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Trajectory for Low Energy Buildings: Infrastructure and Customer Impacts

Prepared by ENERGEIA for
the Department of Environment and Energy

February 2019

ENERGEIA

Executive Summary

Proposed changes flowing from Council of Australian Government's Trajectory for Low Energy Buildings project[1] (Trajectory) are expected to reduce annual electricity consumption of new and refurbished residential and commercial premises by 36 TWh by 2050, compared to current standards. This would represent a 15% overall reduction in Australia's future electricity consumption relative to the baseline and could materially impact the industry's long-term infrastructure plans depending on how consumption reductions translate into reductions in peak demand – the key driver infrastructure needs.

Different types of energy efficiency can have different impacts on electricity infrastructure peak demand due to differences in the timing of the associated end use and the infrastructure peak. The timing of peak demand can vary between low voltage (LV) transformers, the high voltage (HV) conductors they are connected to, as well as the zone substation and sub-transmission line. Finally, changes in the timing of peak demand, e.g. due to solar PV generation, can modify the impact of energy efficiency on peak demand.

Energeia was engaged by the Commonwealth of Australia's Department of the Environment and Energy (DEE) to develop a high-level estimate of the impact of the Trajectory energy efficiency targets, with and without a 10% level of PV adoption, on electricity system peak demand, generation and network infrastructure costs, and the associated impact on customer bills, including vulnerable customers, against a baseline scenario with no Trajectory impacts.

Scope and Approach

Energeia delivered modified[2] energy efficiency impact modelling methodology and benchmarked it against Australian and overseas benchmarks before applying it to estimate the Trajectory impacts on peak demand, generation infrastructure and network infrastructure. We then developed key recommendations for improving the accuracy and reliability of these estimates prior to their use in any Regulatory Information Statement (RIS).

Peak Demand Impact Assessment

Energeia's modified approach to estimating the Conservation Load Factor (CLF) to apply to the Trajectory energy savings found it to be ~0.48, which is 16% lower than the assumption used in the commercial trajectory for low-energy building modelling.

Energeia's modelling showed the proposed Trajectory changes would reduce state-wide peak demand by 8.8 GW and 9.4 GW by 2050 for the Trajectory case and the Trajectory with 10% higher solar PV case, respectively. This represents an 74% reduction in peak demand growth over the period for the Trajectory scenario, and a 76% reduction in peak demand growth for the Trajectory plus 10% solar PV scenario.

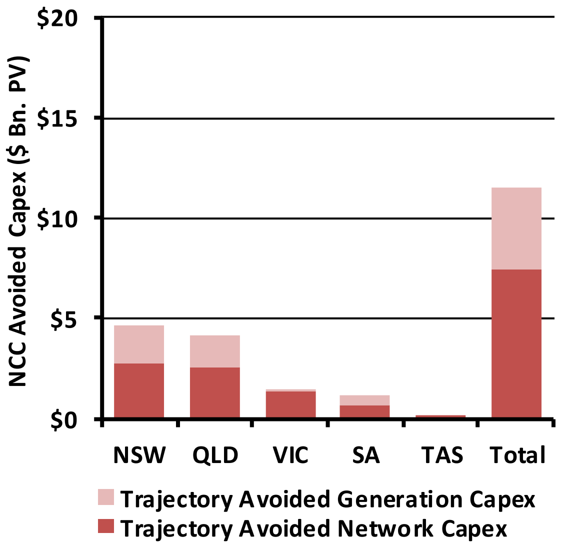
Infrastructure Impact Assessment

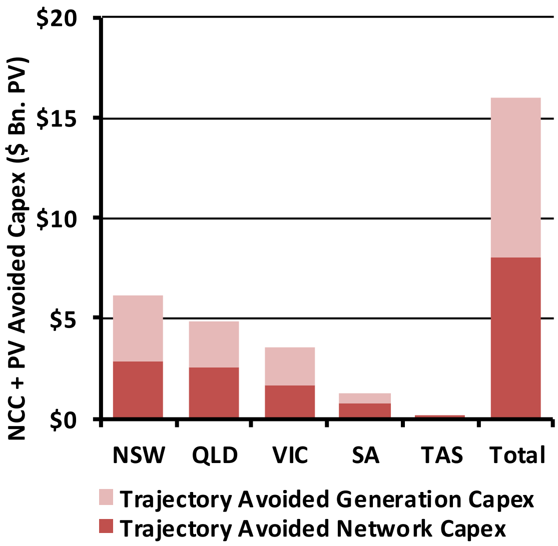
The results of Energeia's modelling of generation and network infrastructure impacts from expected Trajectory and Trajectory plus 10% solar PV energy reductions are shown in Figure A. The analysis shows the proposed Trajectory energy savings reducing cumulative network and generation capex costs by $7.5 billion and $4.1 billion, respectively. Under the Trajectory plus 10% solar PV scenario, the savings rise to $8.0 billion and $8.0 billion for avoided network and generation capex costs, respectively.

[1] On 1 February 2019 Energy Ministers at the Council of Australian Governments agreed the Trajectory for Low Energy Buildings, a national plan that sets a trajectory towards zero energy (and carbon) ready buildings for Australia. In summary the Trajectory proposes three measures: (i) setting a trajectory towards zero energy (and carbon) ready buildings, (ii) implementing cost effective increases to the energy efficiency provisions in the National Construction Code (NCC) for residential and commercial buildings from 2022, and; (iii) considering options for improving existing buildings in late 2019.

[2] A modified approach to the modelling in this report was taken to provide preliminary insight to the benefits and broader impacts of the proposed Low Energy Buildings Trajectory.

Figure A – Network and Generation Capex Savings for Trajectory (left) and Trajectory plus 10% Solar PV (right)





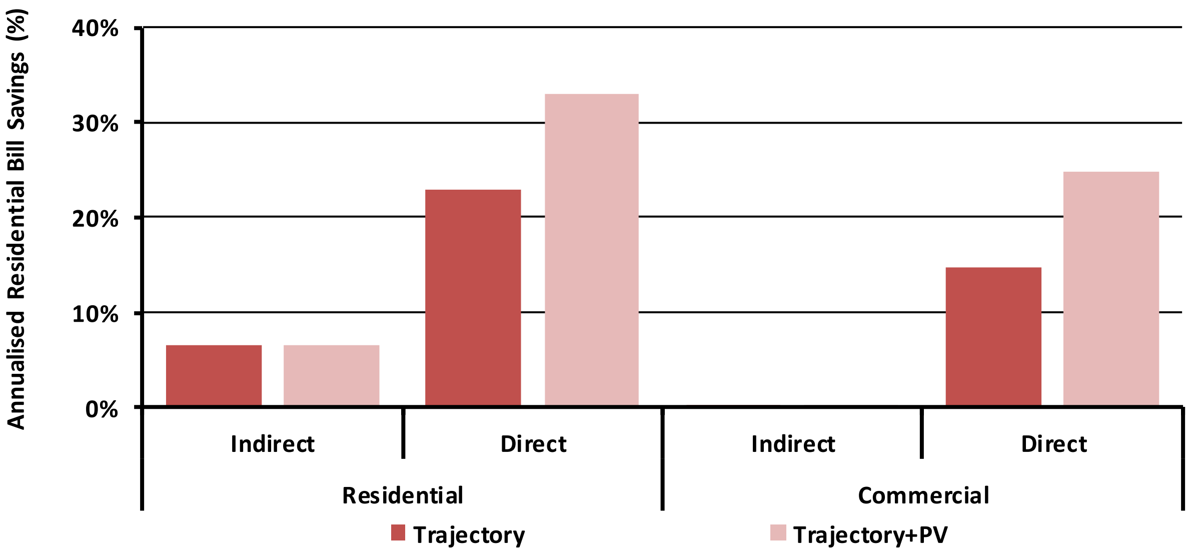
Energeia's analysis of potential negative Trajectory impacts to network and generation infrastructure found that it could increase excess solar PV generation due to less load, which would be exacerbated under the 10% solar PV scenario. However, while this could lead to voltage issues in LV and HV networks in the near-term, we expect rising storage adoption to mitigate this effect in the medium to longer-term.

The other potential negative impact might be asset stranding for distribution networks. However, a 30% reduction in peak demand over a 28-year period, i.e. from 2022 to 2050, is less than 1% per year reduction in consumption or 12.6 TWh per annum. In Energeia's view, this gradual rate of change and advanced warning should enable DNSPs to manage their network capacity prudently so as to avoid asset stranding.

Bill Impact Assessment

The results of Energeia's modelling of bill impacts for customers under the Trajectory and Trajectory plus 10% solar PV scenarios is reported by customer type in Figure B. Vulnerable customers are assumed to only benefit indirectly from the Trajectory via reductions in generation and network infrastructure.

Figure B – 2050 Bill Savings by Customer Type – Trajectory and Trajectory plus 10% Solar PV



Source: Energeia Modelling

From Figure B, it can be seen that residential customers incur greater proportional bill savings than commercial customers. Bill savings in more detail are as follows:

- **Residential Customers** – Directly impacted residential customer annual bills fall by $559 or 23% relative to the baseline by 2050 without including the impact of solar PV. The average reduction across the period is $349 in real 2018 terms. If solar PV is included, bills fall by $801 or 33% in 2050 or an average of $562 over the period. Indirectly impacted customer annual bills fall by $161 in 2050 or 7% over the same period compared to the baseline, or $161 and 7% under the 10% solar PV scenario.[3]
- **Commercial Customers** – Directly impacted commercial customers annual bills fall by $13,500 or 15% under the Trajectory and $22,621 or 25% under the Trajectory plus 10% solar PV case in 2050. The average reduction across the period is $11,620 and $19,620 in the respective scenarios (in real 2018 terms). Indirectly impacted commercial customers, on the other hand, see their bills fall by $161 or <0% under the Trajectory and Trajectory plus 10% solar PV scenarios.[4]

Conclusions and Recommendations

Energeia's modified assessment methodologies are consistent with current state-of-the-art practices but do not fully reflect the complexity of current peak demand across electricity generation, transmission and distribution infrastructure, nor the forecast changes to peak demand and infrastructure with the increasing growth of utility scale renewable energy generation, storage and distributed energy resources.

The accuracy of the Trajectory impact estimates could therefore be significantly improved by refining the following key underpinning inputs and assumptions:

- Peak demand timing by year, state, DNSP and distribution voltage level
- End use correlations with peak demand by year, state, DNSP and distribution voltage level
- Solar PV correlation with peak demand by year, state, DNSP and distribution voltage level
- Network capex assumptions by year, state, DNSP and distribution voltage level
- Generation capex assumptions by year and state

In Energeia's view, an integrated and granular whole-of-system modelling approach is needed to ensure that the key assumptions and interdependencies identified above are correctly accounted for and internally consistent. We also believe this approach is consistent with emerging best practice modelling of distributed energy resources, including energy efficiency measures, within distribution networks.

The above approach requires sub-load data for each major end use, e.g. HVAC, refrigeration, lighting, motors, etc. While these datasets have not been published in the public domain in Australia, existing projects are underway to develop appliance sub-load profiles across Australia.[5] Authoritative overseas sources could be used until the Australian data is released.[6] Existing CLFs also rely on US and other overseas data.

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[3] The NPV of total residential bill savings (2018 terms, real 6% discount rate) is approximately $805, $4,554 and $7,330 for the indirect customer case, the Trajectory case and the Trajectory plus 10% Solar PV case respectively.

[4] The NPV of total commercial bill savings (2018 terms, real 6% discount rate) is approximately $805, $151,792 and $256,142 for the indirect customer case, the Trajectory case and the Trajectory plus 10% Solar PV case respectively.

[5] CSIRO's Energy Use Data Model is planned to include appliance sub-load profile data.

[6] In the US, the Department of Energy provides sub-load data on a major appliance (HVAC, lighting, refrigeration) basis on a representative household or commercial business for a wide range of locations.

Disclaimer

While all due care has been taken in the preparation of this report, in reaching its conclusions Energeia has relied upon information provided third parties as well as publicly available data and information. To the extent these reliances have been made, Energeia does not guarantee nor warrant the accuracy of this report. Furthermore, neither Energeia nor its Directors or employees will accept liability for any losses related to this report arising from these reliances. While this report may be made available to the public, no third party should use or rely on the report for any purpose.

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Structure of this Report

This report is structured as follows:

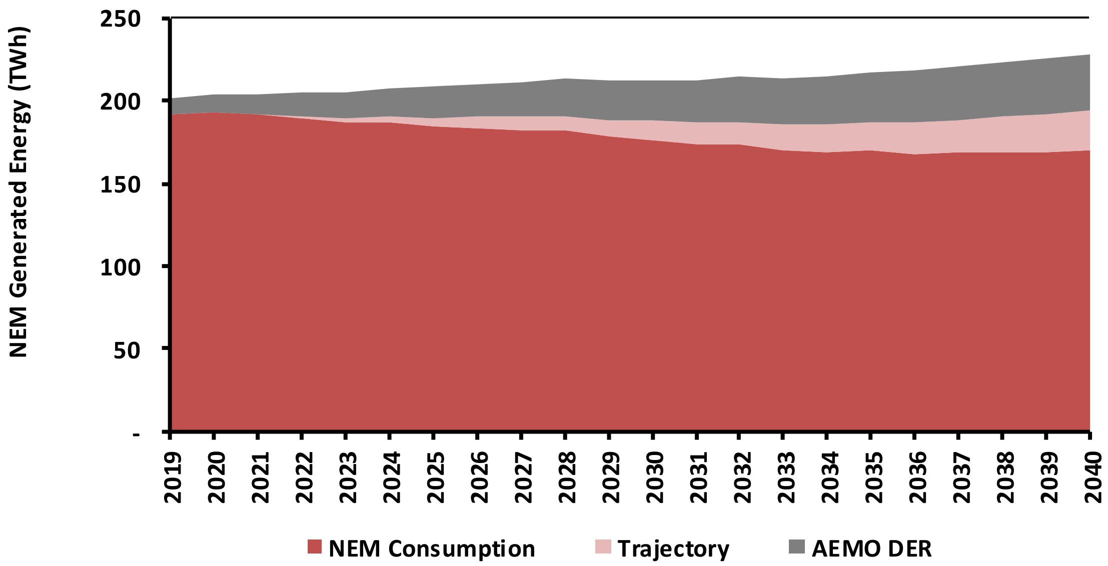
- **Section 1** – Background describes the key requirements for a successful assessment of the Trajectory for Low Energy Buildings impacts, namely an understanding of the importance of peak demand, the various drivers of peak demand timing, and the variance of peak demand spatially and between different levels of the network.
- **Section 2** – Scope and Approach describes Energeia's methodology and approach for undertaking this analysis of the Trajectory for Low Energy Building impact on both infrastructure expenditure and customer bills.
- **Section 3** – Energy Efficiency to Infrastructure Impact Assessment examines the impact of the implementation of the Trajectory for Low Energy Buildings on state level peak demand, network infrastructure expenditure and generation expenditure outcomes.
- **Section 4** – Energy Efficiency to Bill Impact Assessment reports on the results of Energeia's modelling impacts on customer bills for those customers impacted by the Trajectory directly, as well as those customers who only indirectly benefit from the Trajectory.
- **Section 5** – Conclusions and Recommendations summarises Energeia's key recommendations for improving the estimates of energy efficiency impacts through either the application of whole-of-system models and incremental improvements of existing methods.

1 Background

The draft National Construction Code expects to reduce residential and commercial electricity consumption by 36 TWh, over the period to 2050. This expected reduction would represent a 16% reduction in residential electricity consumption and 15% reduction in commercial electricity consumption, compared to the baseline or do-nothing option.

The impact of the proposed Trajectory for Low Energy Buildings (Trajectory) energy efficiency estimates on the National Electricity Market (NEM) is illustrated in Figure 1, which shows NEM consumption (dark red), expected consumption from Distributed Energy Resources (DER) as forecast by AEMO (dark grey), and the forecast avoided consumption from the Trajectory measures (light pink).

Figure 1 – Trajectory Energy Efficiency Impacts on NEM Consumption



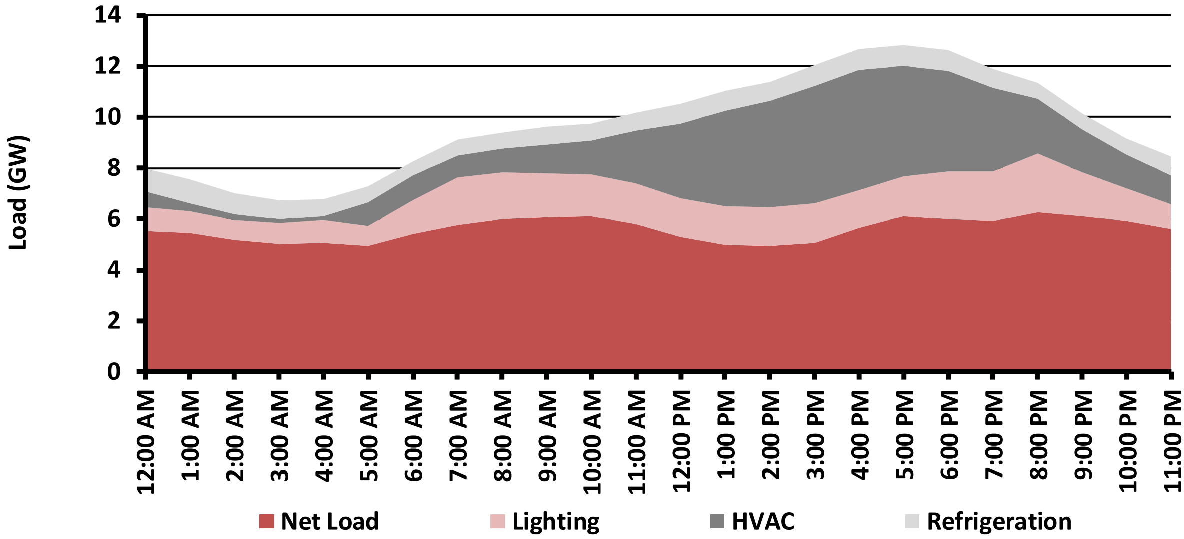
Source: AEMO; Energeia Analysis

The impact of this level of energy consumption on electricity infrastructure spending over the same period will depend on how the Trajectory's measures impact on peak electricity demand. Peak demand, rather than consumption, is the key driver of capital investment in new electricity infrastructure as well as replacement.[7]

Different types of energy efficiency have different impacts on infrastructure peak demand, due to differences in timing of the associated end use load profile and the infrastructure peak, as illustrated in Figure 2, which shows estimated heating, lighting and refrigeration end uses on a recent NSW peak day.

[7] Trajectory peak demand impacts on the configuration and sizing of replacement projects

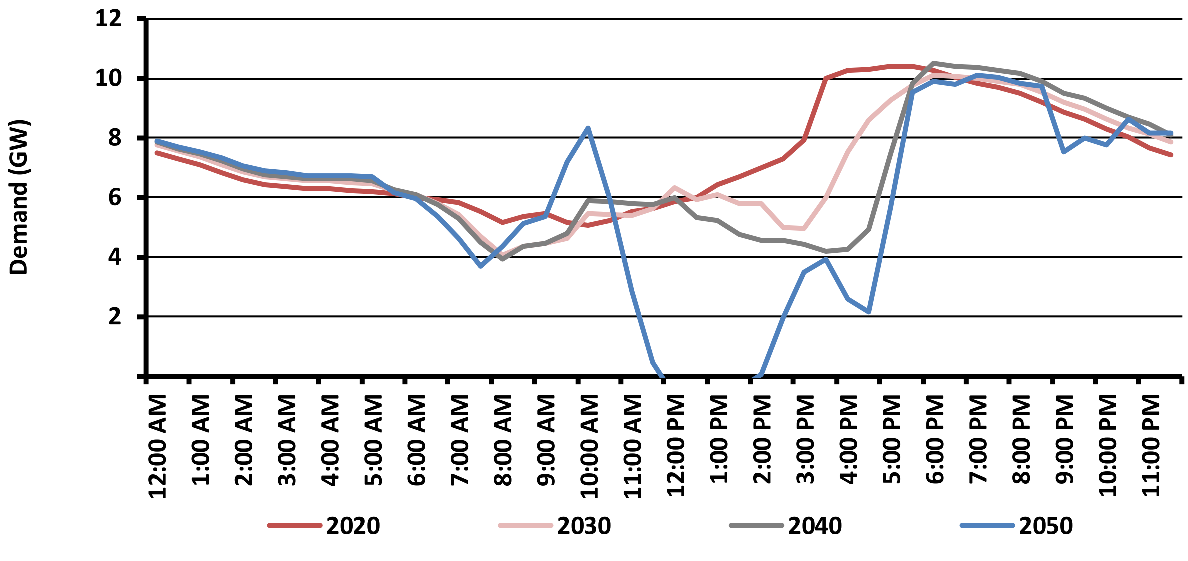
Figure 2 – 2018 NSW Peak Day Load Profile Breakdown (Illustrative)



Source: Energeia Analysis[8]

In addition to determining the appropriate energy efficiency to peak demand ratio for each end use, an accurate estimate of the impact of energy efficiency on peak demand will also need to account for factors impacting on the timing of the infrastructure peak demand over time as shown in Figure 3, such as rising solar PV, storage and electric vehicle investment, as well as the emergence of distribution network level markets.

Figure 3 – NSW Peak Day System Load



Source: Energeia Modelling

The impact of the above factors on distribution network infrastructure peak demand also depends on voltage, spatial and density factors. Peak demand can vary between low voltage (LV) transformers, the high voltage (HV) conductors they are connected to, as well as the zone substation and sub-transmission line.

[8] This illustrative analysis applied NREL sub-load profiles to NSW state load profiles.

2 Scope and Approach

2.1 Scope

Energeia was engaged by the Federal Department of the Environment and Energy (DEE) to develop a high level estimate of the impact of the Trajectory, with and without a 10% level of PV adoption, on system peak demand, generation and network infrastructure costs and the associated impact on customer bills, including vulnerable customers, against a baseline scenario with no Trajectory impacts. Operational expenditure impacts were out of scope.

Importantly, modelling results were to be completed in under a week due to the need for the work to feed into a COAG meeting, limiting the scope and level of depth that could be delivered.

2.2 Approach

In order to deliver the scope of work in the allotted timeframe while managing the associated key risks, Energeia developed the following project delivery approach:

- Collect bottom-up assumptions and inputs from the Trajectory for Low Energy Buildings work to date
- Develop modified approach to estimating peak demand impacts of energy efficiency
- Project impacts across network and generation infrastructure and bills by state and year
- Validate methodology and projections with DEE
- Draft report detailing methodology, resulting projections and key recommendations
- Validate method, results and recommendations with key stakeholders

The following sections of this report discuss the modified methodology, resulting projections, and key recommendations for improving the accuracy and reliability of these estimates prior to their expected application in any Regulatory Information Statement (RIS).

3 Energy Efficiency to Infrastructure Impact Assessment

Developing accurate estimates of the impact of forecast Trajectory for Low Energy Buildings energy usage reductions on electricity infrastructure peak demand involves consideration of the following key factors:

- The mix of end uses impacted by the Trajectory and their expected aggregate load shape during the peak period across state, transmission, sub-transmission, high voltage and low voltage levels.
- The impact of utility and distributed scale solar PV and storage, as well as EV charging, on net system load profiles from the system down to the LV level on a state by state basis.

The following sections outline, firstly, how Energeia estimated peak demand impacts, and subsequently, what these impacts were with respect to the required infrastructure expenditures.

3.1 *Electricity Peak Demand Impact Estimation*

The following sections described Energeia's modified approach to estimating the impact of the Trajectory's energy efficiency on infrastructure peak demand.

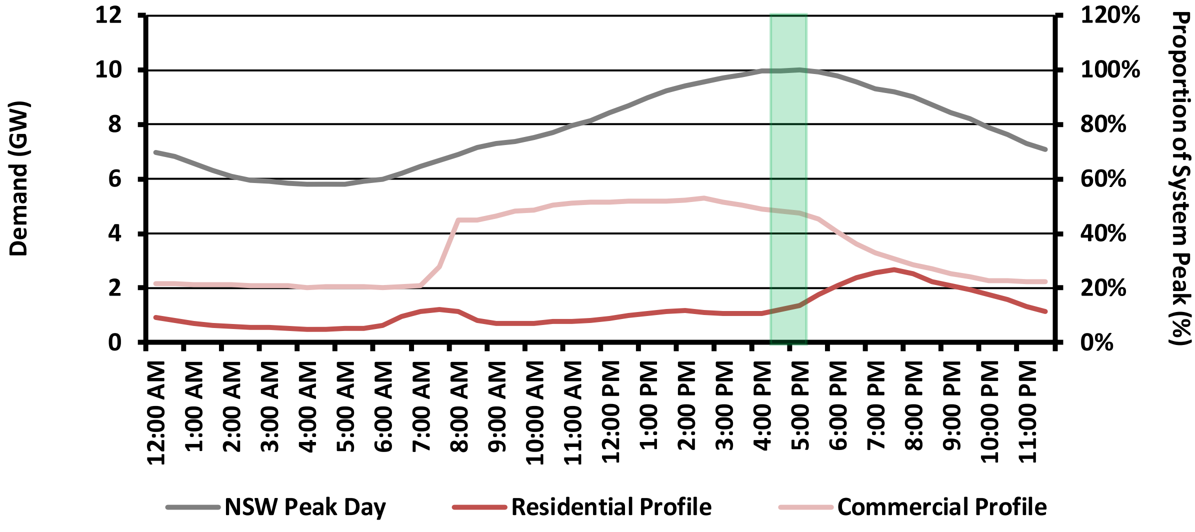
3.1.1 Conservation Load Factor[9]

Developing up a NEM-wide model of sub-load profiles by residential and commercial premise types over the next 32 years to 2050 was not feasible within the project timeframe.

Instead, Energeia developed bottom-up estimates of aggregated residential and commercial loads in NSW and used these to identify the impacts of energy efficiency on peak system demand in NSW. Our NSW based estimate was then validated against a bottom-up analysis of US data and other Australian estimates.

Figure 4 demonstrates the intersection of residential and commercial load profiles across the NSW system annual peak demand.

Figure 4 – Peak Demand Co-incidence

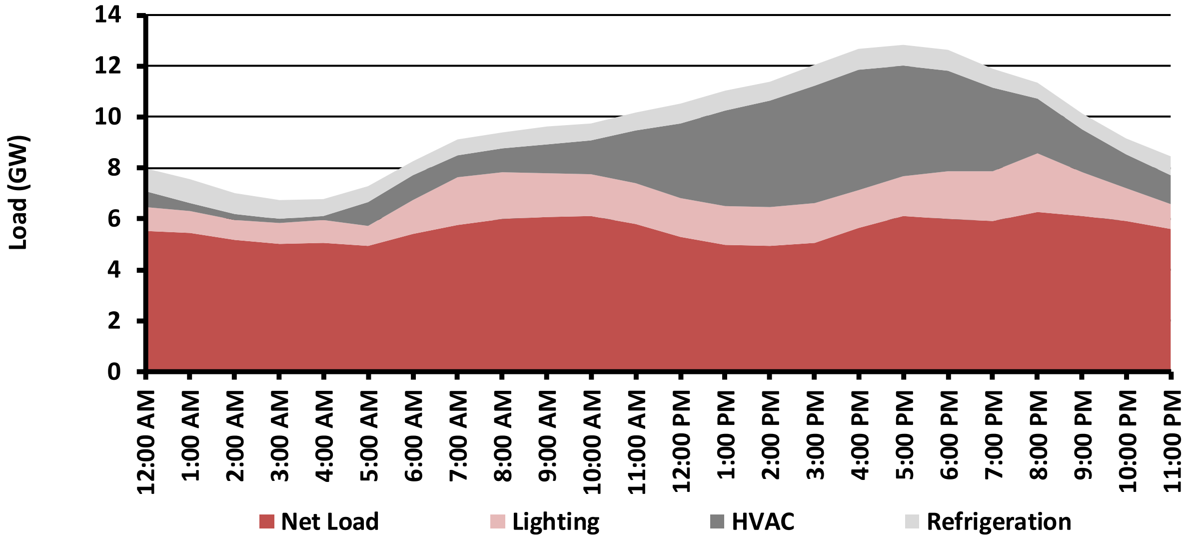


Source: Energeia Analysis

[9] Conservation Load Factor is a ratio that represents the reduction in peak demand attributable to reduced electricity consumption from energy efficiency measures and is calculated as: CLF = Annual Energy Use Reduction (averaged per hour across the year) over the Peak Demand Reduction (in the peak hourly interval).

Energeia developed an alternative estimate using a bottom-up model we developed for the California market, which estimated the end-use weighted average CLF to be 0.475. Figure 5 shows the end-use weighted sub-loads of this model applied to the NSW state wide demand during the peak demand day of the year.

Figure 5 – 2018 NSW Peak Day Load Profile Breakdown



Source: Energeia Analysis

The above CLF estimate was 16% lower than the assumption used in the commercial analysis[10], and comparable to other published estimates, which are reported in Table 1.

Table 1 – Published Conservation Load Factors – Reference Only

Demand Management & Energy Efficiency	Conservation Load Factor
Commercial and Industrial Energy Efficiency	0.40
Residential Energy Efficiency	0.25
Large Commercial Gas Cooling	0.40
Residential Hot-water Substitution	0.30

Source: ISF & Energetics (2010) Building Our Savings

It is worth mentioning that many of the load factors provided were also based on US studies and data.

3.1.2 Peak Demand Timing

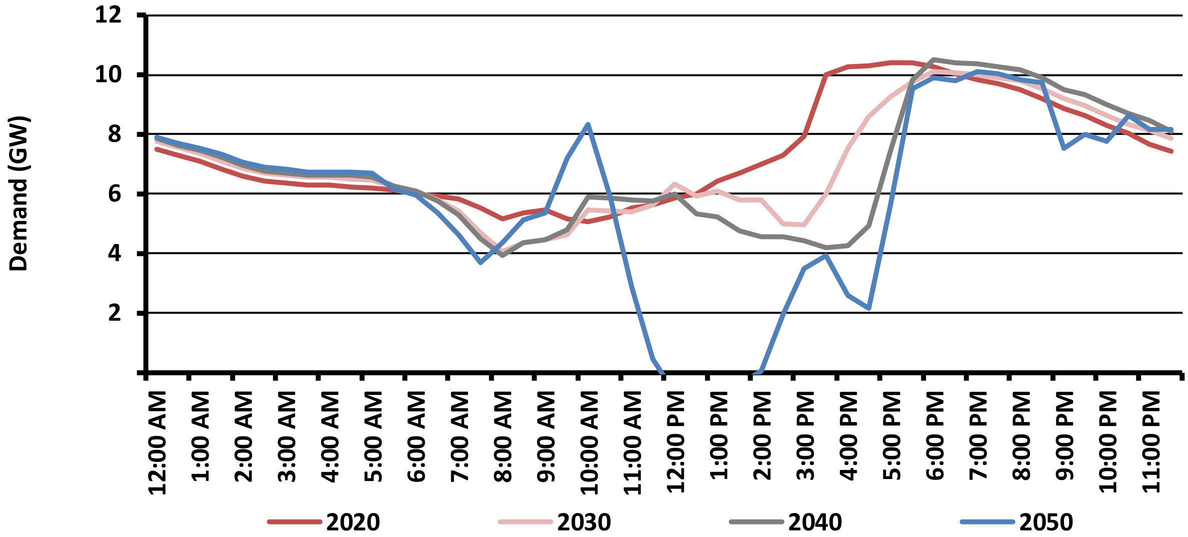
Configuring and running Energeia's end-to-end, bottom-up model of Australia's electricity consumers, load patterns, electricity distribution networks and wholesale power market over the next 32 years to 2050 was infeasible in the time available.

Instead, Energeia focused on state level peak demand net of distributed energy resource (DER) and utility scale renewables over the period to 2050. The resulting 'net system load profile' (NSLP) is what firm or dispatchable capacity is called on to meet; it typically sets the market price and is therefore a key driver of new investment.

The resulting NSLP for NSW in 10-year steps is shown in the Figure 6. The profile is impacted in the first 10-year period by committed investment in utility scale wind and solar PV, leading to what is popularly known as the 'duck curve'. In the following 20 and 30 years, the impact of utility scale storage and distributed energy orchestration can be seen, resulting in some peak clipping and valley filling.

[10] No CLF analysis was included in the residential Trajectory for Low Energy Buildings report.

Figure 6 – NSW Peak Day Net System Load Profiles – 10 Year Intervals



Source: Energeia Modelling

The effect of the changes in the power system over the next 32 years is to move the timing of net system peak as shown in Table 2.

Table 2 – Peak Timing by State and Year

Peak Timing	2020	2030	2040	2050
Queensland	6:00 PM	7:30 PM	9:00 PM	8:00 PM
New South Wales	5:30 PM	6:30 PM	6:30 PM	7:30 PM
Victoria	5:30 PM	5:30 PM	5:30 PM	5:30 PM
South Australia	6:30 PM	7:30 PM	7:30 PM	7:30 PM
Tasmania	7:00 PM	7:30 PM	7:30 PM	7:30 PM

Source: Energeia Modelling, Energy Networks Australia (2016) Network Transformation Roadmap

Under the 10% solar PV scenario, an additional 10% of solar PV energy is added to the NSLP using state based solar PV profiles, thereby impacting on CLFs.

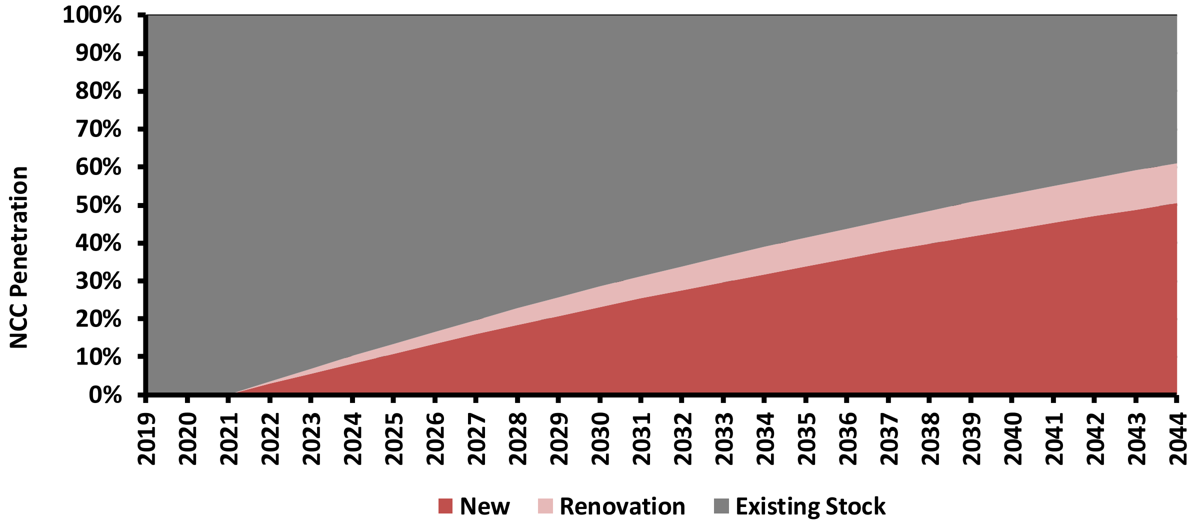
It was not possible in the time available to calculate the effect of the change in peak day timing on each state's CLF. Instead, a single, NEM-wide CLF of 0.475 was assumed, as per Section 3.1.1.

3.1.3 Peak Demand Reductions

Peak demand reductions for each state in each year are calculated by taking the total energy efficiency achieved for that year and multiplying it by the CLF.

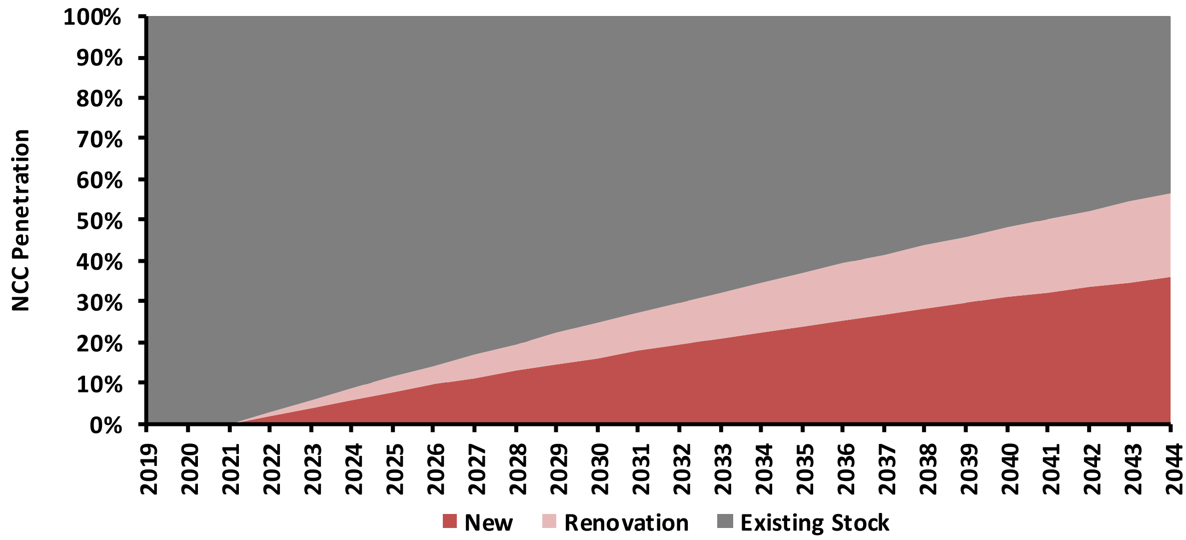
Low Energy Building energy consumption savings are allocated between states based on a bottom-up, consumption weighted estimate of premises. The resulting Low Energy Building allocations are reported in Figure 7 and Figure 8 for residential and commercial energy efficiency respectively.

Figure 7 – Residential Trajectory Adoption Market Share



Source: Energeia Modelling

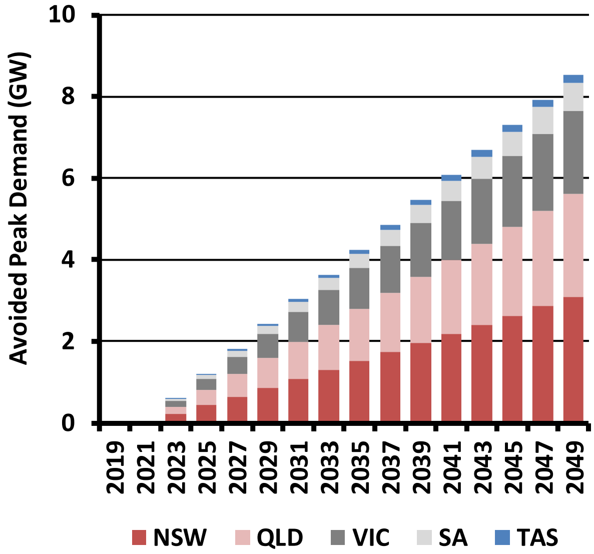
Figure 8 – Commercial Trajectory Adoption Market Share



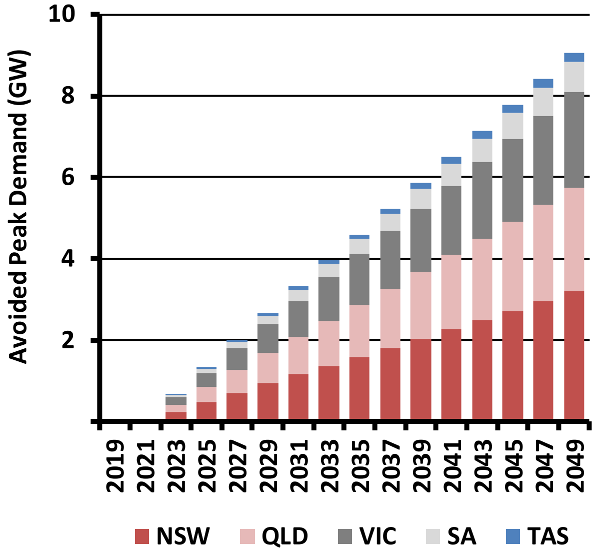
Source: Energeia Modelling

Applying the CLF in each year for each state to the incremental energy efficiency for each state, results in the annual reduction in peak demand, which is reported on a cumulative basis in the Figure 9 for the Trajectory (left) and Trajectory plus 10% solar PV (right) scenarios.

Figure 9 – Cumulative Peak Demand Reduction for Trajectory (left) and Trajectory plus 10% Solar PV (right)



Source: Energeia Modelling



Source: Energeia Modelling

3.2 Infrastructure Impacts

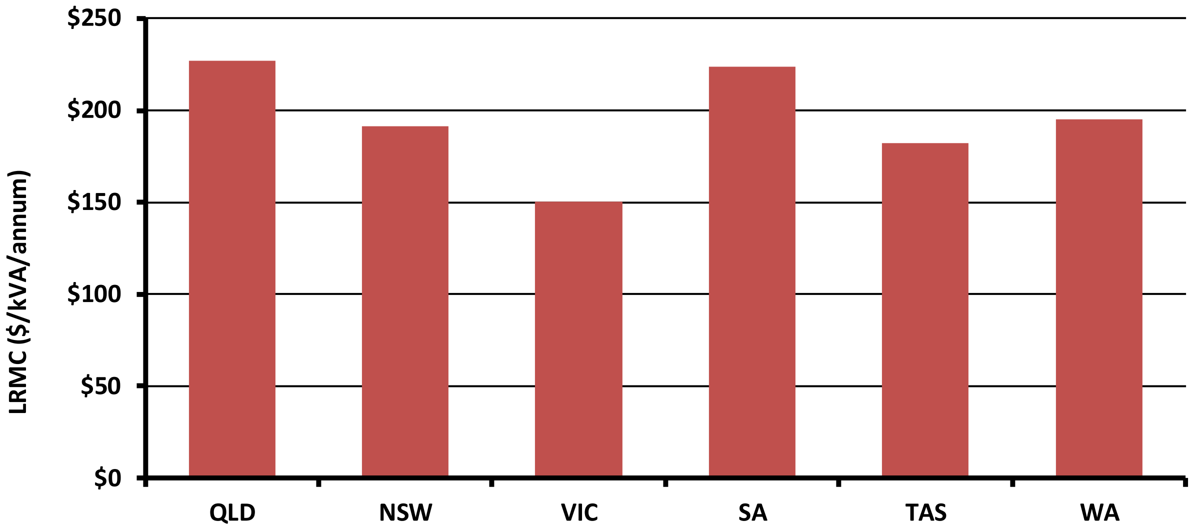
The following section reports on the estimated savings to both network and generation expenditures, and the results of our analysis of potential negative impacts.

3.2.1 Network Infrastructure Savings

Energeia translated the state peak demand reductions calculated above into generation and distribution infrastructure savings by applying customer weighted long-run-marginal-cost (LRMC) estimates for each infrastructure category.

For distribution infrastructure, Energeia applied the latest LV LRMC estimate from each of the distribution network service providers (DNSP) on a consumption weighted basis, reported in Figure 10 by state.

Figure 10 - Distribution Network Service Provider Long Run Marginal Costs

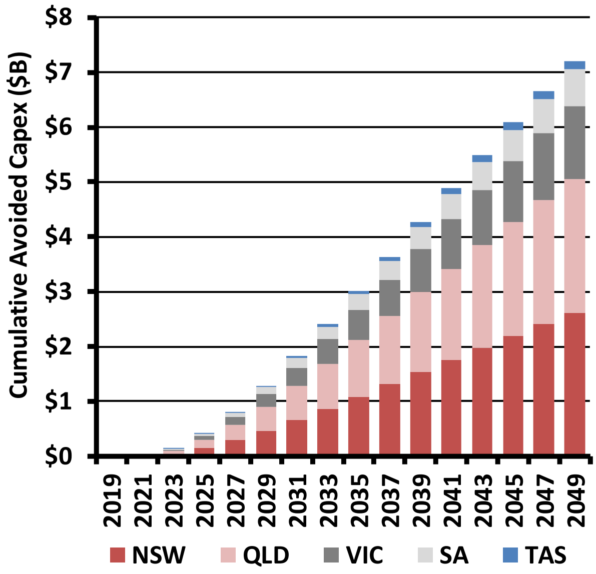


Source: Energeia Modelling

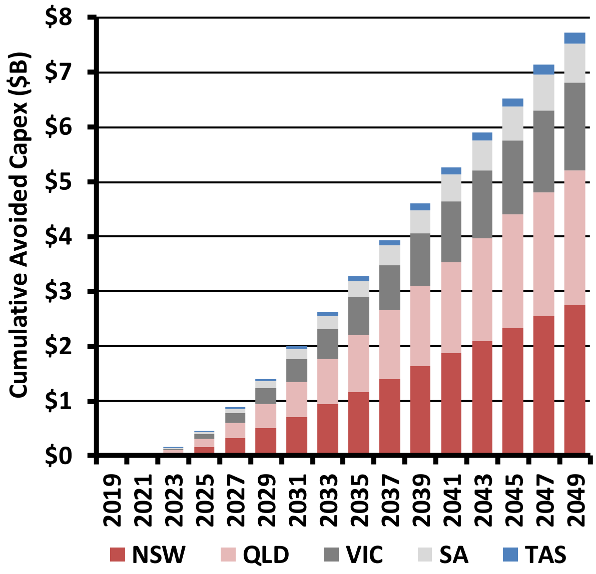
Energeia's view is that the LV level is appropriate for this simplified calculation because even where a customer may connect at a higher voltage such as an embedded network, all residential loads must ultimately include an LV network. For commercial premises, there is also likely to be an LV network as well, though some, larger equipment may connect at high voltage.

Multiplying each state's peak demand reduction by its consumption weighted LRMC results in the projected avoided distribution network capital expenditure (capex) shown in Figure 11 for the Trajectory (left) and Trajectory plus 10% solar PV (right) scenarios.

Figure 11 – Cumulative Capex Savings for Trajectory (left) and Trajectory plus 10% Solar PV (right)[11]



Source: Energeia Modelling



Source: Energeia Modelling

[11] A real 6% discount rate was applied to the avoided capex forecast.

Estimation of potential asset stranding of generation assets and the benefits of avoided transmission investment was excluded from the analysis due to the limited time available.

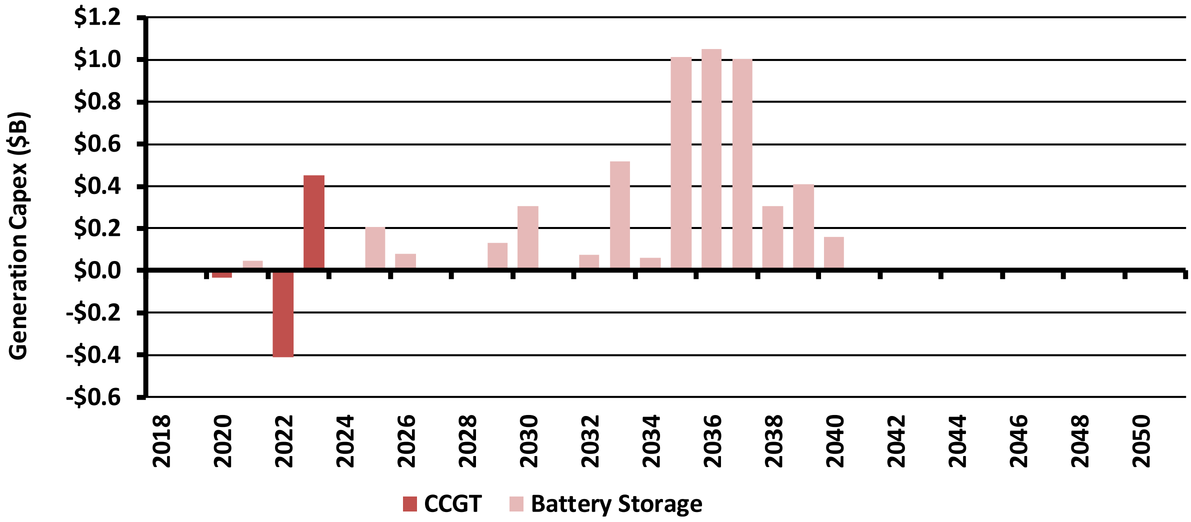
3.2.2 Generation Infrastructure Savings

Generation investment is driven by system peak demand, but also unit retirement and renewable energy compliance. Due to the limited time available, Energeia focused on avoidable investment in generation due to peak demand and did not factor in reduced consumption-based compliance costs.

Generation investment to meet peak demand has traditionally been in Open Cycle Gas Turbines (OCGT). However, higher gas prices due to linkages with the Pacific LNG market and falling storage prices are expected to lead to increasing use of storage and demand side resources to meet peak system demand.

AEMO's recently released ISP identifies a cumulative 2.9 GW and $5.3 billion in capex on firm CCGTs and storage capacity over the period to 2050 based on their forecast of peak demand, as shown in Figure 12. It is important to recognize that while some of this investment is due to retirement, a significant reduction in forecast peak demand would lead to a comparable but not commensurate reduction in investment.

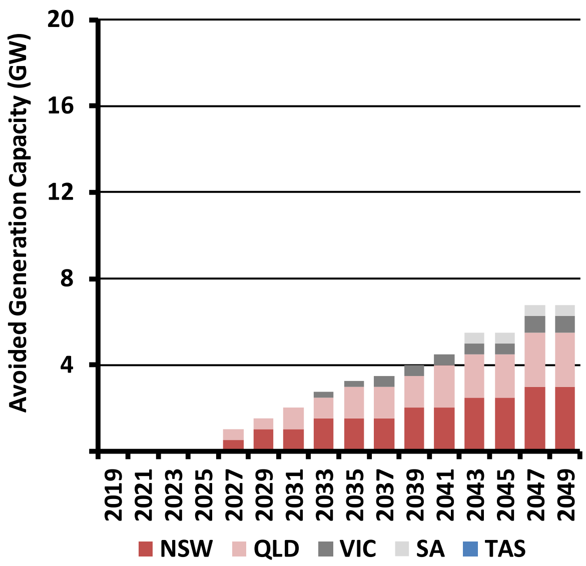
Figure 12 – Cumulative Capex Forecast for OCGT and Battery Storage

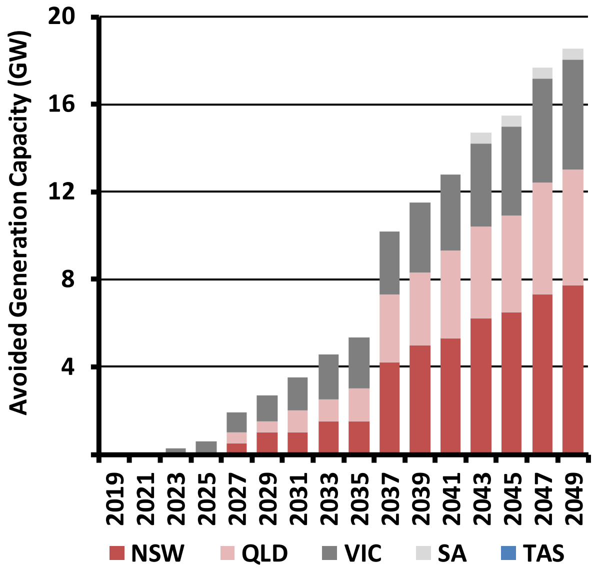


Source: AEMO (2018) 'Integrated System Plan – Generation Outlook Neutral Scenario'

Energeia's approach to estimating the avoidable generation cost developed an estimate of the least cost mix of OCGT and storage generation for each year when investment would need to be made. This approach factored in the minimum unit sizing of OCGTs and storage, which leads to imperfect, lumpy investment in generation. The results of this approach are presented in Figure 13 for the Trajectory (left) and Trajectory plus 10% solar PV (right) case. The additional reduction in the 10% solar PV case is due to lower operational electricity consumption from small scale solar production which does not directly correlate with peak demand reduction.

Figure 13 – Cumulative Capacity Avoided for Trajectory (left) and Trajectory plus 10% Solar PV (right)

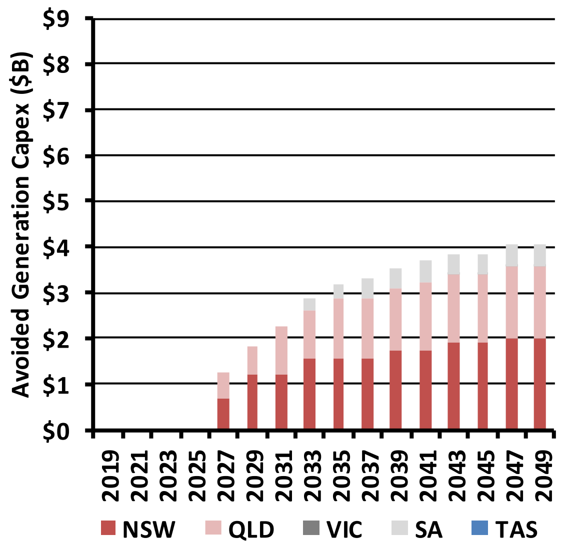




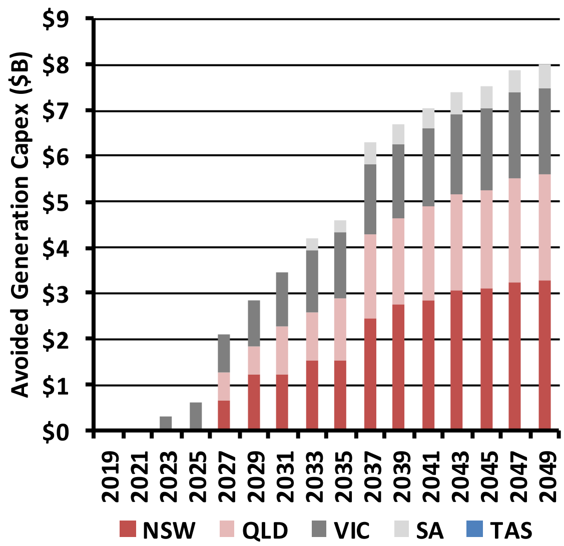
Source: Energeia Analysis

The resulting estimate of avoided generation costs per annum by state are reported in Figure 14 for the Trajectory (left) and Trajectory plus 10% solar PV (right) scenarios.

Figure 14 – Avoided Generation Costs for Trajectory (left) and Trajectory plus 10% Solar PV (right)



Source: Energeia Modelling



Source: Energeia Modelling

3.2.3 Negative Impacts

Energeia also considered potential negative impacts of the Trajectory and Trajectory plus 10% PV scenarios:

- The main potential negative impact we identified was the potential increase in excess solar PV generation, which would be exacerbated under the 10% PV scenario. However, while this could lead to voltage issues in LV and HV networks in the near-term, we expect rising storage adoption to mitigate this effect in the medium to longer-term.
- The other potential negative impact might be asset stranding for distribution networks. However, a 30% reduction in peak demand over a 28-year period, i.e. from 2022 to 2050, is just over a 1% per year reduction in consumption. In Energeia's view, this gradual rate of change and advanced warning should enable DNSPs to manage their network capacity prudently so as to avoid asset stranding.

4 Energy Efficiency to Bill Impact Assessment

Applying Energeia's end-to-end, bottom-up customer model covering all residential and commercial customers in the NEM over the next 32 years to 2050 was infeasible in the time available.[12]

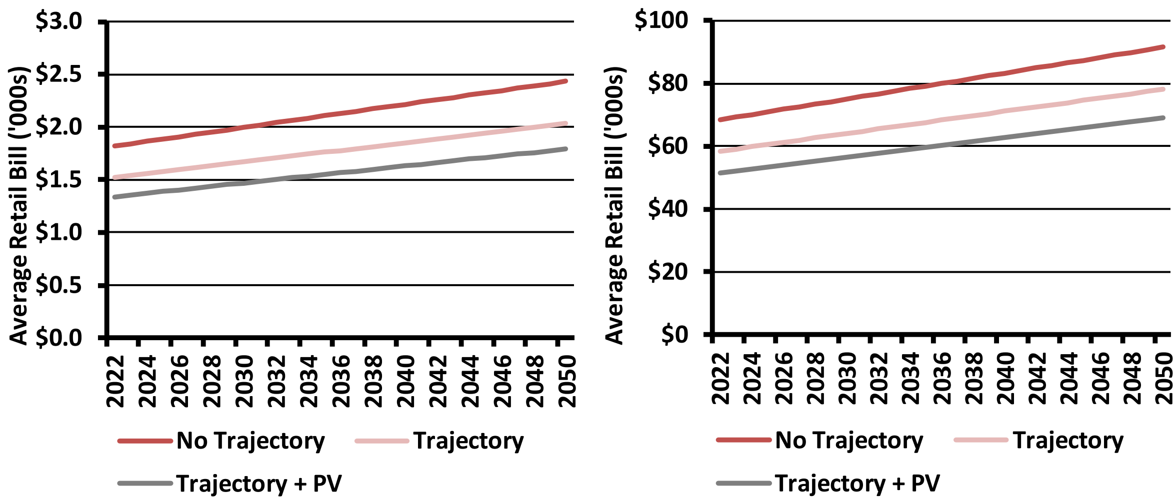
Instead, Energeia developed up a modified approach that estimated bill impacts based on:

- **Direct impacts**, which were estimated as the consumption reduction (in kWh) per customer multiplied by the customer's average cost per kWh and applied to Trajectory impacted customers only.[13] The cost of compliance for the Trajectory were not included in this calculation – only the bill savings.

- **Indirect impacts,** which were estimated as the sum of the avoided network and generation infrastructure costs and allocated across customers living in Low Energy Building impacted premises and those, including vulnerable customers[14], who were not, on a consumption pro-rata basis.

The resulting estimate of annual bill savings for directly and indirectly impacted customers including vulnerable customers, is shown in Figure 15 for residential and commercial customers.

Figure 15 – Annual Bill Savings for Residential (left) and Commercial (right) Customers



Source: Energeia Modelling

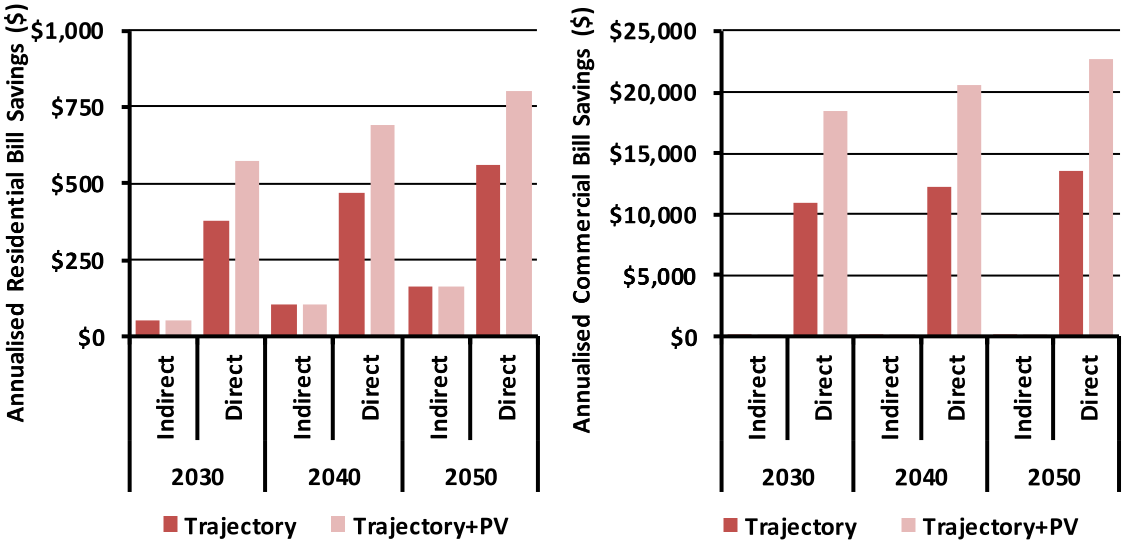
In both figures, the Trajectory (light pink) and Trajectory plus 10% solar PV (dark grey) case are compared to a baseline of a No Trajectory case (in dark red). The savings for direct (i.e. those customers for whom Trajectory measures have been applied in their new or refurbished building) and indirect customers are shown in Figure 16.

[12] This is the model used in the ENA/CSIRO National Transformation Roadmap to calculate customer bill impacts.

[13] All consumption was assumed avoided at the average retail rate, the effect of PV exports was not included.

[14] Vulnerable customers are defined as those who cannot benefit from the Trajectory for Low Energy Building measures directly.

Figure 16 – Indirect and Direct Customer Bill Savings – Annualised Basis (real 2018)



Source: Energeia Modelling

5 Conclusions and Recommendations

Energeia's modified assessment methodologies are consistent with current state-of-the-art practices but do not fully reflect the complexity of current peak demand across electricity generation, transmission and distribution infrastructure, nor the forecast changes to peak demand and infrastructure with the increasing growth of utility scale renewable energy generation, storage and DER.

The best available approach for estimating the impact of energy efficiency measures would utilise a whole-of-system electricity model to estimate the Trajectory project's impact on peak demand across each infrastructure type, sub-type and location, and the associated impact on customer bills by key customer segment. A whole-of-system approach would ensure that key system interdependencies are correctly accounted for and internally consistent.

The following sections summarise the key limitations of the traditional approach to estimating the peak demand impacts of energy efficiency, as well as the approaches adopted for their report, and summarises Energeia's recommended approach for any RIS, and how it can be practically achieved.

5.1 Peak Demand Timing

Due to time constraints, Energeia's modified approach used a single type of peak demand, state peak demand, as a proxy for peak demand throughout the distribution network. Moreover, the timing of peak demand was fixed over the study period, despite expectations of significant changes in the timing of peak demand due to significant changes in the nature and mix of demand and generation resources, including storage and electric vehicles.

A granular, integrated approach to modelling peak demand would estimate peak demand across the high voltage, zone substation, sub-transmission and transmission networks, and endogenously account for changes in underlying demand due to rooftop PV, electric vehicles and other DER including storage. While this may sound impossible, new methods and technology enable this level of modelling integration and granularity.

5.2 Energy Efficiency Impacts

Energeia's modified analysis of proposed Trajectory impacts assumed a single, static, volume weighted average CLF over the study period, limiting its accuracy.[15]

A granular, integrated approach to modelling energy efficiency impacts would use sub-load level modelling to provide a more accurate picture of peak demand impacts down to the end use level. The use of end use load profiles also enables interactions with other system dynamics, such as demand response, virtual power plants, and distribution system operations, to be endogenously accounted for in the modelling.

The above approach could deliver estimates of CLFs by premise type and end-use by state over time, which could be applied in other energy efficiency related work.

The above approach requires sub-load data for each major end use, e.g. HVAC, refrigeration, lighting, motors, etc. While these datasets have not been published in the public domain in Australia, existing projects are underway to develop appliance sub-load profiles across Australia.[16] Authoritative overseas sources could be used until the Australian data is released.[17]

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15 Furthermore, the adoption of energy efficiency measures was assumed to take place evenly across the building stock with no allowance for the differential build rates by jurisdiction or region, or the changes in building stock characteristics through replacement or refurbishment. This is another limitation that could be addressed through additional analysis of the spatial distribution of building turnover rates.

16 CSIRO's Energy Use Data Model is planned to include appliance sub-load profile data.

17 In the US, the Department of Energy provides sub-load data on a major appliance (HVAC, lighting, refrigeration) basis on a representative household or commercial business for a wide range of locations.

5.3 Long Run Marginal Network Costs

Similarly, the estimation of avoided network and generation costs is based on the simplification of a single point estimate for long run marginal costs for the entirety of distribution network services area. Marginal cost assessment on a voltage, asset category (e.g. LV) and locational and basis over time, taking DER into consideration, would significantly improve the accuracy of the energy efficiency cost and benefit estimates.

In California, calculation of locational marginal costs is becoming the standard to ensure that DER including energy efficiency are correctly valued.[18] Data is available from Regulatory Information Notices (RINs), which may be used to provide more granular estimates down to the asset category and spatial level, and Energeia has used this data to develop locational marginal cost estimates in Australia.

5.4 Long Run Marginal Generation Costs

To estimate the impact of energy efficiency measures on generation capital expenditure, Energeia modelled changes to plant entry or exit decisions to estimate the fleet mix used to meet the reduced energy consumption Trajectory energy efficiency measures.

A limitation of this analysis was that the recently imposed (as of the December 2018 COAG meeting) reliability obligations were not modelled and new generation costs data has been released. These limitations could be addressed through modelling of the reliability obligations and the latest generation cost data.

Energeia, together with other industry stakeholders, has participated in the consultation process for the 2019 generation cost update[19], which is focused on improving the accuracy of costs estimated for both variable renewable energy generation and storage technologies required to firm their output.

5.5 Impact of Solar and Storage Adoption

In estimating the impact of DER on Low Energy Buildings, this analysis has assumed a constant adoption rate and passive solar PV generation. This potentially mis-estimates both the benefits and the costs of solar PV for the community as a whole, and for consumers, networks and generators in part.

A limitation of the scope and approach agreed for this analysis is that the forecast rate of adoption for rooftop solar PV, smart solar PV inverters, battery energy storage and electric vehicle charging has not been modelled. The current approach is also limited because it does not model the dynamics and interplay between excess solar PV, smart inverter control, battery charging and discharging, electric vehicle charging and grid demand over time.

Best practice in this space, is forecasting solar PV, smart inverters, battery storage and electric vehicle adoption on an integrated basis due to the strong interdependencies between these technologies. A bottom-up, integrated modelling approach is capable of delivering an integrated approach to forecasting adoption as well as forecasting operation, and each premises' overall contribution to coincident peak demand. It will also be important to consider the effects of DER orchestration technology, e.g. Virtual Power Plants.

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[18] Energeia has recently completed a project with the Los Angeles Department of Power and Water that examined the potential of a portfolio of energy efficiency, demand response and distributed energy resources to delay or remove the need for the replacement of retiring gas power generation plant.

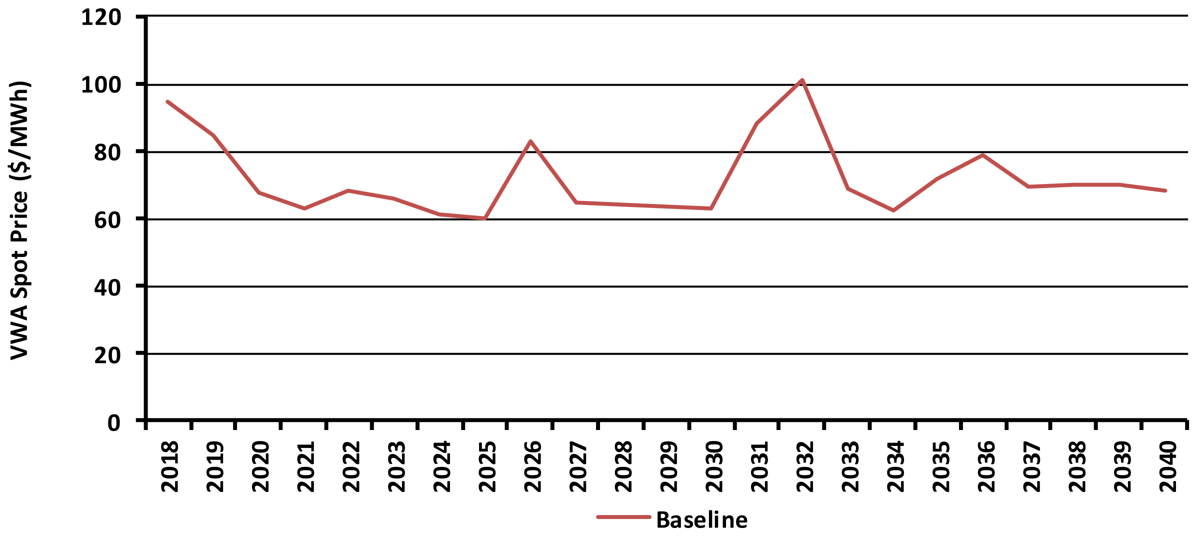
[19] CSIRO annually releases new large scale generation cost estimates: https://www.csiro.au/en/News/News-releases/2018/Annual-update-finds-renewables-are-cheapest-new-build-power

Appendix A – Assumptions

A.1 Electricity Price Outlook

Energeia's internal view on the 'baseline' business as usual wholesale electricity prices over the next 20 years, accounting for the currently scheduled and predicted coal fire generation exits.

Figure 17 – Wholesale Electricity Price Forecast

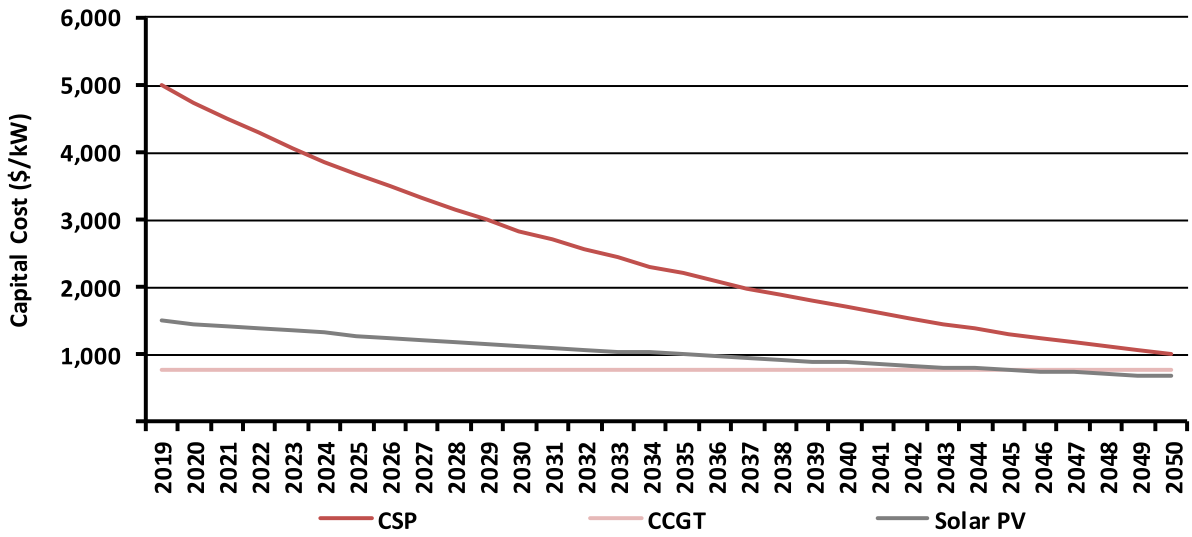


Source: Energeia Analysis

A.2 Generation Costs

Energeia used its in house view of future generation costs in determining the avoided generation infrastructure expenditure. Our view is based on continued price declines of both Solar PV and Concentrated Solar Power (CSP), large scale gas generation capital expenditure is expected to remain flat as it is a mature technology.

Figure 18 - Generation Capital Cost Forecast



Source: Energeia Analysis

Energeia's Industry Specialists are empowering the energy sector by providing the latest research and consultancy services focused on electricity

Heritage

Energeia was founded in 2009 to pursue a gap foreseen in the professional services market for specialist information, skills and expertise that would be required for the industry's transformation over the coming years.

Since then the market has responded strongly to our unique philosophy and value proposition, geared towards those at the forefront and cutting edge of the energy sector.

Energeia has been working on landmark projects focused on emerging opportunities and solving complex issues transforming the industry to manage the overall impact.

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