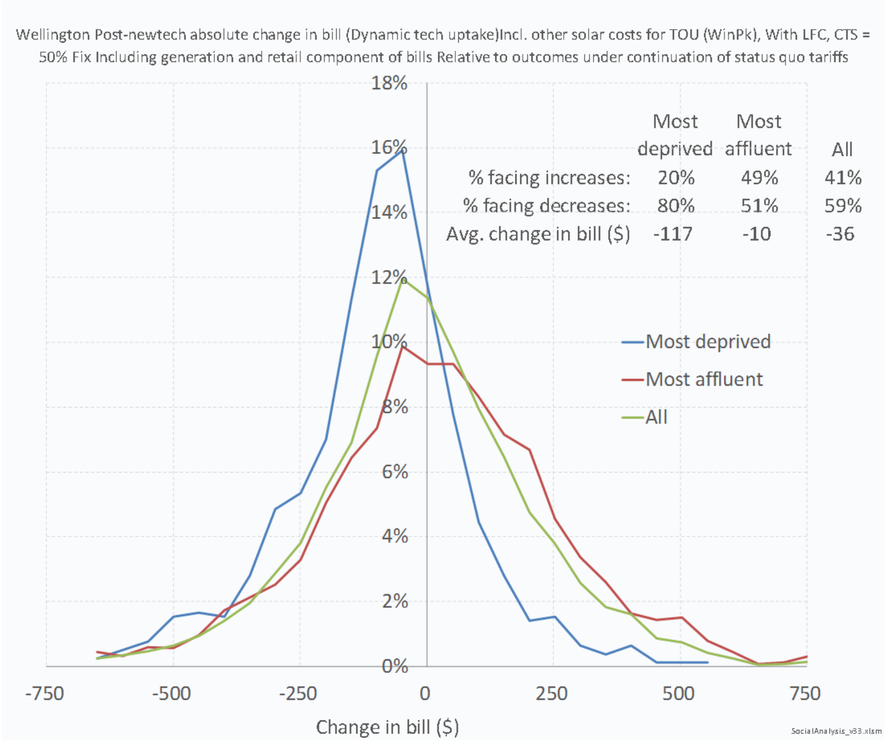


Figure 87: Auckland

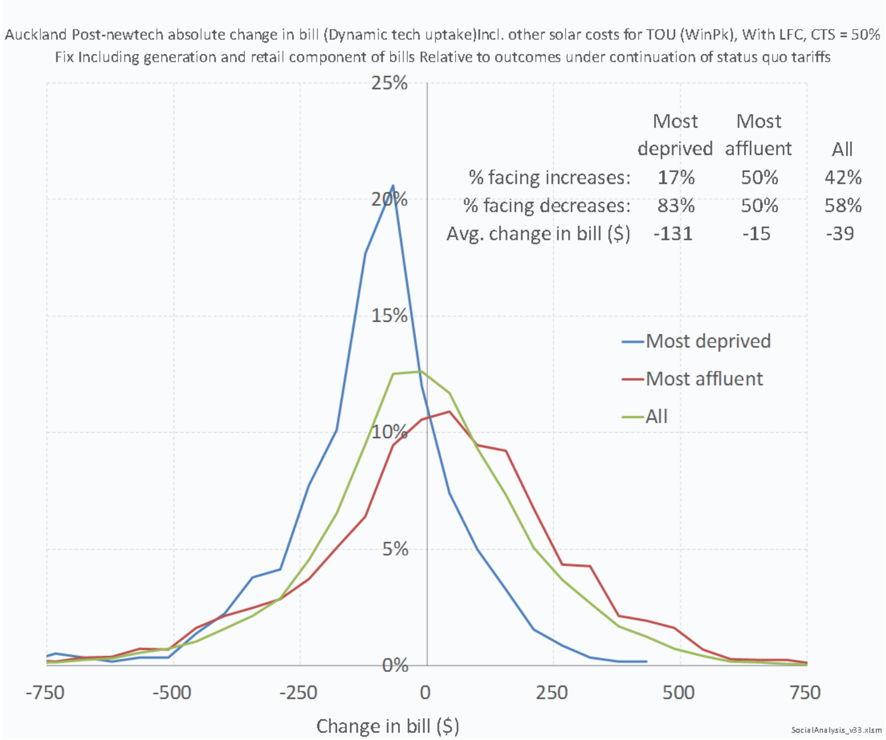


Figure 88: Christchurch

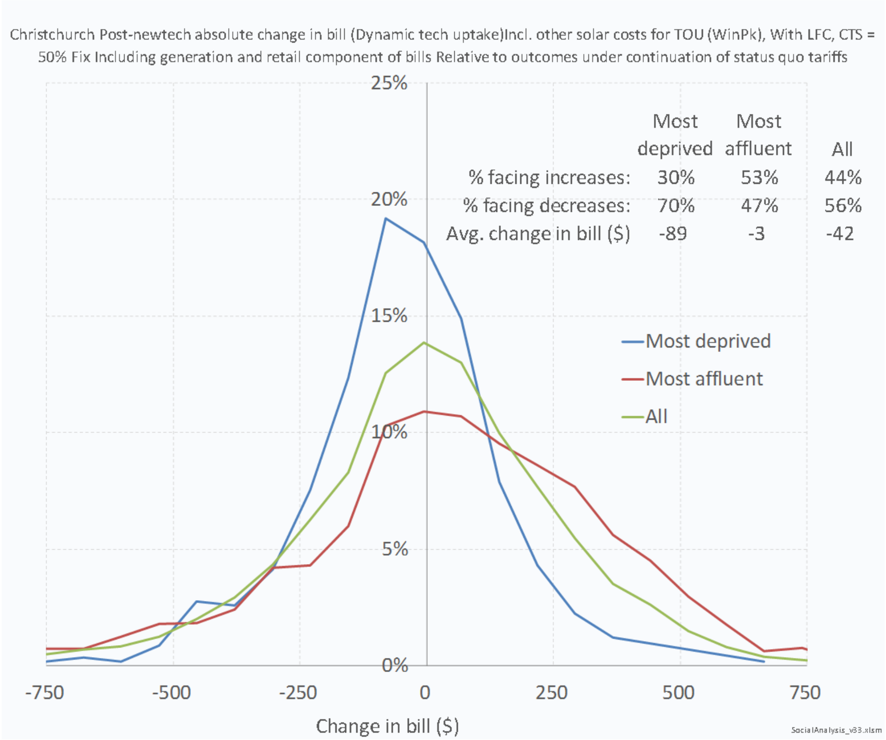


Figure 89: Dunedin

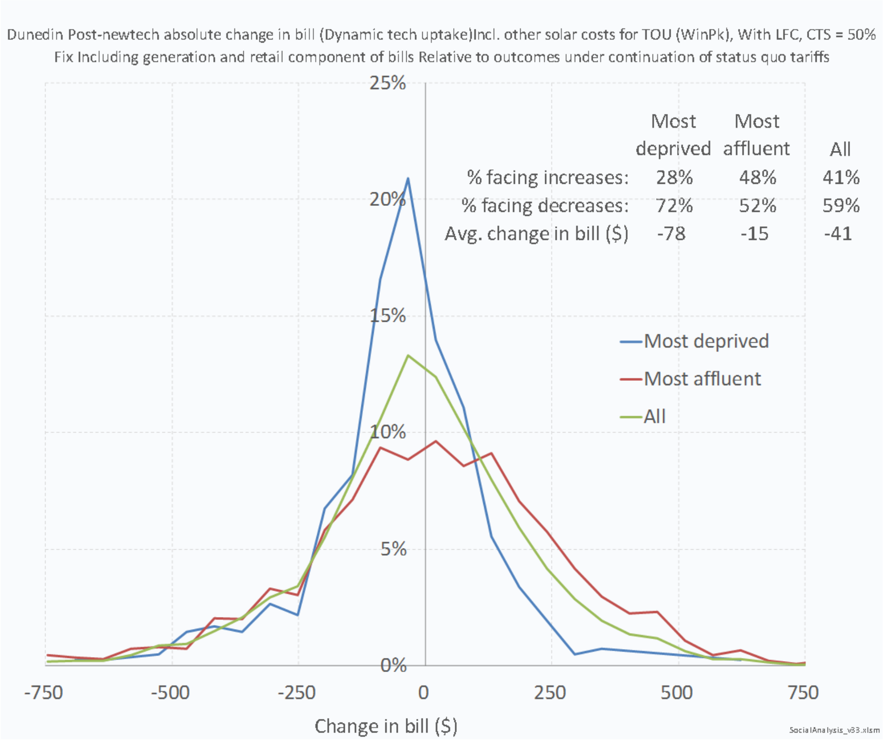


Figure 90: Hawkes Bay