Total Household Energy Costs NZ

Prepared for the Electricity Networks Association

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23 November 2022

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Executive summary

The transition to a decarbonised energy sector will required considerable investment in renewable energy, provisions for system security, distribution and transmission.

It begs the question: what can we expect for total annual average household energy costs through to 2040?

The answer is simple: from 2026 all electric households can expect the total annual electricity cost, including the capital costs required to switch, to be lower than the combined petrol, gas and electricity bills (including the relevant capital costs) they would pay otherwise.

Of course, nothing is ever quite that simple. Each household starts with its unique configuration of fossil fuel use, electricity use and total energy needs across heating, cooking, hot water and vehicles. One of the key variables is each household's transport patterns. One of the biggest gains in total household energy costs is the switch from internal combustion engines (ICEs) to mains charged electric vehicles (EVs).

The issue with EVs is that even though the fuel and operating cost of an EV is lower than an ICE today the capital cost of an EV is higher and a second hand market is limited. Even when the cost of new EVs is at parity with ICE vehicles, households that replace vehicles with second hand vehicles may struggle to make the switch for some time.

For household appliances the cost of replacing fossil gas space heating, hot water and cooking appliances with electric appliances is not trivial, and the whole of life cost benefits aren't as pronounced as the whole of life cost benefits of switching from an ICE to an EV.

The addition of domestic rooftop solar helps reduce the cost of mains power but, again, the capital cost is a barrier. The ideal configuration for households is rooftop solar plus batteries. However, while the installed cost of solar has fallen considerably in recent years, the cost of batteries is more stubborn.

The barriers to electrifying total household energy costs don't change the maths. For those that can manage the upfront cost of the switch, the total annual household energy costs will be lower than households who don't switch.

The primary benefit to switching stems from the reduced operating and maintenance costs of an EV compared to that of an ICE. In Figure 1 we compare the annualised household appliance and transport costs (including capital costs) of households using gas appliances, a bit of electricity and an ICE vehicle, with all-electric households. Figure 1 is a summary of Figure 10, which considers several combinations of household appliances and vehicles. Figure 1 shows the relative benefits for households which make the switch in a given year. As purchasing a vehicle in a given year 'locks-in' the capital cost, purchasing an EV in a given year locks in the annualised *cost differential* at that point in time for the lifetime of that vehicle.

So, in summary, we conclude that from 2026, all electric households can expect the total annual electricity cost, including capital costs, to be lower than the combined petrol, gas and electricity bills (including the relevant capital costs) they would pay otherwise.

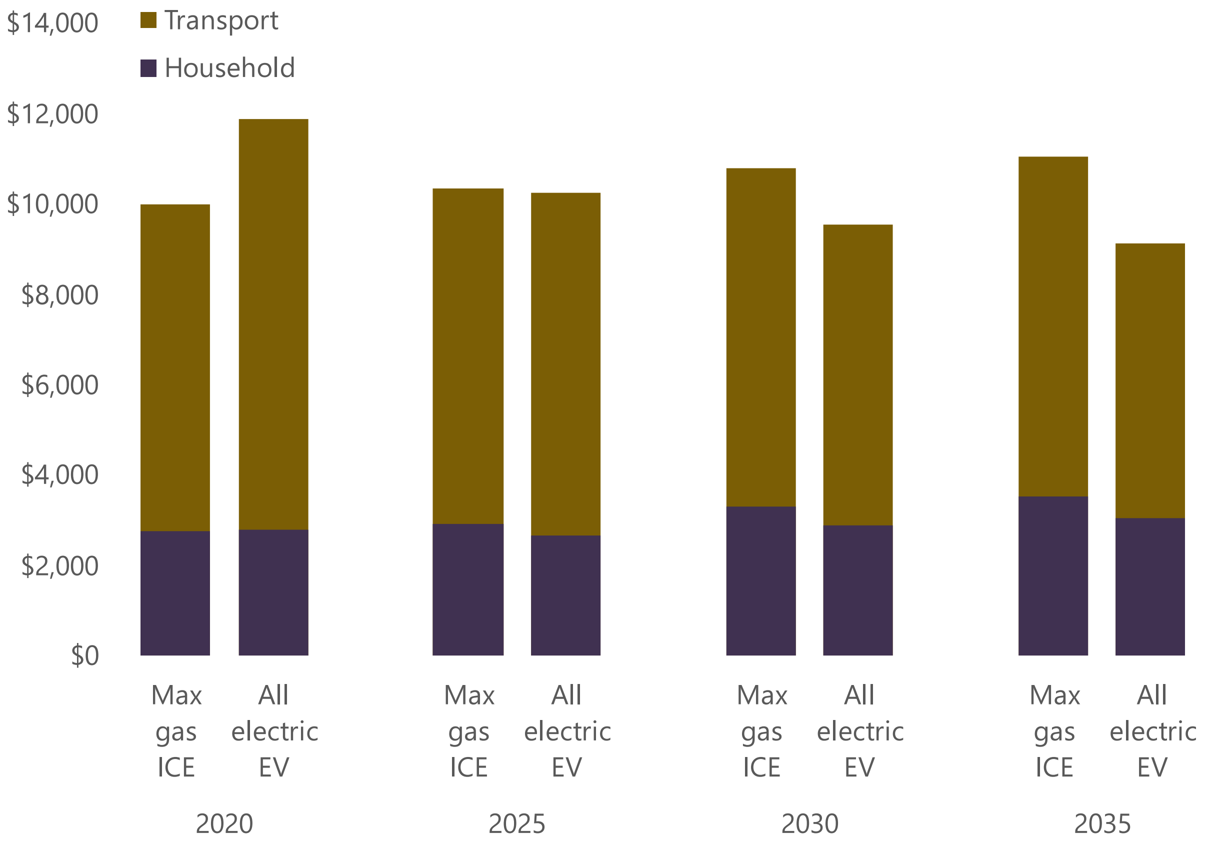

Figure 1 Annualised household appliance and transport costs (including capital costs) for households that make the switch to electricity in a given year.

1. The analysis

The question we address in this paper is:

What can we expect for total annual average household energy costs through to 2040?

The question arises partially because it's an interesting question given the transformation decarbonisation is bringing to the electricity sector, but partially because commentary on the subject can be confusing. The question around decarbonisation is whether less reliance on thermal fuel and the higher investment associated with meeting greater electrification demand can be done without raising average household energy costs overall. The confusion around statements on the subject tends to come mainly from the difference between what may happen to electricity prices as distinct from electricity bills and total energy bills (costs). The confusion may also be exacerbated by the difference between real prices and nominal prices. Different assessments may treat the capital costs of appliances and vehicles differently. There is the added factor of whether households already have rooftop solar installed or not.

Our approach:

- We explored the Rewiring Australia and Rewiring America work.
- We explored the relevant work carried out by the Climate Change Commission.
- We checked how total household costs were referred to in the government's Emissions Reduction Plan.
- We have been able to take into account the findings of a 2022 report by Boston Consulting Group.
- We elected to present a view of total household energy costs based on the CCC model outputs so the emphasis would be on the method rather than the assumptions.
- We note the directional impact changes in assumptions would have on the outcomes but have not provide a sensitivity analysis.

Each piece of work presents a legitimate conclusion based on the assumptions they made and the approach they took. Our approach has been to simply address the question set out above relying solely on the 2021 CCC data.

Rewiring Australia[1] - quoted below - is helping Australians to collectively narrate and illustrate the positive outcomes possible for Australia, and the world, in transitioning to rapid decarbonization using an "Electrify Everything" strategy:

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[1] In 2019 Saul Griffith and Alex Laskey founded Rewiring America to increase the U.S. climate policy ambition. Their strategy is to shift the climate narrative from one of sacrifice to one of practical solutions and savings. In late 2020, Saul used tools initially developed with the U.S. Department of Energy to model US energy flows and futures, and applied these to the Australian market. In 2021 The Australia Institute partnered with Saul and analyst Josh Ellison to complete the work of articulating and communicating the abundant commercial and environmental opportunities a rapid transition to clean electrification presents in Australia. Rewiring Australia launched in September 2021.

The model considers detailed household energy and vehicle use data (by state) and projects the capital and operating costs of the electrified substitution technologies each year through to 2035. Price and performance improvements of rooftop solar-PV, batteries, EVs and 8 key household appliances are modelled through the same period with known cost reduction learning curves. A balancing model is used to compare existing household energy costs with future costs that include the balanced replacement items and ongoing fees.

The most economical path to powering our everyday lives is to significantly increase rooftop solar take-up and fully engage the associated storage capacity in vehicles, house-batteries, and thermal systems, including hot water. Roughly 3 million Australian homes already have solar power infrastructure on their roofs and are receiving some of the lowest costs of delivered electricity in the world.

As much as there are lessons to be learnt from the Rewiring Australia project, the starting point for a New Zealand study is quite different. At issue is the penetration of rooftop solar and the cost of rooftop solar in Australia compared with New Zealand. Even so, the approach is comprehensive. Specifically, the Rewiring Australia study takes account of the difference between the annualised cost of financing an EV compared to an ICE for a vehicle brought in a particular year. As shown in Figure 2 the cost of an EV falls below a new ICE in 2027 and from that year on, the difference in the annualised finance costs becomes a benefit that can be taken into account when the total household energy cost is assessed.

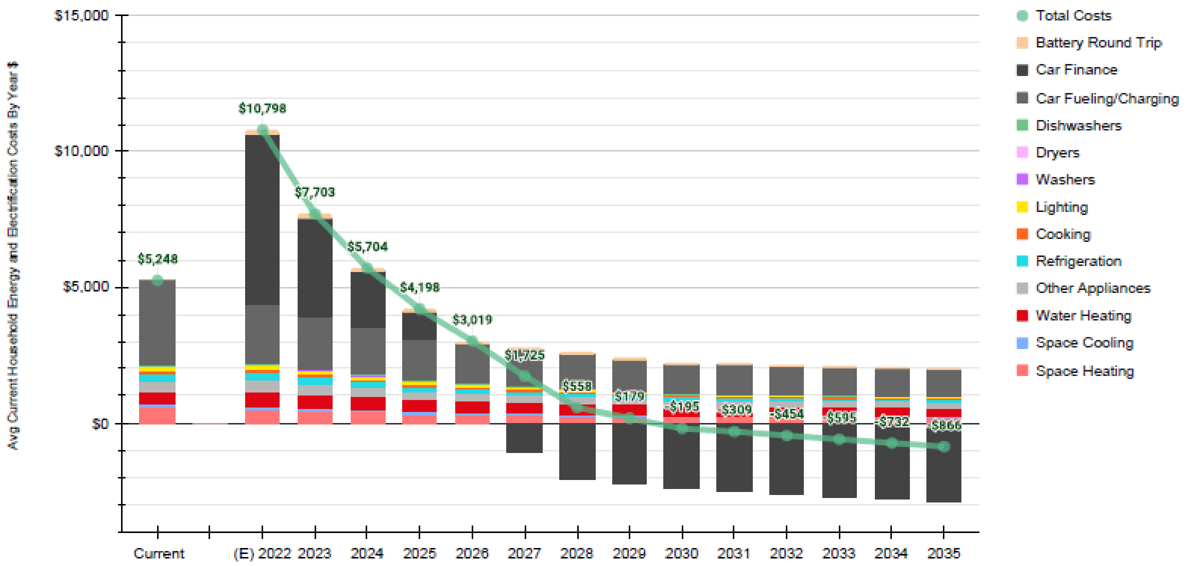

Figure 2 Australian household energy costs – current versus financed electrified household with solar and battery. Compared to electrified household with financed solar, battery and cost difference of appliance and electric vehicles (Source: Rewiring Australia)

Otherwise, real household energy costs halve, falling from ~A$2000 per household per annum to just under A$1000 per household per annum

What is particularly relevant for New Zealand in the Rewiring Australia is its narrative around EVs:

> Electric vehicles are approximately 3.5 times more efficient at converting energy into motion, and therefore unlock significant energy savings per household, and significant long-term cost savings when fuelled by (or charged with) cheap renewable electricity. Even charging an electric vehicle with the existing electricity grid will approximately halve fuelling costs, and if we charge our electric vehicles with our rooftop solar and home battery, we are looking at around ~67% savings in our fuelling costs.

This narrative is backed up by Bloomberg New Energy Finance:[2]

> Under the Economic Transition Scenario, passenger EV sales continue rising quickly as battery prices fall. Unsubsidized price parity between EVs and internal combustion vehicles is achieved in most segments and countries by the late 2020s. EVs also cost far less in fuel and maintenance. Clean energy technologies get cheaper as they are deployed, through economies of scale. Unlike speculative predictions about future tech breakthroughs, economies of scale have been observed in clean energy for 40 years and can be relied on when planning for the future.

The Climate Change Commission's supporting evidence to its advice to government on the emission budgets included an appraisal of total household energy costs in New Zealand.[3][4] Chapter 16 looks at:

> What impacts the climate transition may have on households and communities in Aotearoa, specifically the health co-benefits, changes to household bills, access to transport and the impacts of land-use changes.

Figure 3 reproduces figure 16.3 from the CCC supporting evidence. It compares the annual average cost to a household that relies on fossil gas for household energy (heating and cooking), and an internal-combustion engine (ICE) vehicle for transport ('Household 1') versus a household that uses electricity for household energy and owns an EV ('Household 2').

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[2] Bloomberg NEF Electric Vehicle Outlook 2022 See here

[3] Climate Change Commission advice to the New Zealand Government on its first three emissions budgets and direction for its emissions reduction plan 2022 – 2025, Ināia tonu nei: a low emissions future for Aotearoa, May 2021

[4] Climate Change Commission, 2021 Supporting evidence, Part 4: What could this mean for New Zealanders?, Chapter 16 Households and communities. See here

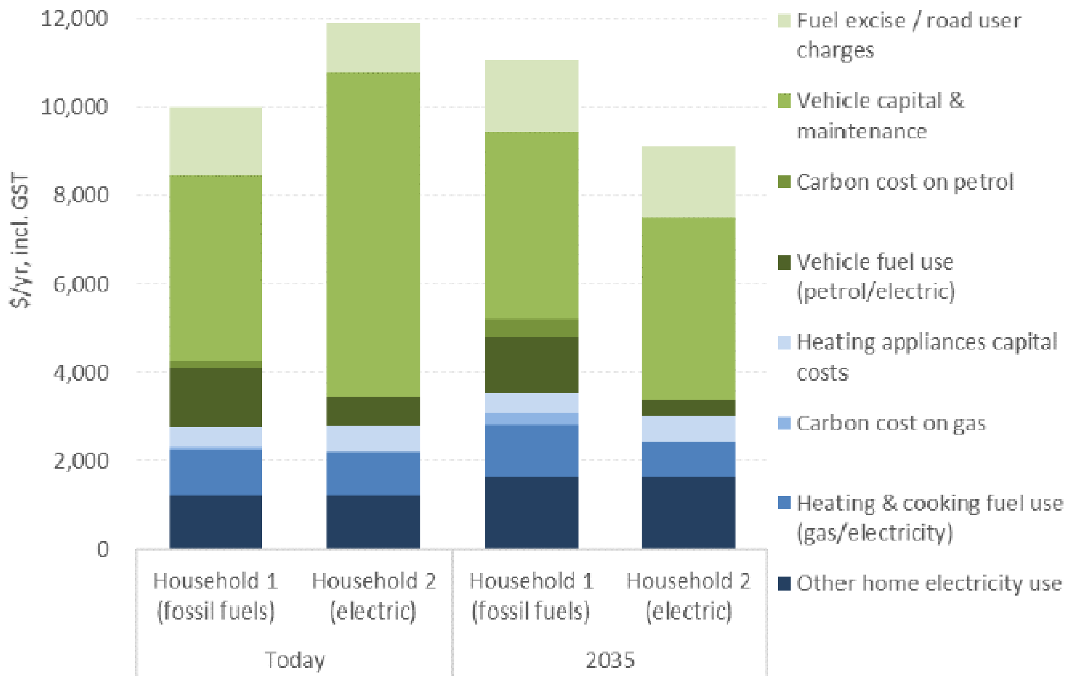

Figure 3 *Household average annual vehicle, heating and cooking costs under the demonstration path today (2020 in CCC) and in 2035. Household 1 has an ICE and uses gas for heating and cooking and Household 2 has an EV and uses electricity for heating and cooking.(Source Climate Change Commission)*

We note:

- The new vehicle capital and maintenance cost is lower in 2035 for the all electricity household compared with both household 1 and 2 today.
- The total household cost for the all electric household is lower in 2035 for the all electric household compared with both household 1 and 2 today.
- Major shifts are other home electricity use (mainly hot water heating) and vehicle fuel use (petrol/electric)

BCG recently released a Decarbonisation Roadmap for New Zealand Electricity Sector.[5] BCG's conclusion is consistent with the CCC's and our conclusion that a wholly electric household, including vehicles, will see lower electricity bills than a household that retains an element of fossil fuel use, especially ICE vehicles. BCG provides 5 scenarios and summarises its overall conclusion as:

> The energy transition will ultimately lead to lower average household energy bills – around 10% lower in 2030 and 45% lower in 2050 – as consumers benefit from significant fuel savings due to the electrification of transport.

[5] Boston Consulting Group: The Future is Electric A Decarbonisation Roadmap for New Zealand's Electricity Sector. October 2022. BCG was commissioned to write this report on behalf of several participants across the electricity sector. Concept Consulting conducted the quantitative modelling of pathways used in this report.

> EVs are already near-economic from a whole-of-life perspective. The CCC predicts that the whole-of-life cost of EV ownership will reach parity with internal combustion engines (ICE) in 2026 and will be 20% lower by 2030. By 2035, their modelling suggests a household with an EV would save more than $1,000 in energy costs per year relative to a household with an ICE vehicle.

We have explored the Climate Change Commission's underlying model and data outputs to understand more fully what trends and tensions are at play with a view to understanding what we can expect for total annual average household energy costs through to 2040.

The model underlying much of the CCC work is the 'Emissions in New Zealand (ENZ) Model'. This model was developed by Concept Consulting, with contributions from the Commission. The version that we have used to form our own analysis was finalised in 2021, and was the basis for much of the analysis behind the CCC's 'Ināia tonu nei: a low emissions future for Aotearoa'. We understand that the CCC continue to update this model with more recent data and information to help from their ongoing advice.

Figure 4 focuses on the electricity prices used in the CCC modelling.

This shows that for the average domestic household in New Zealand, the fully variablised real price of electricity (c/kWh) is expected to rise steadily from 2024. We note that the variable component of the price will decline but that is replaced by an increasing fixed component for lines charges.

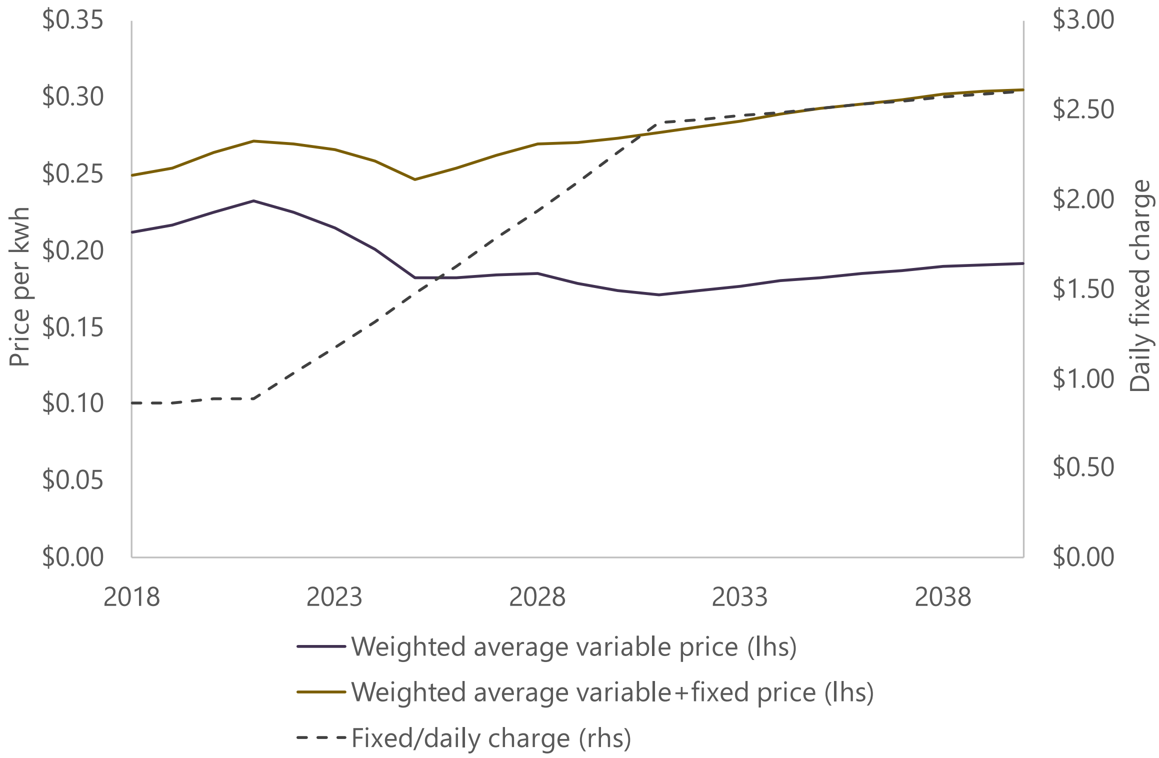

Figure 4 Electricity prices - all electric household (excluding vehicle recharging)

We are conscious that switching from fossil fuel to electricity, whether it is gas use in the house (space heating, hot water or cooking) or a petrol driven car, incurs an upfront capital cost, and so the option of switching to all electric is challenging for many households. We don't deal with the equity issue here. We simply show for those that can and do make the switch, they can expect to be better off from the time they switch, and we show by how much. We note that the Emissions Reduction Plan sets actions to achieve an equitable transition to a low-emissions world.

Households do not tend to turn over appliances like they turn over vehicles. To switch our space heating and/or cook tops and/or hot water heating can be time consuming and expensive so it may be hard for many households to find the motivation to do this. The issue with light vehicles is that even though the fuel and operating cost of an EV is lower than an ICE today, the capital cost of an EV is higher, and the second hand market is limited. Even when the cost of new EVs is at parity with ICE vehicles, households that replace vehicles with second hand vehicles may struggle to make the switch for some time. Indeed, CCC modelling suggests that, even in 2040, the average purchase cost of a second hand EV will be 20% more expensive than the equivalent ICE vehicle.

For the purpose of illustrating the average annual household energy costs over time, we have used the same approach as has been used by the CCC, BCG and Rewiring Australia/America. That is, we show the annualised capital cost of pursuing a fossil fuel versus an electrified option in a given year. This approach 'locks' the household into the capital cost path of the year the vehicle was purchased.

Figure 5 focuses on the combined energy cost for three representative household types:

- Max gas where the household uses natural gas for space heating, cooking and water heating and electricity for the remaining uses.

- Gas water heating where the household uses gas for water heating but electricity for everything else
- All electric where the household uses no gas at all and relies on electricity for all of its energy needs.

For the purpose of Figure 5, we hold total energy use constant so there is no reflection of any advances in energy efficiency. This aligns with the methodology used by CCC in its household energy cost comparison, extracted as Figure 3 above. Also, the representative household does not have rooftop solar.

Here we see the household energy costs, excluding transport, rising steadily from 2025. The all electric house experiences the lowest rate of increase because the slope of the gas price increase is steeper than the slope of the electricity price increases over the period.

Note this cost includes the annualised finance cost of electric appliances.

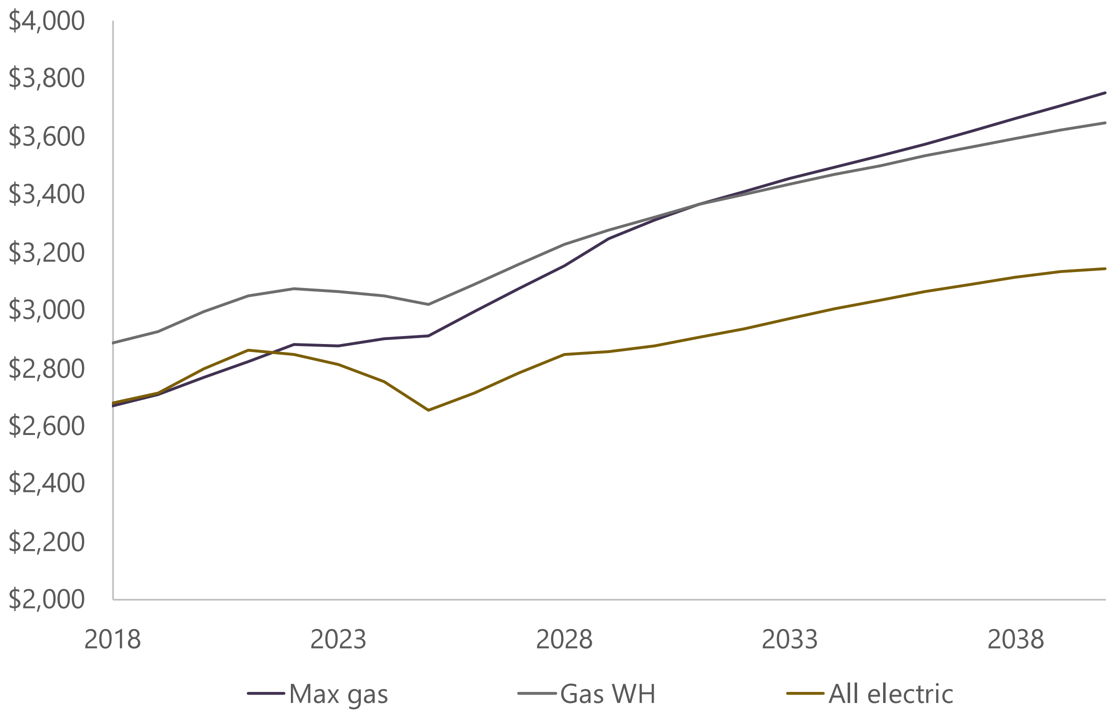

Figure 5 Annual household energy and appliance costs

Figure 6 turns to the transport component of household costs. The ICE line reflects a rising VKT[6], and petrol prices increasing solely in response to the carbon price, less an offset for more improved fuel efficiency over time.

The line representing EV costs is the equivalent of Rewiring Australia's combined car finance and car fuelling/charging series. It combines the annualised lifetime costs of an EV compared to an ICE (for demonstration purposes we use a petrol car), purchased in a given year. Lifetime costs include capital,

[6] Vehicle kilometres travelled

maintenance, roading and fuel/charging costs. This series represents the total light passenger vehicle transport costs for a single vehicle household. We see that the EV line crosses the ICE line around 2026.

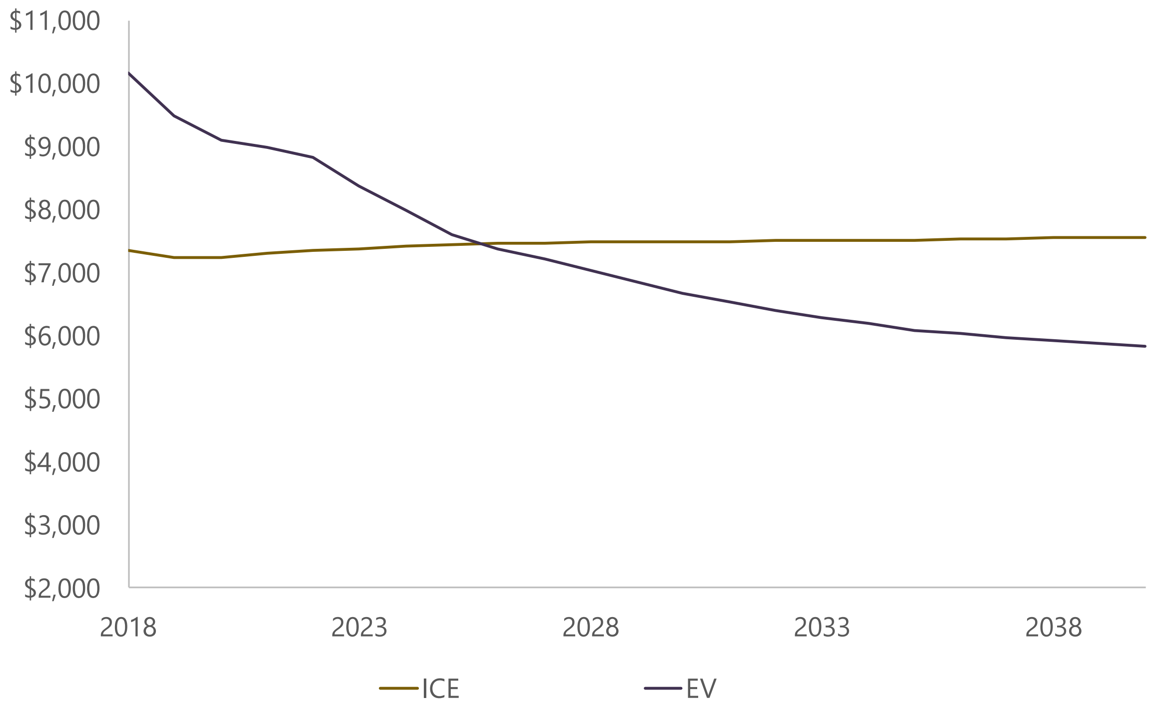

Figure 6 Annual transport costs

Figure 7 compares the energy costs, excluding vehicle capital costs, for an all-electric household that uses an EV versus an ICE vehicle. This shows that, even today, the ongoing running, operating and maintenance costs of an EV are cheaper than those of an ICE. As above, this is primarily due to the cost-efficiency of converting electricity into motion compared to fossil fuels.

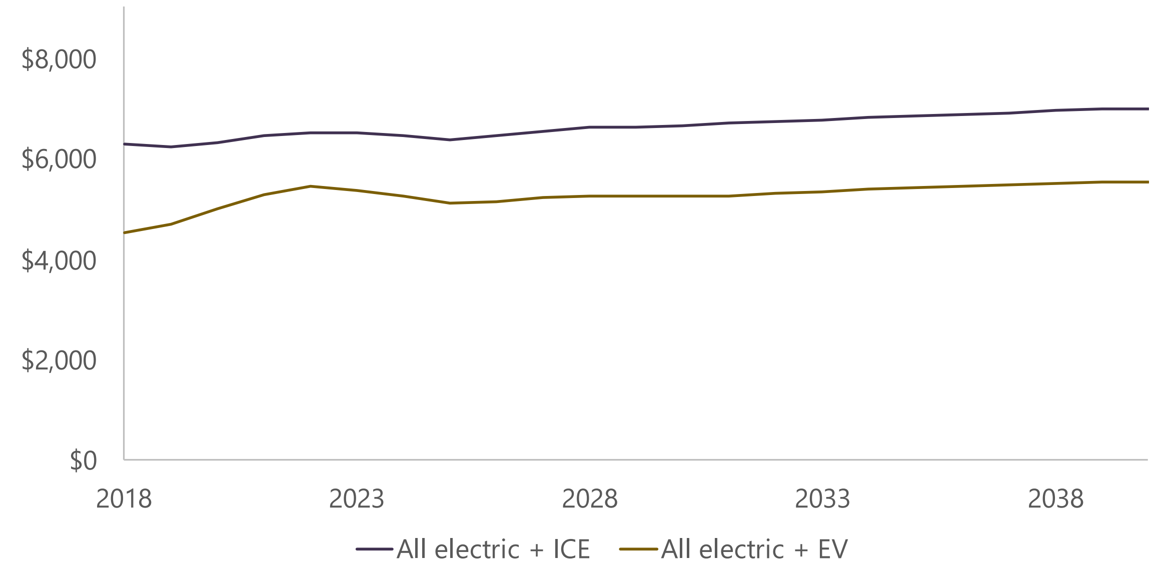

Figure 7 Annual household energy costs, excluding vehicle capital costs

Figure 8 shows the annualised capital cost of an average EV compared to that of an ICE, for both new and used vehicles. A new EV achieves purchase cost parity around 2033. However, despite the gap in the purchase cost of a second hand EV decreasing significantly over time, it remains approximately 20% more expensive to buy in 2040.

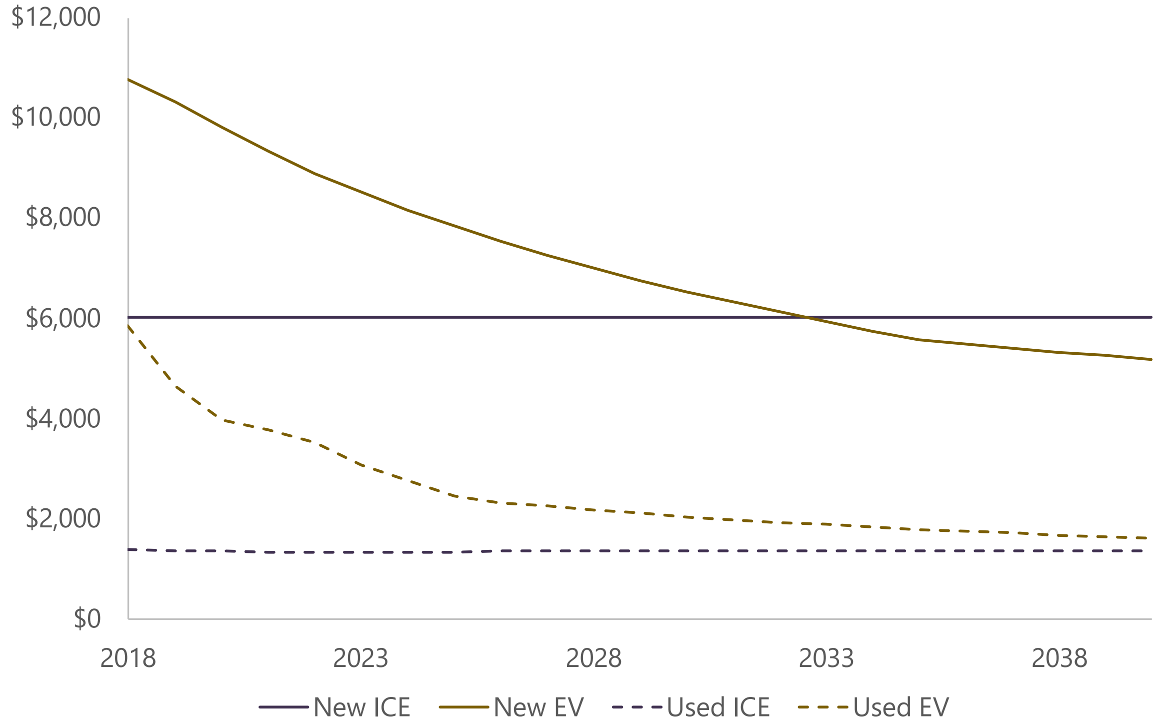

Figure 8 Annualised vehicle capital cost by purchase year

Figure 9 combines the cost differentials for annualised vehicle capital and the operating and maintenance savings of an EV versus an ICE. It shows that by around 2025/2026, the increased capital outlay for a used EV (compared to an ICE) is more than offset by the annual savings in running costs.

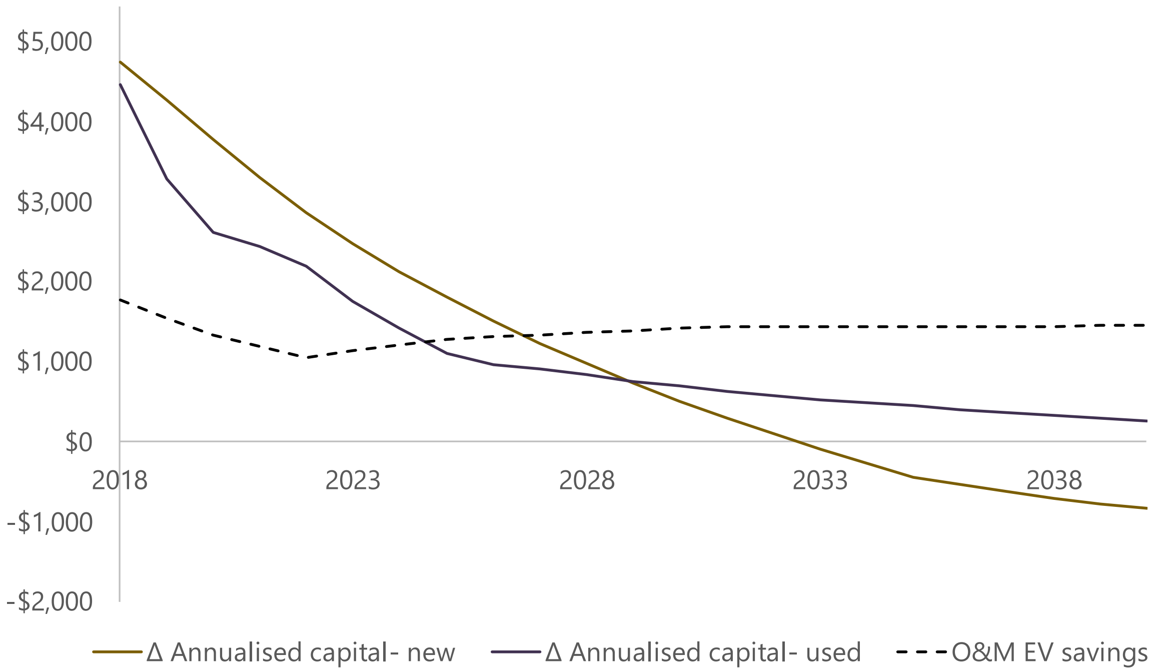

Figure 9 Transport cost differentials

In Figure 10 we present the annualised costs for 6 combinations of natural gas and electricity use for household appliances, and the annualised lifetime costs of an EV versus an ICE vehicle. This shows the relative benefits for households which make the switch in a given year.

The primary benefit to switching stems from the reduced operating and maintenance costs of an EV compared to that of an ICE. As purchasing a vehicle in a given year 'locks-in' the capital cost, purchasing an EV in a given year locks in the annualised *cost differential* at that point in time (i.e. the difference between the lines) for the lifetime of that vehicle. We note that the differential does slightly increase over time, due to the increasing relative price differentials between gas and fossil fuel costs (including carbon costs) versus electricity.

We see that from 2025 – 2026 an average household that switches to an EV for their transport needs has lower total annual household costs than a household that continues to replace its cars with ICE vehicles. From that point on, out of the 6 scenarios, the superior total annual average household cost is enjoyed by households with all electric appliances and EVs.

This begs the question: if the all-electric household and transport is the cheapest household energy cost, why would any household not move to that scenario? Reasons are:

- The cost of switching out appliances is not trivial
- For many households the capital cost of EVs is prohibitive. The lower a household's annual VKT the less compelling the whole of life cost of the vehicle will be. The feebate scheme was designed precisely to ease the capital cost shock and it has been successful.
- The uptake of EVs is also limited by vehicle availability and liquidity in a second hand market. It may be inhibited to some degree by the density of charging infrastructure and range anxiety, although both of these should be subsiding.

The Emissions Reduction Plan doesn't repeat this analysis because it is more focused on the policy response to the recommended budgets. In recognition of the importance of encouraging the switch to EVs, the ERP says:[7]

> The Government will build on existing policies to accelerate the uptake of low- and zero-emissions vehicles

But all that aside, a clinical decision based on whole of life vehicle costs would result in a decision to switch to EVs sometime after the mid-2020s. By 2040 the real annual difference between max fossil fuel and all electric is ~$2,400

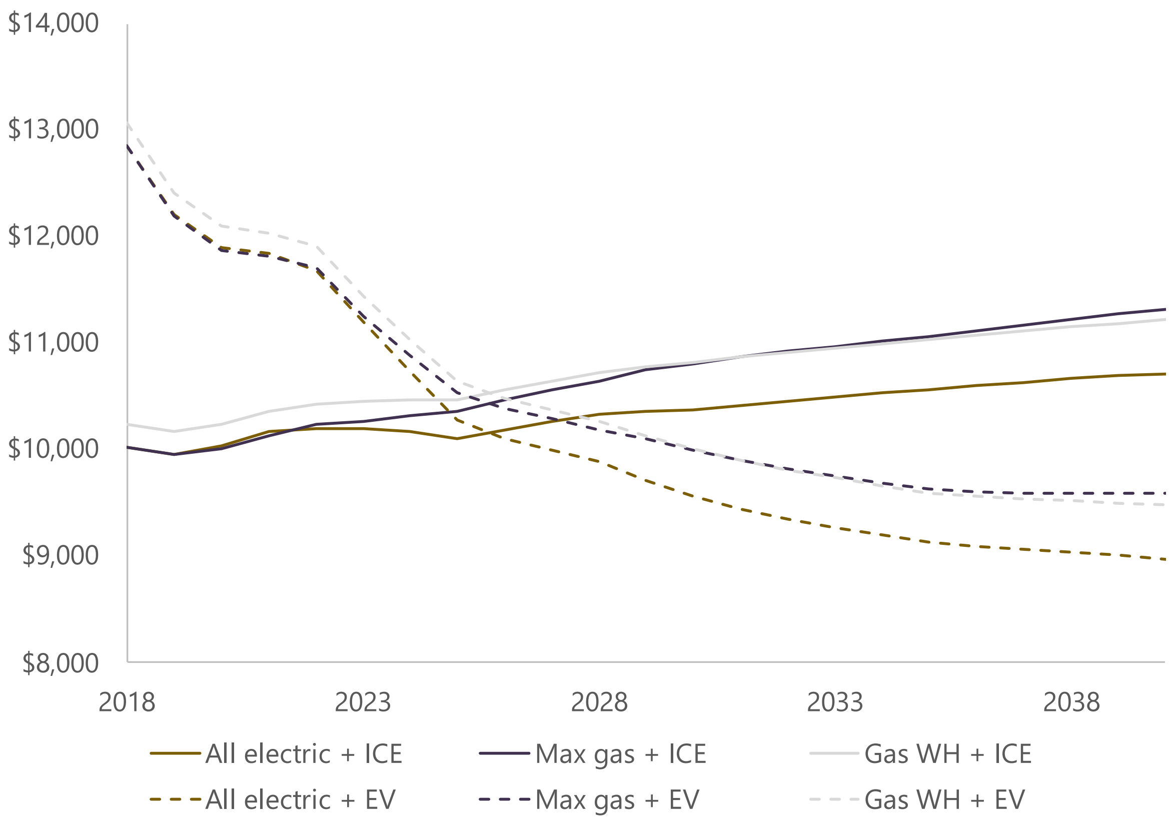

Figure 10 Annual household energy, appliance and transport costs

We note that if wholesale energy costs are higher than forecast, if distribution capex is higher than forecast and/or if EV capital costs don't fall as fast as expected, the all electric household line would be higher than shown and, therefore, may cross in a later year. However, what is inevitable is that the lines will cross, based on the relative efficiency of electricity vs fossil fuels and their respective prices. The total cost of household energy, including vehicle capital costs, will be lower for the all electric household, but the cross over to when it will be lower may be later.

We recognise that for the reasons discussed above and other preferences, there will not necessarily be a rush to switch electricity household appliances and light vehicles. However, Figure 11 shows an indicative path of relative costs, primarily driven by the switch from an ICE to an EV. For consumers

[7] Emissions Reduction Plan Action 10.2.1: Accelerate the uptake of low-emissions vehicles

who purchase an EV from the mid-2020s, based on the CCC assumptions, their total household real energy cost would be lower than if they were to stay with the ICE vehicle. This is even in the face of rising real electricity prices and higher *electricity* bills.

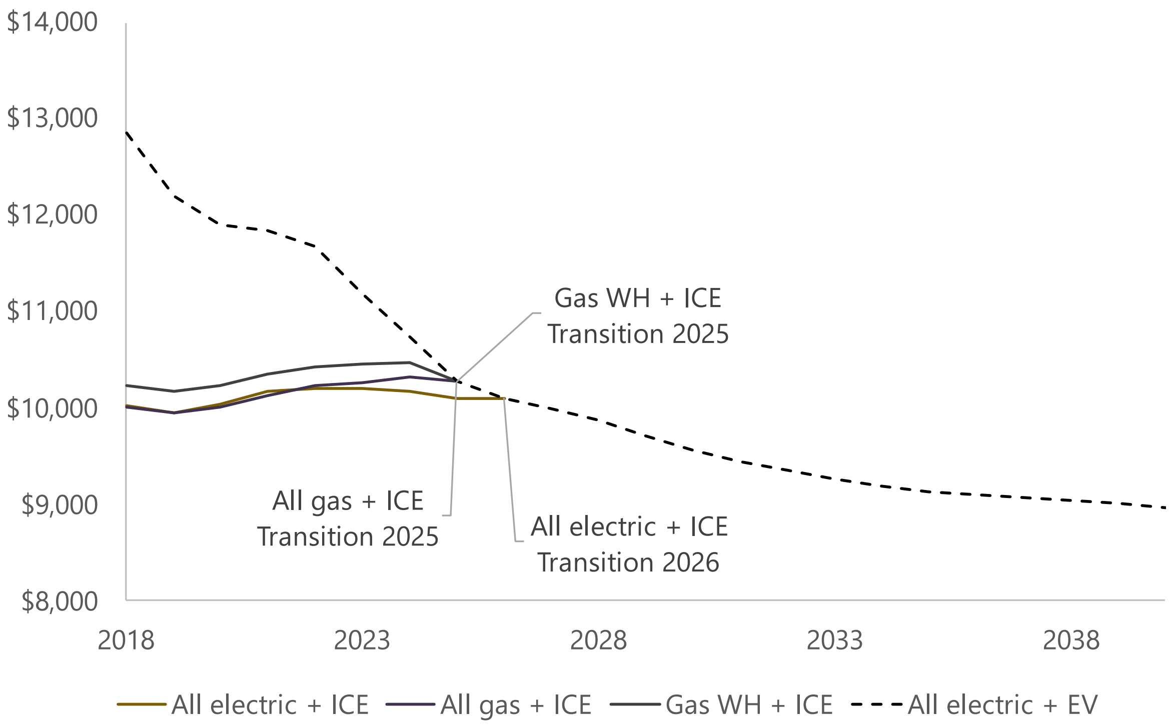

Figure 11 Single stage transition to "All electric household + EV"

As an addendum, we tested the CCC data to see the impact of rooftop solar. This is important because rooftop solar plus batteries features strongly in the Rewiring Australia analysis. The assumed cost of solar in Australia is $1/Watt unsubsidised, but the cost of installing solar is significantly higher in the US and New Zealand (~$3/W). Including batteries increases the installed cost further.

For this exercise we looked at the impact on household energy costs based on the CCC data noting:

- CCC models rooftop solar for total national generation/demand, not for the household energy wallet
- We have extracted cost (capital + ongoing fixed and variable costs) and availability assumptions from the model to form our analysis
- Oversimplification applied for solar savings – all solar generation is used by the household as it is generated (no buy back or battery assumed)

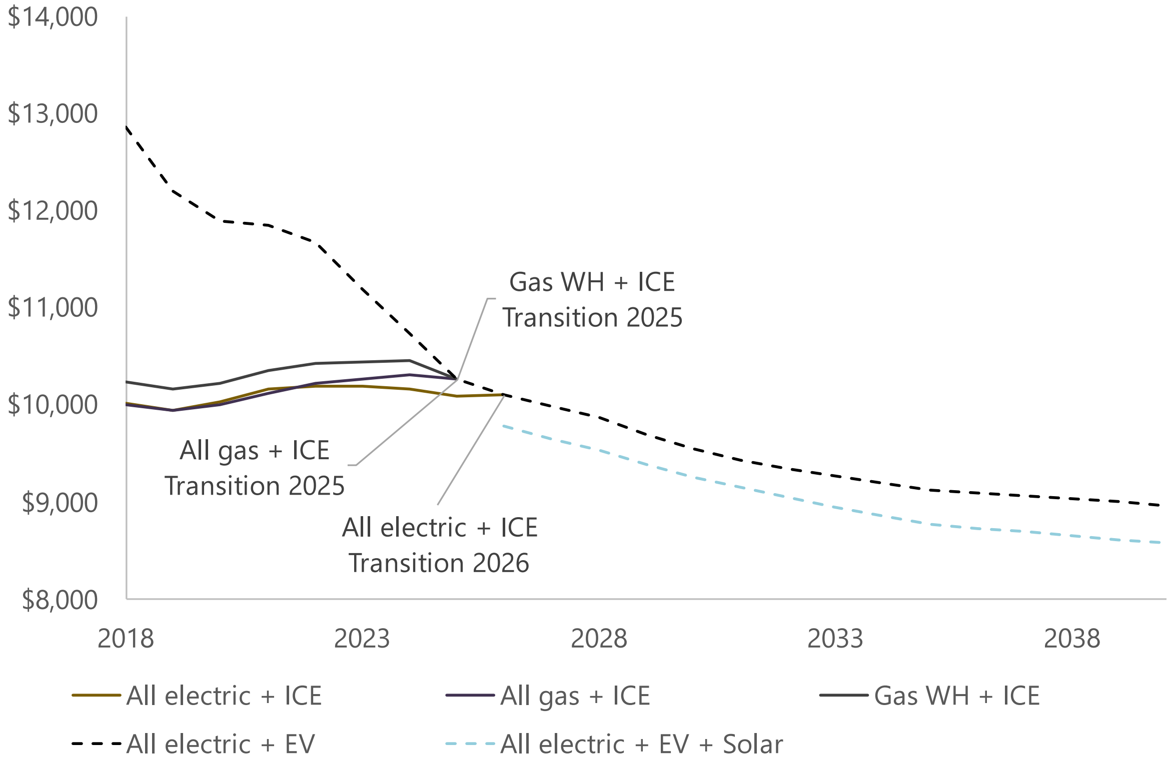

Figure 12 Transition to "All electric household + EV" with Solar

On this basis we would advance our conclusions from this study as follows:

Consumers who switch all of their energy use to electric, will see lower total household energy costs than if they were to stay with their existing combination of fossil and electric energy use. Installing rooftop solar could further reduce total household energy costs.

2. Assumptions

We based our analysis and modelling on the CCC's model inputs and outputs. Our assumptions include those that we make and important assumptions the CCC makes that are relevant to our work.

Sapere assumptions

While we make a few assumptions for our modelling, we align ourselves with the assumptions the Climate Change Commission makes in its report/modelling. This is primarily for comparability purposes.

- All dollar values are presented in real terms ($2020). This aligns with the CCC modelling
- Household useful energy is held constant over time, and equal for gas and electric households. Delivered energy also remains constant over time and is dependent on fuel type. Again, this aligns with the CCC modelling of the snapshot household energy costs presented in their Figure 16.3.
- Capital and maintenance costs are annualised figures based on the lifetime costs of appliances and vehicles. This is extracted from the CCC modelling, and aligns with its Figure 16.3 methodology.
- Rooftop solar:
  - 3.5 kWh installation based on CCC assumed average rooftop solar installation size.
  - 14.5% capacity factor. This is the same as the CCC use.
  - Electricity is used as it is generated (i.e. no buy-back or cost of batteries/storage)

Many of these assumptions differ from what is in the 'macro' level modelling that CCC completed. For instance, they model increased thermal efficiency of houses over time (i.e. space heating useful energy would decrease over time). However, to improve understanding and demonstrability, we assume less changes over time. In this way, we also do not force capital expenditure assumptions, such as in the case before where a household would have to improve their thermal efficiency over time.

It is also important to note that the modelling represents an 'average household'. In other words, there will be a distribution of household energy and transport use, which will likely shift crossover/breakeven points, and it's possible that no household looks exactly like the one used for modelling purposes.

Climate Change Commission

- Petrol prices increase (in real terms) due only to increasing carbon costs over time.
- Small improvements over time in fuel efficiency for both petrol and electric vehicles.
- VKT per vehicle per annum increase 0.5% per annum.
- EVs predominantly charge at home (increasing over time, with < 90% from 2027).
- Retail electricity prices shift towards cost-reflective pricing over the period 2022-2031.
- Gas fixed charges remain constant, while variable charges increase over time, primarily due to decreased demand (from less gas ICPs). This is because allowable revenue scales at a less than 1:1 ratio; transmission revenue decreases by 30% of demand, distribution revenue decreases by 60%.

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