ATA Response to Frontier Economics' Draft Report on Household Fuel Models

May 2017

This is the ATA's final response to Frontier Economics' draft report on the modelling and methodologies for the ATA's household fuel choice project. This has been developed following discussion with the reference group and the Frontier team – and incorporates much of their feedback – but does not have the explicit endorsement of the reference group.

In this response, we address the key issues that Frontier has identified, discuss them, and give our response. The accompanying document *Summary of Frontier recommendations and ATA response* responds to each recommendation from the summary tables in the draft report.

The general approach

Frontier advises that a top-down approach – using aggregated actual consumption data allocated to major appliances using conditional-demand regression analysis – is likely to be simpler and more accurate than ATA's bottom-up approach, which uses assumptions about appliance types and usage to model appliances' energy usage and adding it to underlying consumption profiles to calculate bills.

We agree that Frontier's proposed approach is simpler, and that it is likely to be more accurate in understanding the comparative economics of existing household appliances. However, the objective of this project is to estimate future costs of new appliances – comparing new efficient gas appliances with equivalent new efficient electric appliances doing the same work. We don't believe this can be done with sufficient accuracy using usage data based on an unknown mix of appliances of various ages – and our responses to some of Frontier's suggestions highlight the potential inaccuracies of using a top-down approach for this purpose.

Significantly, this project is not attempting to assess the relative competitiveness of gas and electricity as household fuels across the NEM; rather, it is seeking to inform households facing an appliance replacement choice of the relative economics of choosing a gas or electric replacement. This is encapsulated in the project's 'problem statement':

Technological changes in heating, hot water, and cooking appliances mean that people's understanding of the economics of different fuels may be out of date. Increasing fuel prices make the cost outcomes more significant. Accurate information on the economics of gas and electricity as household fuels for new appliances will help consumers make informed decisions about appliance replacement, and inform public policy.

The fundamental issue

A number of the issues Frontier identified in the models and methodology are related directly or indirectly to the inconsistency in how the different loads are calculated.

Marginal cost of heating, high and low weekday usage differences

ATA's approach was to calculate annual heating and cooking loads, but daily hot water loads. Electric hot water loads were added to households' underlying consumption profiles, while gas loads were calculated monthly and electric heating and cooking loads calculated annually. This led to inaccuracies in calculating the marginal cost of electric heating and cooking, and led to complexity in the modelling process. It also made it difficult to account for different heating behaviour of households with low and high weekday usage.

Climatic variability of household consumption

Additionally, our use of a limited number of underlying consumption profiles diminished the climatic variability of household consumption because while heating and hot water calculations were based on climatic conditions, cooling differences were not reflected in the profiles. This did not adversely impact heating calculations (because heating and cooling do not significantly overlap) but affected solar calculations and the marginal cost of electric hot water

Impact of solar generation on all end-uses

Because heating and cooking were not reflected in load profiles, we were unable to calculate the contribution of solar generation to those loads. Our decision to only offset hot water with solar was largely driven by this (though the limited overlap of heating with solar generation and the low energy use of cooking made it a small inaccuracy).

ATA RESPONSE

We intend to address all of these issues by making a fundamental change to our approach. ***We will build a heating and cooling model that will use NatHERS and E3 data[1], along with 30-minute air temperature data,[2] to determine heating and cooling energy requirements.*** *This model will use the parameters such as the temperatures at which heating or cooling is required and the temperatures to heat and cool to, in order to produce 30-minute heating and cooling loads to be added to underlying consumption profiles. These combined profiles will be used in Sunulator to calculate electric heating consumption, and will thus be available for solar calculations. The heating profiles can also be aggregated as daily loads for gas heaters for use in Gasulator.*

The cooling profiles will add more granular climatic variability to the household profiles. This will improve the credibility of the household profiles and ensure that cooling is accounted for when calculating the impact of solar generation to electric heating and hot water costs.

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[1] Eric Peterson, *Climate zone mapping for air conditioners and heat pump devices*, Equipment Energy Efficiency Program (E3), Commonwealth of Australia (Department of Industry), 2014

[2] Previously purchased from the Bureau of Meteorology for use in Sunulator http://www.ata.org.au/ata-research/sunulator

Because we will be adding cooling to all profiles, we will need new underlying consumption profiles that don't have cooling. We will use interval data from southern Victorian households matching our household types' composition that have gas heating, cooking, and hot water, and no cooling (or with cooling removed, which is easily done with southern Victorian profiles because they have few cooling days).

(Our interval data library contains a large number of Victorian profiles with demographic descriptors.) We will sense-check our profiles against actual customer profiles of similar households in different climate zones.

Because the heating and cooling profiles are based on 30-minute interval data, they can easily be adjusted for the low-weekday-usage households to reflect their lack of weekday heating and cooling.

Overall, this approach will accurately model heating and cooling energy usage for the various household types and locations; improve the calculation of the impact of solar on the economics of fuel choice; and improve cost calculations in general by fully capturing the impact of consumption amount on marginal cost.

Household types and scenarios

Frontier considers that the underlying consumption profiles don't appear to reflect household composition or geographical differences in consumption; are too limited to be representative of the diversity of household consumption profiles across the NEM; and show too much variance from day-to-day to have credibility as underlying consumption. They also note that not including apartments is an oversight.

Household composition

We agree that there are inconsistencies in the assumed composition of the household types and the consumption profiles assigned to them – and in the labelling of household types in the models. This was largely due some lack of clarity in our written methodologies, and some errors made when revising them (from the 2014 methodologies).

ATA RESPONSE

We have revisited the household profiles (which are derived from actual consumption profiles) corrected the household composition information, and clarified the dwelling types. We have also selected new profiles for the Large Home and New Build, because we identified flaws in their original profiles. These changes have been reflected in the modelling where relevant (e.g.: hot water model, which is based on the number of people in each household type).

ATA is confident that the profiles for all household types now align with their assumed composition.

Original household name	New household name	Dwelling type	Adults	Child-ren	Energy usage profile
1: Large house	1: Large home	Large detached (3-star)	2	3	High consumption profile
2: Small house	2: Small and frugal	Small detached or semi-detached (3-star)	2	-	Low consumption profile
3: Stay-at-home family	3: Medium home – young family	Medium detached (3-star)	2	2	Medium consumption, moderate weekday usage
4: Working couple	3: Medium home - older family	Medium detached (3-star)	2	2	Medium consumption, low weekday usage
5: New build	5: New build	Large detached (6-star)	2	3	Medium–high consumption profile

Geographic differences

Frontier considers that the household profiles do not adequately reflect differences in consumption patterns in different geographic areas, and recommended that we use different profiles for different climate zones.

ATA RESPONSE

Among the many drivers of energy consumption, cooling, heating, and hot water are most impacted by climate. ***Because we will calculate heating, cooling, and hot water loads separately, and climate-related factors are part of the modelling approach, climate-related differences in underlying consumption are of less significance*** *than if the profiles were representing all consumption.*

Household representativeness

Frontier considers that our households are not diverse enough – in terms of composition, and thermal performance, among other things – to represent the variety of household types and consumption patterns in the NEM.

ATA RESPONSE

ATA agrees that our approach is not granular enough to account for the many different household types and energy consumption behaviours in the NEM. We don't have the capability to undertake the project at that level of granularity. We have chosen household types to represent typical mainstream household types (guided in part by AGL's research that households with dependent children are among the most sensitive to fuel costs), and ensured that our profiles cover typical low, medium, and high consumption patterns so the results are indicative of the impact of fuel choice for different levels of consumption. The choice to presume a 3-star energy rating is made partly for simplicity, and partly because we consider 3-star to be fairly common for houses with ceiling insulation and whose occupants are wealthy enough to be owner-occupiers and able to make an informed choice about appliance replacement and fuel type. In the end, the results only hold for the sample households we have chosen.

ATA is confident that the choice of household types is sufficiently diverse to make the findings significantly relevant for many households in the NEM, and generally informative for many more.

Credibility of underlying consumption profiles

Frontier considers that the underlying consumption profiles show too much day-to-day variability (with unusual patterns of peaks and troughs) to have credibility as representing consumption of appliances other than heating, hot water, and cooking. They recommend the use of actual consumption data to sense-check the profiles.

ATA RESPONSE

The underlying consumption profiles are derived from actual profiles from households with gas cooking, heating, and hot water. Some supplementary electric heating may be present, but this may also occur in any household regardless of the primary heating appliances they use. Variance in underlying consumption is explained by variation in household activities, such as going away for a holiday, having houseguests, or household members doing different types of activities with different usage of electrical appliances for various periods of time.

ATA is confident that the underlying consumption profiles are credible.

Apartments

Frontier notes that increasing numbers of household live in apartments, and that the absence of an apartment household type reduces the representativeness of the households.

ATA RESPONSE

ATA agrees that apartments are increasingly significant, especially in cities. However, we also note that fuel and appliance choice is much more limited for many apartment dwellers. Many apartments are not suitable for reverse cycle air conditioner (RCAC) installation or heat pump hot water systems due to lack of external space for the heat pump. Additionally, many apartments have bulk hot water arrangements, so apartment owners have no control over their hot water appliance. Cooking loads alone are too small to have much significance. Also many apartments are rented so occupants have no ability to choose fixed appliances or fuel sources.

ATA agrees that inclusion of an apartment household type would add value, but not enough to justify the additional work required for this project. We will consider including an apartment archetype in subsequent projects of this nature.

Cost calculations

Frontier notes that bill calculations are done incorrectly, thus not reflecting the true value of additional costs or savings from appliance options; that changes in consumption caused by changing costs are not reflected; that seasonality is not reflected; and that future costs are not credibly forecast.

Accuracy of end costs

Frontier notes that the various models used in the project calculate costs differently. Most significantly, bills are calculated using entire household consumption on actual tariffs for the business-as-usual case; but the running cost of replacement appliances in some scenarios is calculated separately on a flat-tariff basis. This means that interplay between fixed and variable tariff components, and the effect of tariff blocks on unit costs, is not factored in.

ATA RESPONSE

ATA agrees that the approach to calculating costs is imperfect. This reflects the lack of block tariffs in 2014 when the project was first undertaken, and a decision to use the per-kWh charge as the energy cost, rather than the derived per-kWh cost from the total bill (including the fixed charge).

We agree that the re-emergence of block tariffs in recent years warrants a new approach, and that the project objective to capture the cost difference between appliance replacement choices (rather than the specific energy usage cost of the appliance(s) in question) is consistent with using whole bill rather than discrete energy usage cost differences.

Our new approach to modelling (described above) allows us to add all electric loads to Sunulator and calculate bills on those combined profiles, properly reflecting the actual cost. Loads calculated in Gasulator are also calculated as whole bills (two-monthly in Victoria and quarterly in other states) in order to accurately incorporate tariff blocks and seasonal tariff differences.

Cooking loads are too small to make a significant difference – but we will ensure they are calculated at the appropriate tariff rate based on the whole bill for each billing period.

Impact of cost changes on consumption

Frontier notes that energy usage is elastic and that changes in consumption driven by changes in energy costs are not reflected in the modelling.

ATA RESPONSE

ATA agrees that our methodology does not reflect elasticity of consumption. However, we note that elasticity depends on numerous factors, including personal factors, and differs for different appliances, locations, and so on. We are not aware of sufficient credible data on elasticity of consumption to allow it to be reflected in our modelling, and don't have the resources to find it or integrate it if it is available. ***The purpose of this project is to estimate the cost differences for providing the same heating, hot water, and cooking energy with different fuels.*** *If a household switches fuels and, because of lower costs, heats more often, that's a good outcome for them in that they gain greater comfort, which is of value to them, and it does not undermine this modelling. Further, given the variability of rebounds, a single value is not appropriate: better to apply no rebound but point out to readers that they may wish to adjust the savings values to take into account their own lifestyle choices.*

Seasonality

Frontier considers that seasonality is not reflected in the modelling because of inconsistency in how tariffs are calculated.

ATA RESPONSE

ATA agrees that with the previous method of calculating the running costs of some appliances on an aggregated basis, the impact of seasonality on block tariffs was missed in some cases. The new approach to calculating bills (described above) corrects this. Because the underlying consumption profiles comprise 48 x 365 interval data drawn from actual household data, seasonality is captured. And Gasulator already calculated bills over different periods depending on common practice in each jurisdiction, to capture the seasonal nature of gas consumption and the particular structure of gas tariffs.

ATA is confident that seasonality is now represented in usage profiles and captured in the modelling approach.

Future tariffs

Frontier notes that accounting for future tariff changes should be done by using scenarios to forecast future tariffs to account for the impacts of various possible changes including to fuel costs, climate policy, and tariff structures. Specific advice for forecasting future tariff changes would be preferable; use of publically available data and forecasts is acceptable.

ATA RESPONSE

ATA agrees. ***In the absence of specific advice on tariff futures, we have used AEMO forecasts to estimate long-term price changes.*** *We note that short-term price movements are more significant for consumers; but long-term changes are more relevant for determining the economics of appliance and fuel choice over the lifetime of appliances.*

We will also apply demand tariffs to some scenarios as a sensitivity analysis. We do not believe it is necessary to model 'capped' or fixed-price tariffs because these are based on underlying conventional or demand tariffs.

Appliance loads

Frontier notes that the hot water and heating loads generated by ATA's models differ markedly from NSW usage data arrived at via regression analysis of IPART's 2015 Household Survey; that some of the inputs to the hot water model do not reflect normal usage; that the way heating cost is calculated is flawed; and that modelling only all-electric and all-gas cookers (thus excluding dual fuel cookers) limits the applicability of the cooking findings.

ATA RESPONSE

We note that, as discussed above, there has been a misalignment between household composition and usage profile for some household types. This has now been revised, and will have some bearing on comparison of appliance energy loads determined by our modelling with those derived from surveys of actual household energy usage.

Hot water loads

Frontier shows that ATA's estimate of hot water energy usage is significantly higher than what was determined via regression analysis from the IPART 2015 Household Survey. However, we note that Frontier used our calculations for electric storage hot water for comparison. This is the most energy-intensive form of hot water, which we are including primarily for comparison with heat pump hot water systems (which have significantly higher upfront cost but significantly lower energy requirements). Our measurement (around 2,500 kWh per year for the small house) also aligns with our anecdotal experience of electric storage hot water systems, which typically use between a third and half of the total electricity usage of a typical household, and are only affordable on off-peak tariffs. Frontier's figures (around 900 kWh per year for the small house) align more with typical heat pump hot water system consumption.

ATA RESPONSE

ATA has sense-checked its hot water loads against numerous estimates based on actual data. Estimates vary significantly: our calculations align with Sustainability Victoria's estimate of typical gas consumption for hot water in Victoria, and are fairly close to estimates by Sustainability Victoria[3] (40–50 litres per person per day) and the NSW Department of Environment and Heritage[4] (30-50 litres per person per day) when we consider that those estimates are of hot water from the tap, including some cold water mixed in; whereas our approach measures hot water from the system before it is mixed. We believe it is more appropriate to benchmark against hot water usage than energy usage because our calculations are for new, efficient appliances that will use less energy for the same output than existing appliances, whose average efficiency will be lower. Our building blocks approach is based on a survey[5] undertaken by Clearwater for Victorian water businesses on household water usage activities.

ATA is confident that our approach is robust and, when sense-checked against other estimates of both energy and water usage, are credible.

[3] http://www.sustainability.vic.gov.au/services-and-advice/households/energy-efficiency/at-home/hot-water-systems/hot-water-running-costs

[4] http://www.environment.nsw.gov.au/households/hot-water-systems.htm

[5] https://www.clearwater.asn.au/user-data/research-projects/swf-files/10tr5---001-melbourne-residential-water-use_brochure.pdf

Hot water usage activities

Frontier noted that our estimates for dishwasher and washing machine use – once per day – did not align with data from the 2015 IPART survey – 3.5 times per week. However, they did not note that ATA is only using dishwasher and washing machine hot water loads for a sensitivity analysis in capital cities, to illustrate the impact for households that do wash frequently.

ATA RESPONSE

We acknowledge that our usage estimates are not typical – but note that our inclusion of dishwasher and washing machine hot water usage was to measure the impact of atypical usage. We also note that while actual measurement of appliance usage in Melbourne households[6] found average dishwasher usage similar to IPART's (3.1 times per week) but higher washing machine usage (4.9 times per week, with 31% of washes using hot water). This illustrates again that there is no definitive data on appliance usage in Australian households. ATA contends that actual measurements and household surveys of appliance usage give more reliable results than estimates based on total household energy usage.

ATA will continue to model hot water usage without dishwasher and washing machine usage (as most dishwashers and many washing machines heat cold water internally, and most washing machine uses are cold water only). *We will also model hot water usage with hot washing machine loads (1 per 2 adults, and 1 per child, per week) for each household type, as a sensitivity analysis for households with high hot water usage.*

Heating loads and calculation of heating cost

Frontier notes that ATA's heating loads are substantially below those derived from IPART's Household Survey for NSW households.

ATA RESPONSE

We note that our usage data is based on the primary heating appliance only, and using reverse cycle air conditioners (RCACs); whereas the IPART data is presumably averaged over different electric heating technologies, some being much more energy-intensive (e.g. resistive underfloor heating), and some being supplementary heating (e.g. small electric fan heaters in bedrooms or studies) that our modelling does not include. We also note, as Frontier does, that household usage of heaters varies enormously, and cannot be fully captured by any one systematic approach.

ATA contends that use of heating loads derived from NatHERS and E3 data on the heating output energy required to heat dwellings in specific locations is appropriate. *Our new modelling approach increases the credibility of heating loads. We will model some high-heating scenarios in heating dominated climate zones as a sensitivity analysis, by adjusting the temperature-to-heat-at and temperature-to-heat-to parameters in the heating model.*

[6] https://www.clearwater.asn.au/user-data/research-projects/swf-files/10tr5---001-melbourne-residential-water-use_brochure.pdf

Calculation of heating cost

Frontier notes that heating loads do not vary as would be expected between different household types (e.g. those with members at home during working hours and those without) and locations (e.g. more heating used in inland locations and colder climates). They recommend using hours of heating rather than total annual heating loads.

ATA RESPONSE

ATA agrees that measuring heating energy on an hourly basis would improve the outputs of the models, especially with regard to different heating loads for stay-at home household types, with capturing the amount of heating that can be supplied by solar PV for the solar scenarios, and with enabling more accurate cost calculations by incorporating heating loads into interval data before calculating bills. As discussed above, ***we are building a heating/cooling model using Bureau of Meteorology (BoM) temperature data and heating/cooling-load data from NatHERS and E3 to add heating (and cooling) into load profiles,*** *accounting for weekday and weekend differences for non-stay-at-home household types.*

ATA is confident that the NatHERS and E3 data from which the heating loads are sourced, when combined with BoM temperature data, reflects the differences in heating requirements of different locations.

Cooking appliances

Frontier notes that ATA models presume either all-electric or all-gas cookers, when in fact many homes use dual-fuel cookers.

ATA RESPONSE

We agree that our models don't capture dual-fuel cookers, and that available data supports anecdotal evidence that they are becoming more commonplace. We note that all types are widely available in retail stores, and a cursory examination of a few different retail catalogues suggests that gas cookers cost more than electric cookers, and dual-fuel cookers cost more than both. Cooker costs in general vary enormously, with higher-priced models retailing for more than ten times the cost of low cost ones. Because energy usage of cookers is relatively small, capex can make opex immaterial.

Because cooking loads are so small, the difference fuel choice makes is likely to only be significant when switching from gas to electric cooking enables disconnection from the gas network (and thus removal of the fixed charge). Thus, ***ATA proposes to make no change to the cooking methodology.*** *However, we will model dual-fuel cookers against both types of single-fuel cookers in some scenarios as a sensitivity analysis.*

(Frontier also noted that there is some inconsistency in the models as to whether cooking loads are scaled for different household sizes. We have verified that cooking loads are appropriately scaled to household size in all calculations, and corrected the erroneous data that was present, though not used in calculations).

Solar PV

Frontier notes that in calculating the impact of solar PV, ATA is not including the energy usage of heating and cooking; that the solar system size of 5 kW is not broadly representative; and that actual solar generation is often lower than expected.

Consumption it offsets

Frontier notes that solar generation will offset some heating and cooking loads, especially for stay-at-home households but also for other households, particularly on weekends – and that this should be reflected in our approach.

ATA RESPONSE

ATA agrees that solar generation will offset more than just underlying consumption and hot water. We excluded heating and cooking from the model because they were not calculated by being added to usage profiles in the same way that hot water was – and to take a conservative approach to estimating the impact of solar generation on electricity bills.

Because we are now adding heating (and cooling) to usage profiles, they will be offset by solar as appropriate.

Solar system size

Frontier notes that the 5 kW system size modelled for this project does not reflect the fact that many households have smaller systems.

ATA RESPONSE

This issue has been discussed with the reference group. We consider that 5 kW is an appropriate choice for a new system (ATA modelling confirms that larger systems are more cost-effective even when daytime usage and feed-in tariffs are low), but is not reflective of existing systems, which are generally smaller if they are more than a few years old. Data on average size of PV systems that disaggregates older from very new systems; but our experience (from our solar advice service) suggests that 2.5 kW is probably a reasonable average size for existing systems.

We will model 5 kW systems for the new solar scenarios, and 2.5 kW systems for existing solar scenarios. *We will also model some larger (between 3 and 4 kW) existing systems as a sensitivity analysis.*

Actual solar generation

Frontier notes that solar generation varies considerably across households due to a range of factors, and that this is not captured by Sunulator which calculates 'ideal' yields.

ATA RESPONSE

ATA agrees that solar generation varies enormously due to a range of factors. However, Sunulator does not calculate 'ideal' generation. It does assume a well-planned installation; but also de-rates generation by 12 per cent to account for sub-optimal conditions that may arise. It is not feasible for it to account for actual generation for every possible situation. Like all the modelling, it attempts to capture what is typically achievable with good choices, rather than every possible outcome.

ATA proposes no changes to the way Sunulator calculates solar generation.