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# Victorian Tariff Innovation: Let's compare the price of progress.

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## Abstract

The introduction of smart meters in Victoria has created opportunity for retailers and distributors to create efficiencies and provide value-add services for customers. In particular, having smart meters installed in every household and small business opens the door for tariff progress through the creation of innovative pricing structures that can be applied at 30 minute intervals – This has led to some cutting edge electricity offers in recent time, such as Dodo's 'Hour of power' (free electricity from 6-7am every day) and AGL's 'Free Saturdays'.

Whilst innovative tariffs are a great example of progress in the Victorian electricity market, they also highlight an inherent obstacle in the lack of consumer awareness and industry knowledge – Whilst the savvy, well-educated consumers can find great deals, the rest of the consumers don't have enough general knowledge of the industry to understand the difference between one offer and the next. Because most Victorian consumers are unable to identify or understand simple elements of their bill, such as supply charge and usage rates, they are in no position to understand the impact of 'flexible pricing' tariffs on their overall costs. To that end, the more innovative a tariff is, the more difficult the task of assessing and comparing offers is.

So whilst tariff progress is greatly improved through the use of smart meters, broad consumer benefit of that progress can be hampered.

To combat these issues, the Department of Economic Development, Jobs, Transport and Resources (DEDJTR) has created an online price comparison website ('Victorian Energy Compare') which simplifies the comparison process for all Victorian consumers. With a recent bill and answers to a few simple questions, users of the Victorian Energy Compare website can easily navigate the electricity market to receive a recommendation of the best offers for their individual needs – often demonstrating a significant benefit in switching, to the tune of around twenty five percent or hundreds of dollars!

## Introduction

In July 2013 Victoria introduced Flexible Pricing tariffs<sup>1</sup> to allow retailers and distributors to charge variable prices across the forty eight, thirty minute intervals of each day. This pricing structure was introduced to allow a more even distribution of costs for consumers and allow them to take advantage of lower prices during 'off-peak' and 'shoulder' periods when those prices would be an advantage to them.

Research completed in July 2012 showed that there was an equal distribution between consumers who would be better off with a flexible pricing tariff and consumers who would wouldn't be.<sup>2</sup> Without changing usage habits, many consumers in Victoria have an electricity profile that is well suited to innovative structures. For example, for those who use a disproportionate amount of electricity overnight or on weekends, instant savings can be experienced from switching to a Flexible Pricing offer.

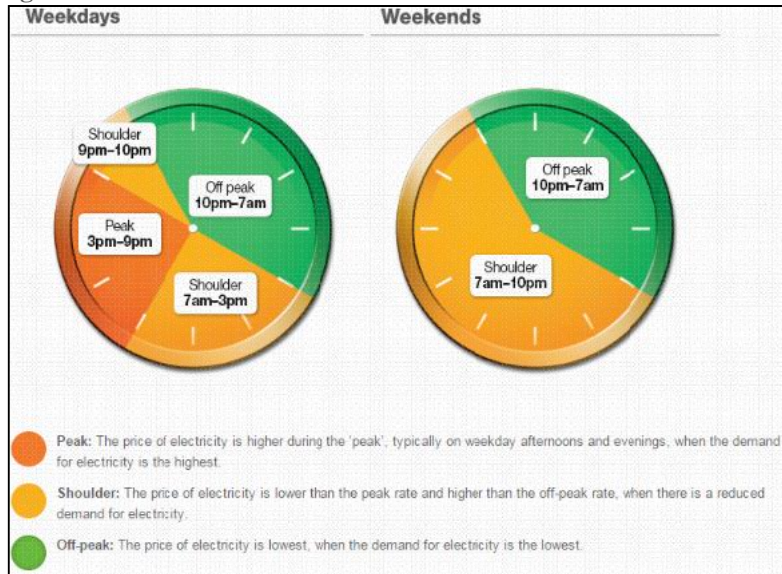
## Flexible Pricing

When Flexible Pricing tariffs were introduced, a 'common-form' structure was agreed on in an effort to help consumers understand how flexible prices work before they became too complex. To meet the common-form structure, an offer had to match the time bands shown in figure 1 below and there were conditions surrounding when and how the prices could change.

<sup>1</sup> Advanced Metering Infrastructure (AMI Tariffs) Order, Victorian Government Gazette, 19 June 2013.

<sup>2</sup> Advanced Metering Infrastructure Customer Impacts Study – Stage 2, Deloitte, July 2012.

Figure 1



With the common-form approach to flexible pricing, consumers were able to get a sense of how the new tariff structure was applied, and how it would impact the way they pay for (and potentially use) their electricity if they adopted such a tariff. However, whilst the common form approach helps consumers to understand Flexible Pricing from a conceptual standpoint, there is still a requirement for consumers to have a deep knowledge of their household usage and usage patterns to make any meaningful assessment as to whether they can benefit from a flexible pricing offer. As such, the value of this tariff innovation is hampered by a users' ability to compare new tariffs to their current tariff.

## Innovative offer structures

In 2014, retailers started to innovate further with their tariff offerings to consumers. Two prime examples are Dodo's 'Hour of Power' offer and AGL's 'Free Saturdays' offer. Both of these offer types are only possible thanks to the implementation of smart meters and rely upon usage data at thirty minute interval granularity.

Dodo's 'Hour of Power' offer was centred around the concept of charging users zero cents per kilowatt hour between 6am and 7am every day. For many standard households, this is likely to be a busy period when many electricity appliances are in use. To users who meet that profile, the hour of power offer could be quite attractive, and quite advantageous.

AGL's 'Free Saturdays' offer is another innovative tariff offer and it is exactly as it sounds. For consumers on this structure, there will be no charges applied to any electricity usage on a Saturday in the first year of their contract. Additionally, there would be no supply charge applied to Saturdays in the first year either. Again, this is likely to be a reasonably attractive offer to anyone who uses a lot of electricity on a Saturday. Even consumers who just use a standard amount of electricity on a Saturday may still find this an attractive offer on the grounds that it appears to be a discount in the vicinity of  $1/7^{\text{th}}$  of the weekly costs.

Whilst innovative tariffs like common-form flexible pricing, Dodo's Hour of Power, and AGL's Free Saturdays are all great examples of the opportunity to create new offers, attract and reward new customers, and increase the level of competition, they all include an inherent difficulty that consumers may or may not realise – they cannot be compared to a current offer, or against each other, without a thorough understanding of usage habits and consumption rates.

## Tariff innovation leads to complexity

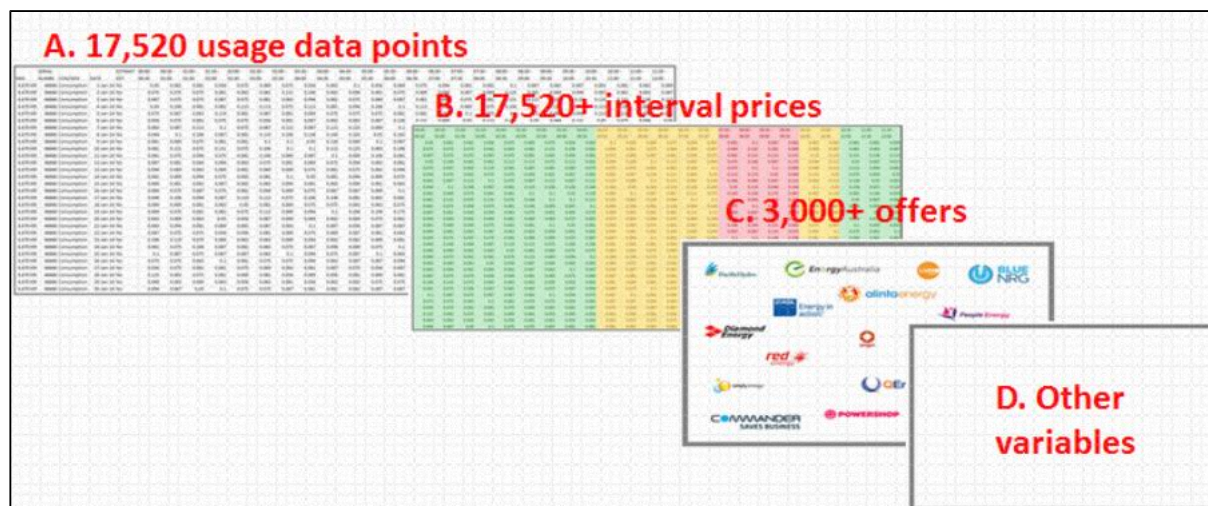
In isolation, tariff innovation in Victoria has both opened up the market and drawn attention to the willingness of some retailers to create unique offers to attract new customers. However, this progress comes at a price, the trade-off for that progress is that consumers can no longer look at the rates on their bill and easily compare them against a new offer – even if the numbers are similar, the application of those numbers may vary significantly. This is very important to address as research shows that having the ability to understand energy offers for the purpose of making the right energy decision is a top issue for consumers.<sup>3</sup> To that end, the price of progress by way of tariff innovation is a sacrifice in simplicity for consumer decision making. Hopefully, the sacrifice is only a short term one - over time the industry will develop strategies and tools to aid consumers in their decision making needs...And that is where the Victorian Government's online price comparison tools come in to the picture.

## Online price comparison tools – *My Power Planner*

Prior to launching Flexible Pricing, the Victorian Government assured consumers that they would provide them with a tool to help make informed decisions about choosing to adopt such a tariff. Off the back of that assurance, the government launched a website in September 2013 called 'My Power Planner'. The My Power Planner website was a comprehensive tool which housed all generally available electricity offers in Victoria (3,000+).

To provide accurate comparisons in a smart meter and flexible pricing environment, the underlying maths can become quite complex. The My Power Planner website was underpinned by a complex algorithm which mapped a year's worth of usage data against 3,000+ offers and then accounted for the many variables present in the calculation such as discounts, concessions, and GST. Figure 2 below is an example of what the My Power Planner website calculated for each and every user, but more importantly, it shows what is really required to derive a comprehensive and meaningful comparison for individual consumers.

Figure 2



As part of the development of the My Power Planner website, research was conducted to ensure the website had the capacity to categorise different user types and accurately estimate their electricity usage – a process that would be necessary for anyone who wasn't able to get their hands on their own smart meter data from their retailer or distributor. During development of the website, a survey was completed of nearly 1,000 Victorians, mapping their answers to a range of energy behaviour questions against their actual smart meter data. After the data was collected, a clustering approach was taken to analyse the data and create a decision tree capable of allocating users to their relevant clusters. The research found that most users fit into one of three or four different energy profiles each season of the year – leading to 54 profile variations.

<sup>3</sup> *Consumer Priorities*, Australian Energy Market Commission, December 2014,

The 54 profiles were coded into the website and the users could be assigned their annual profile by answering 12 questions each with a variety of multiple choice responses. Once assigned an annual profile, the website would use energy usage information from a users' bill to scale the profile up or down, allowing the website to generate an annual usage profile with 17,520 estimated data points – emulating the accuracy of an actual smart meter data file.

With the sheer volume of offers, and the complex task of accurately estimating household energy usage to the required granularity, there is an inherent difficulty in tariff comparison which cannot be overcome by most users.

Whilst tariff progress can lead to both simpler and more complex options for consumers, at any point where both exist at the same time, independent and trustworthy tools will need to be readily available to ensure consumers are equipped to understand how they are affected by them. If those tools don't exist, it will be very difficult for the average consumer to engage with the market.

### **Online price comparison tools – *Victorian Energy Compare***

After operating the My Power Planner website for two years, an enhanced website was launched by the Government which expanded on its functionality and usability. Taking on board feedback relating to the complexity of My Power Planner and the areas users sought greater support, a new website (Victorian Energy Compare) was launched in October 2015. Victorian Energy Compare was redesigned to provide a much simpler user interface as well as include a broader comparison function which included solar feed-in tariffs and gas offers.

In two years of operation, the My Power Planner website received over 280,000 unique visitors. In the first three months of operation, the Victorian Energy Compare website has received over 90,000 unique visitors. Whilst the percentage of users who reported a positive experience for both websites was above seventy percent, there was also a significantly high percentage of users who reported they were 'not sure' the website helped them find a retail tariff that better meets their needs.<sup>4</sup> What these figures (and the associated comments left by users) indicate, is that even when presented with balanced, independent information and a ranked list of energy offers, consumers can still feel like they don't know what is best for them when there is so much to choose from or when they lack confidence in their understanding of the market.

The Victorian Energy Compare website does as much to simplify offer information as possible. The primary approach to achieve this is to provide users with a ranked lists of offers that focuses on price. An underlying principle of the Victorian Energy Compare system is that users should be focussed on finding the most cost-efficient offers for their circumstances irrespective of the associated tariff structure.

Figure 3 below is a view of the Victorian Energy Compare ranked offers screen, it shows how the website seeks to draw users to compare offers at the annual price level and only investigate offer structure at the detailed level (figure 4). Due to the comprehensive calculation that occurs to generate the list for each user, the results that are returned come with a very high degree of confidence. Users of the website can then drill down into all the offer information as they wish, but the first impression is relative to finding the best deal.

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<sup>4</sup> Taken from a user survey applied to the website. This includes approximately 4,500 responses to the My Power Planner website, and over 1,000 responses to the Victorian Energy Compare website.

Figure 3

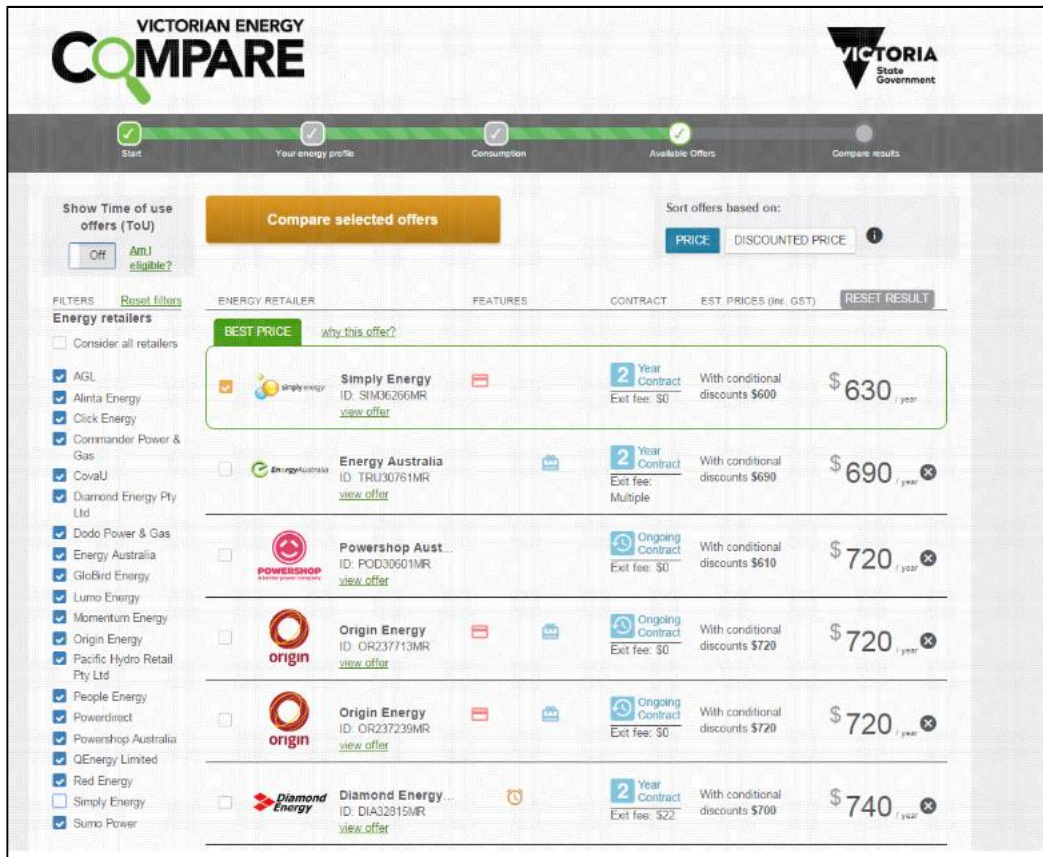


Figure 4

The screenshot shows the Victorian Energy Compare website interface. At the top, it features the 'VICTORIAN ENERGY COMPARE' logo and the 'VICTORIA State Government' logo. A progress bar indicates the steps: Start, Your energy profile, Consumption, Available Offers, and Compare results. Below this, three energy offers are displayed side-by-side:

- Simply Energy:** ID: SIM36268MR, www.simplyenergy.com.au, 13 88 08. Offer: VIC Simply Guaranteed 27 eBilling/Direct Debit. Price: \$630/year. With conditional discounts \$600. Offer Specifics: Cooling off period: 10 days, Green Power: 9%, Rate type: Single rate, Contract term: 2 year, Exit Fee: \$0.
- EnergyAustralia:** ID: TRU30767MR, www.energyaustralia.com.au, 13 34 66. Offer: Rate Fix Home - Time of Use. Price: \$730/year. With conditional discounts \$730. Offer Specifics: Cooling off period: 10 days, Green Power: 0%, Rate type: Time of use, Contract term: 2 year, Exit Fee: Multiple.
- Origin Energy:** ID: OR237688MR, www.originenergy.com.au, 13 24 61. Offer: Origin Maximiser (Flexible Pricing). Price: \$750/year. With conditional discounts \$750. Offer Specifics: Cooling off period: 10 days, Green Power: 0%, Rate type: Flexible Pricing, Contract term: None, Exit Fee: \$0.

Each offer card includes buttons for 'View rates and details', 'View this offer', and 'What's next?'. At the bottom right, there are options to 'email these results' and 'print these results'.

Part of the difficulty for consumers wanting to compare offers is that each offer has a large volume of information supporting it. A standard energy price fact sheet is generally two or three pages long and the average Victorian user has between 100 and 300 offers available to them. Based on that, to compare just two or three offers against each other, a consumer has to be willing and able to absorb as much as ten pages of information, which of course is far more effort than an average consumer expects (or wants) to invest.

## Conclusion

In simple terms, the price of progress in the tariff space comes down to complexity. As tariffs progress and become more innovative, consumers need to increase their understanding and engagement in the market as well as have tools and third parties at their disposal to reduce the complexity of the information and the difficulty of the decision to move from one tariff to another. For most consumers, price is the commanding factor in any decision about tariff change. Whilst many varied elements play a role in the decisions of each consumer, the average consumer will be most interested in the impact on the cost of running their household energy. For tariff innovation to progress at a strong rate, more time needs to be spent considering how to encourage and help consumers engage. Tools like the Victorian Energy Compare website play a role in responding to market changes in this space, however they can only be useful if communication and engagement is high and consumers are willing to learn more about energy and engage more with the energy industry - Progress needs to exist not just with industry participants but with all energy users.



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Timothy O'Leary

# Rating existing housing stock for energy performance - development of an Australian national scheme

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## Abstract

The mandatory disclosure of residential building energy, greenhouse and water performance has been a key goal expressed in Australian government building energy and carbon emission reduction targets. A major issue for the Australian real estate industry since a proposed scheme was mooted in 2011 is what will mandatory disclosure look like?

This paper provides an analysis of home energy efficiency rating and the current Residential Building Mandatory Disclosure (RBMD) landscape in Australia at both the Commonwealth and State/Territory level. The release of a Regulatory Impact Statement (RIS) including an assessment of the costs and benefits of various options for a national scheme provides a measure of likely regulation and practices around house sale and lease transactions.

Some five years on since the introduction of more stringent energy efficiency performance regulations for new housing and the declaration by an Australian federal government that states and territories adopt energy performance disclosure mechanisms for older houses at point of sale or lease, issues with implementation and the perception of stakeholders and the tools that may be employed are investigated as are wider energy efficiency and sustainability issues to do with the nation's housing stock.

Keywords: mandatory disclosure, home energy efficiency

## Introduction

In Australia, the regulation of energy efficiency of buildings is covered by a range of Commonwealth, State and Territory agencies. In 2009 specific measures to increase energy efficiency of buildings were set out in a Council of Australian Governments (COAG 2009) agreement with measures specifically for residential class buildings proposing:

- the phase-in of mandatory disclosure of residential building energy, greenhouse and water performance at the time of sale or lease, commencing with energy efficiency by 2011;
- an increase in energy efficiency requirements for new residential buildings to six stars, or equivalent, nationally in the 2010 update of the Building Code of Australia with full implementation by all states by 2011.

The latter of the measures outlined above has now been implemented in all Australian states though with some variations, such as in Queensland where the ‘six star’ measure can be achieved with significant concessions for utilising an outdoor living space as part of the house design. The first of the two measures listed above has not been implemented to date though it should be noted that in the area of the Australian Capital Territory (ACT) which predominantly relates to housing within and around the national capital Canberra, a system of house energy performance disclosure at point of sale has been in place for well over a decade. The ACT stands alone as having implemented a system of residential mandatory disclosure, whereas other states have grappled with implementation of such a scheme for their older existing housing stock.

Understanding user behaviour and the occupancy profile of any housing unit irrespective of its construction form is fundamental to an assessment of housing energy efficiency. In some studies the existing housing stock is presented as a more fruitful area of energy demand reduction than new housing, as ratings using the current crop of tools for measuring energy efficiency show existing homes can be well below the new 6 star standard and can be as low as 1 – 2 stars. The Moreland Foundation (2011) in a recent study of older housing in Victoria found the average energy rating of the existing houses was 1.3 stars, indicating just how much less efficient typical existing houses are compared to newly built houses. The sample of houses was small but represented a spread of ages typical of inner city homes built in the period ( 1900- 1980) Some houses had no ceiling insulation, poor window performance and had high level of air infiltration due to inadequate draught proofing and sealing.

This paper presents analysis of an Australian Federal Government initiative around various options for a nationwide Residential Building Mandatory Disclosure (RBMD) scheme. It provides an examination of a Regulatory Impact Statement (RIS) around the proposals together with analysis of some key housing industry stakeholder’s points of view through public submissions around these government proposals. This principal aim of this research paper is then to promote a greater awareness amongst property professional particularly in the residential sphere in Australia of RBMD proposals and housing energy efficiency labelling. It provides an analytical framework around both the technical considerations of house energy rating and policy goals for the possible future implementation nationally of a mandatory disclosure scheme for housing energy efficiency in Australia.

## Australian House energy rating schemes (HERs) and energy efficiency initiatives

According to Reardon (2005) rating tools for Australian households that have been developed to fall into two broad types, although some combine both approaches.

- “Those that predict performance at the design stage, such as house energy rating tools.”
- “Those that measure the actual performance of the building, including behaviour and appliances.”

This distinction between the two types is important because it defines how the tools can be used. Predictive tools that have standardised user profiles may be used for regulatory purposes by providing a comparison between buildings that assumes similar behaviour patterns. These tools attempt to predict the future performance of new or existing buildings by eliminating the influence of current user behaviour. Tools that provide feedback on how people are actually using a given building are more valuable for examining how occupant behaviour might be changed to reduce a building’s impact on the environment, but these tools cannot be readily used for



regulatory purposes. These tools are particularly useful at tracking improvements to the environmental management of a building. Aspects of building environmental performance that can be rated include:

- Performance of individual appliances and fixtures such as fridges, shower heads, gas heaters etc.
- Performance of individual building elements such as windows.
- Performance of a combination of elements such as the building envelope.
- Performance of a whole building

Current regulation for new housing in Australia allows the use of one of three separate software tools to demonstrate compliance with mandated minimum performance targets. The energy rating of new single dwellings can be determined by computer software provided that it complies with the relevant Australian Building Codes Board (ABCB) *Protocol for House Energy Rating Software*. Regulatory House Energy Rating Schemes (HERS) in Australia such as the Nationwide House Energy Rating Scheme (NatHERS) have traditionally only assessed the thermal performance of residential buildings, that is the anticipated annual heating and cooling energy demand. HERS tools calculate the heat energy gains and losses associated with the design of the building in a particular location, and determine how much artificial heating and cooling may be required to maintain human thermal comfort. HERS software accredited under NatHERS can be used to assess compliance with the Building Code of Australia (BCA) and other regulations. The rating using a 0 – 10 stars band is a graded adjustment taking into account house size and location as climate influences heating and cooling loads and the size of a house floor area will affect the heat transmission for a given wall area.

The aforementioned Regulatory HERS in Australia do not include the energy use of appliances or the embodied energy of building materials, although work is underway to broaden Australian HERS tools to cover other energy impacts such as lighting, hot water, and major fixed appliances. This is work incorporated by CSIRO (2010) in its release of the beyond 2<sup>nd</sup> generation tool Accurate Sustainability, now in version 2.3.313 . New South Wales building regulatory processes use a variation of NatHERS called the Building Sustainability Index (BASIX) which is an online, predictive assessment tool. The designer of a house or unit enters data about the dwelling into the BASIX tool. Requested information includes ‘site location, house size, type of building materials, and fittings for hot water, cooling and heating’ (NSW Department of Planning, 2006). After analysing this data, the BASIX tool provides a score for the design against its water, thermal and energy performance.

The Australian Capital Territory (ACT) acting independently of other states and territories first introduced a RBMD scheme in 1999, later revised under the Civil Law (Sale of Residential Property) Act 2003. The scheme which seeks disclosure of the buildings energy efficiency operates independently from the Australia Building Code and the ACT state planning and building approvals processes. Initially when introduced the star rating scale was a 1 – 6 stars scale due to the use of the earlier developed 1<sup>st</sup> generation assessment NATHERS based software tools outlined above, however since the introduction of 2<sup>nd</sup> generation thermal assessment modelling it now uses the 1 – 10 star model corresponding to the current NatHERS starbands. All ACT ratings are under one NatHERS climate zone, being climate zone no. 24 Canberra, ACT. Essentially in the Australian Capital Territory if as a vendor you are about to sell a dwelling you occupy or one that is occupied or rented to tenants, you need to disclose to prospective purchasers the current level of energy performance of the dwelling. Real Estate Agents, vendors and energy assessors will need to ensure that advertised EERs comply with the *Civil Law (Sale of Residential Property) Act* however the direct responsibility is with the vendor for the provision of the EER certificate. Section 20A of the Residential Sales Act authorises the ACT Planning and Land Authority (ACTPLA) to make guidelines for the preparation of EER statements (the Guidelines). As a vendor under the ACT EER scheme you need to:

1. include the EER value in all sales advertising of the property; for example, EER 3
2. provide a copy of the EER Statement to the purchaser
3. ensure that the EER Statement forms part of the contract for sale.

The Queensland government in 2010 briefly introduced a somewhat more holistic however less technically rigorous sustainability declaration method of disclosing information on a properties energy systems. The sustainability declaration was a compulsory checklist that had to be completed by the seller (vendor) when selling a house, townhouse or unit. The checklist was designed to identify the property’s environmental and social sustainability features in these key areas: energy, water, safety and access. The declaration was designed to be completed by the property owner or a delegated individual. If an owner was unable to complete the form, they could seek help from another person to complete it on their behalf as long as the owner signed it. To comply with the scheme a copy of the completed sustainability declaration was required to be conspicuously

displayed whenever a home was open for inspection by the seller, such as at an open house. The Queensland scheme however was scrapped in July 2012 with no replacement currently under consideration. Research by Bryant & Eves, (2012) in a survey of real estate agents operating under the Queensland sustainability declaration model found that whilst a high level of compliance with the provision of declaration existed there was widespread disengagement with the sustainability declaration process from both sellers and buyers. In fact the survey they undertook indicated that a massive 98% of buyers do not ask for a copy of the sustainability declaration at any time during the sales process. In Queensland a secondary market developed in online ‘sustainability declaration’ providers who for a fee as low as \$100 would help the owner generate the necessary declaration based on self-assessment of their properties features in the 4 key areas.

In other states in Australia no mandatory disclosure scheme currently exists for sales of existing homes however a property’s energy supply profile can be part of the requirements to show vendor information. An example of this requirement is in South Australia under the relevant real estate sales legislation through the SA Office of Consumer Affairs (2010) where the following question is required to be addressed in some fashion; “*How energy efficient is the home, including appliances and lighting? What energy sources (e.g. electricity, gas) are available*” This is part of the Form R3 the standard form for statutory disclosures used in real estate transactions in South Australia. There have been recent moves by the Victorian Government to develop a web based Residential Efficiency scorecard assessment tool that uses features of HERs type assessment, that would require a user to register and be appropriately trained in house energy assessment and that would provide advice to prospective house purchasers of the cost and benefits of improving the energy performance of the property in question. Some background details to the scheme were announced at a Victorian government energy summit held in August 2015 and according to the Fifth Estate (2015) the move shows hopefully the Victorian government was seeing there is consensus building around mandatory disclosure and minimum energy standards across the residential sector. It is anticipated in 2016 that further particulars of this scheme will be released.

## Energy bill data and occupancy factors – avoiding the problem of rating the user and not the building

Irrespective of any mandatory disclosure mechanisms, Australians can voluntarily self-assess their homes energy efficiency under such freely available assessment tools as the NABERS home energy tool which uses historical billed energy data to rate a houses energy performance (see figure 1 below).



Figure 1: NABERS Home rating online assessment - source [www.nabers.org.au](http://www.nabers.org.au)

According to NABERS (2015) to rate any home for energy efficiency requires the last 12 consecutive months of energy bills. Energy use is compared to the average home and a rating scale using 1 (poor) to 5 (excellent) is assigned to the house adjusted to account for how many people live in the home and how many weeks each year your home is occupied. The tool also provides a rating for house water consumption based on water bills. This role of data from energy bills also used in some overseas schemes has been investigated in South Australia in a report by Sustainable Focus (2010) commissioned for the government in anticipation of adoption of a RBMD scheme in Australia. This report proposes that billing data be used as a check against whatever other tool(s) are selected to determine household energy performance and in the opinion of the report's authors the question of a role for energy billing data in Mandatory Disclosure appears to be missing from the current national debate or proposed models of RBMD. In their view it is critical that historical energy consumption information be provided that is useful to the new owner/lessee and/or the vendor/lessor. This information will be useful if it can enable the comparison of different dwellings likely energy performance and provide practical guidance on how to improve energy performance. The information must also be usable by real estate agents, so it should highlight both good and bad features, and possibly flag options for improvement that might be feasible in the sale process.

Billing data however, is not found to be a reliable predictor of future energy performance in a recent study by O'Leary et al. (2015). Observations from their case study of energy rated houses also in South Australia using detailed energy monitoring and bill data showed marked variation in individual household energy use patterns for houses of similar star ratings. The mandated roll out of smart meter technology in Victoria ( Smartmeters 2015) in the past four years seen as initially problematic in part due to consumer consultation and information issues has seen metering utilised more as an electricity demand management tool than an energy performance disclosure mechanism. Fundamentally the user behaviour issue remains a big concern for any disclosure scheme using consumption data, as the research suggests strongly that human behaviour challenges building performance evaluations and that recognition of the diversity of inhabitants and comfort scenarios is required when considering regulation and standards. Housing occupants can use three or more times as much energy for heating as their neighbour, while living in exactly the same type of home (Gram-Hanssen, 2010). This suggests that even if the building fabric is robust and well insulated with suitable thermal mass, and the home has an efficient energy source, it will still be the inhabitant who ultimately determines how energy efficient a home will be. Even if the amount of energy consumed by the building for heating and cooling space is low, occupants will still be free to use as much energy as they like for appliances and hot water systems.

## **Proposed national model of a residential mandatory disclosure scheme**

July 2011 saw the release of a consultation Regulation Impact Statement (RIS) for mandatory disclosure of residential building energy, greenhouse and water performance with a following consultation period for industry stakeholders, groups and individuals to comment on proposals. The latter half of 2011 saw the policy development process initiated by the COAG declaration of 2009 whereby measures or various options were modelled for regulatory implementation, consumer and market acceptance as well as national and state level cost benefit analyses. The options (Allen Group 2011) proposed are broadly classified as;

- regulatory options ( choice of options, nos 1 -4 )
- non-regulatory options ( option 5)
- assessment opt-out ( option 6 )
- base case – maintain current approach

The proposed options ( see table 1 below) would apply to the sale and/or lease of all types of residential buildings (separate houses, semi-detached houses, flats, units and apartments), with the possible exception of housing associated with shops and offices, mobile homes, hospices and aged care accommodation as well as social and remote housing. The preliminary findings of the RIS study based on market information indicates that there are regulatory and non-regulatory options for intervention where the community would be better off with intervention than without it. That is, there are a number of options where on the basis of the modelling undertaken the benefits exceed the costs. The question of costs and benefits is contested. Residential Building Mandatory Disclosure is characterised by a mandated aspect, which drives the costs, and a voluntary aspect, which drives the benefits. Given this fact, the estimated costs are fairly certain, whereas estimated benefits are inherently uncertain. In particular, the benefits are largely driven by the assumed voluntary investment response (or uptake rate). There is not enough information to measure the level of uncertainty around the assumed uptake rate, but it is likely to be large.

Option	Advantages	Disadvantages
1. Full Thermal Assessment	<ul style="list-style-type: none"> <li>• Site-specific</li> <li>• Most accurate</li> <li>• Based on NatHERS thermal performance</li> <li>• Requires homeowner to engage with assessor which enables the transfer of information</li> <li>• Recommendations tailored to homeowners specific needs</li> </ul>	<ul style="list-style-type: none"> <li>• Requires full house plans and/or significant assumptions that increases the costs and may reduce effectiveness of recommendations</li> <li>• May create additional confusion for homeowners and the marketplace about NatHERS and the difference between NatHERS and RBMD</li> </ul>
2. Simplified Thermal Assessment	<ul style="list-style-type: none"> <li>• Site-specific</li> <li>• Focuses on the 'built-in' capacity of a house to achieve sustainability outcomes, rather than the 'bolted-on' features such as water tanks etc</li> <li>• Currently more cost effective than option 1</li> <li>• Good transition option to facilitate long-term adoption of option 1</li> <li>• Requires homeowner to engage with assessor which enables the transfer of information</li> <li>• Recommendations tailored to homeowners specific needs</li> </ul>	<ul style="list-style-type: none"> <li>• Less accurate (than option 1)</li> <li>• Requires a number of assumptions that reduces the site-specific accuracy, and which can cause confusion</li> </ul>
3. Online self assessment	<ul style="list-style-type: none"> <li>• Easy to create and track data</li> <li>• Contains a minimum judgment of thermal performance</li> </ul>	<ul style="list-style-type: none"> <li>• Does not require an assessor which can lead to errors and requires the assessment to be overly simplistic and/or rely on large assumptions</li> <li>• Does not provide homeowners with new and tailored knowledge about their property</li> <li>• Almost impossible to provide quality assurance</li> <li>• Will tend to focus consumers on 'bolted-on' features such as water tanks, rather than those aspects which are 'built-in' and reduce consumption</li> </ul>
4. Self assessment checklist	<ul style="list-style-type: none"> <li>• Identifies the houses which have easy to understand sustainability features (ie water tanks, solar hot water, PVs)</li> </ul>	<ul style="list-style-type: none"> <li>• Does not provide a comparable rating</li> <li>• Does not consider 'built-in' features of thermal performance that reduce consumption</li> <li>• Does not require an assessor which can lead to errors and requires the assessment to be overly simplistic and/or rely on large assumptions</li> <li>• Does not provide homeowners with new and tailored knowledge about their property</li> <li>• Impossible to provide quality assurance</li> <li>• Anecdotal evidence (from QLD Sustainability Declaration) indicates people prefer not to indicate the presence of features</li> </ul>
5. Public education campaign	<ul style="list-style-type: none"> <li>• Can articulate one message clearly (ie, black balloons)</li> </ul>	<ul style="list-style-type: none"> <li>• Cannot provide site specific information</li> <li>• Does not provide nationally consistent and comparable data</li> <li>• No guarantee that message is heard or that action is taken</li> </ul>

Table 1: SUBMISSION TO RBMD RIS; COMMENTS ON OPTIONS 1 -5 Source: *Regulatory Impact Statement (RIS)* Public submission by Association of Building Sustainability Assessors , September 2011

Thermal efficiency assessment as described in this papers section on HERS requires adequate and accurate knowledge of the thermal mass, insulation levels and zoning of a dwelling and this in turn is reliant on adequate and accurate knowledge of the construction materials and any thermal barriers or insulation within the wall structure. Such a high level of assessment as proposed in option 1 is arguably only feasible and cost-effective in newer homes for which current, accurately drawn floor plans exist. Option 2 provides a more simplified assessment of the thermal performance of the building shell and less detailed analysis of the components (appliances) related to energy efficiency and due to its much lower cost is modelled as the most desirable from a cost/benefit standpoint.

Not a great amount of detail is provided as to what real level of assessment is required for both the building and its components however some have pointed to the type of assessment carried out under the now defunct Commonwealth government green loans scheme which contained little information on the building elements. It must be noted that, for most existing housing, house plans either no longer exist, are not held by the current home-owner, and in the case of Councils and other regulatory authorities, have often be lost or at best archived and are thus not readily accessible so the question of whether house plans are needed is a clear 'game changer' in the scenarios of option 1 versus 2.

Further options proposed (listed as options 3 and 4) use a self-assessment method to achieve the desired outcomes. Whether home owners will either not perform any such assessment accurately – for the same reasons of perception of potential loss as are applicable to lessees and real estate agents, or they will simply get it wrong is a key question surrounding these options. Human nature being what it is, vendors have a vested interest in not spending any money on a property they intend to sell. Additionally, they do not have any incentive to highlight potentially price-sensitive failings of their property. For that reason, there is an argument that the provision of assessments must not be performed by vendors, lessees or real estate agents as all have a vested interest in minimising the true situation. This would be akin to allowing vendors to provide ‘building construction’ examinations, or ‘pest examinations’ such as those currently required by most lending authorities and which are paid for by purchasers.

Option 5 is a non-regulatory option, which addresses the government’s objective to tackle the market failure associated with a lack of information through a public education program and publicity campaign. Under this option of voluntary uptake through public education and publicity campaigns government would conduct a public education program and publicity campaign to increase awareness of the importance of improving the energy, greenhouse and water performance for residential buildings, and the opportunities that home owners, tenants and landlords have to improve the performance of buildings. This option could adopt a voluntary checklist approach similar to that outlined in Option 4. Option 5 appears designed to some extent, take advantage of the existing trained assessors such as Green Loans and for Professional development of real estate agents under this public information approach would be of significantly less magnitude than options 1 to 4.

Option 6, the ‘opt-out’ approach would appear to still require agents to receive training on the regime in order to fully inform clients of their obligations and opt-out choice. Those not wishing to have a zero rating – potentially the majority - would still need to be taken through the disclosure reporting documentation so the professional development impact would not differ greatly from options 3 and 4.

## **National Residential mandatory disclosure -- problem identification, stakeholder perceptions and public acceptance**

The Australian RMBD regulatory impact study does state that “*the market for residential buildings suffers from information problems*”. Specifically it states that there is a “*market failure*” in the housing market leading to “*information asymmetry (unevenness)*” with the following undesirable outcomes being observed today, it states:

- “*It is difficult to distinguish between high and low quality buildings (in relation to energy, water and greenhouse performance) at the time of purchase/lease*”
- “*Adverse selection (the market for lemons)*”
- “*High quality products driven out of the market*”

ABSA (2011a) in its publically available submission agrees that the problem of building inefficiency is created by information asymmetry and missing information, however, they believe that in addition to these two issues, that the problem is further complicated because the market doesn’t value the information, nor understand what to do with such information and that “*you can’t manage what you can’t measure*”. They favour options 1 and 2 and contend that a good rating scheme should encourage innovation by providing flexible compliance paths and not be overly prescriptive. Also that it should have the capacity to benchmark higher performance and be able to measure both minimum mandated and better performance. It should integrate the use of current rating tools and allow more impact categories to be added as housing and its impact on the environment become more understood for instance the question of embodied energy.

Results from surveys commissioned by the Clean Energy Council (2011) indicate that the problem is more complex than information asymmetry, where it is stipulated that Australians it seems, want to take action to reduce their house energy demand but are prevented from doing so by lack of information and support. In their survey 95 per cent of people said they were concerned by rising energy costs and 89 per cent said they were

willing to take action to use less energy, half knew little or nothing at all about the key aspects of their energy use. 73 per cent of respondents said they would welcome more information on how they could use less energy or use it more efficiently.

The Residential Development Council (2011) in its submission to the RIS consultation suggests that the implementation of a mandatory disclosure scheme will have a long term impact and as such it is important to get the policy right and that any scheme requiring mandatory disclosure of energy, greenhouse and water performance should “include a **public education program and publicity campaign to increase consumer awareness about the importance of improving the environmental performance of all residential buildings (existing and new)**” and “secure the **national implementation of a single scheme with a consistent method of assessment and measurement**” with a further goal to “**end consumer confusion and 'star overload' in the residential sector, especially regarding energy efficiency**”. Red-tape and the burden of compliance and the cost of compliance is an issue raised by a number of stakeholders such as the Law Society of South Australia (2011) in its submission stating “*the society’s initial view is to express disappointment that the RBMD initiative should seek to impose yet another layer of compulsory disclosure upon transactions conducted throughout Australia on a daily basis.*”

The RBMD consultation RIS envisages that social housing would be treated somewhat differently to other residential property types under a mandatory disclosure scheme however it does not specifically identify how the treatment of social housing would differ, recommending that this should be a matter for separate analysis. Tenants in social housing, as in the market generally, are responsible for paying ongoing energy and water bills and it is envisaged that residential mandatory disclosure can provide information to tenants to foster investment in energy efficiency measures following occupation of the building. Because they are not the owners of the property (either the building envelope or the major fixed appliances), and because they tend to have lower than average incomes, there may be little capacity for such investment by social housing tenants. The social benefits to having an improved housing stock are well documented however it remains a key concern for the acceptance of a scheme to ensure methods in place for assessing energy efficiency in a social housing context avoid the risk of providing either poorly understood information or actual misinformation to tenants and low income households with undesirable consequences.

On the question of who can provide the assessments used in energy performance disclosure ABSA (2011b) estimates there are over 2000 home energy assessors trained in “2nd Generation” software and that numbers are reasonably well spread across Australia, particularly in NSW, Vic, Qld and WA but are concentrated in capital cities. Wide geographical spread is not essential as assessors receive most plans electronically and can work from anywhere. Numbers are well distributed across the three software packages available under the National Software Protocol: AccuRate, FirstRate and BERSPro. Green Gurus (2011) contend that real estate agents and property managers are at the front line in the housing sector when people are choosing to buy or rent a home and are the missing link so far in optimising the flow of information on energy and water efficient homes. They conducted a study in WA where participating agents confirmed that marketing strategies which highlight the benefits of sustainability concepts, products and their services will be paramount to increasing demand for sustainability advice. The study found that informed real estate professionals are able to identify cost savings including subsidies available for the properties they manage/sell and communicate these to their client. They have also started to include sustainability information in their marketing material to promote the green credentials of the properties they are selling.

## Conclusion

Residential Building Mandatory Disclosure is a federal government initiative which although due for phased introduction in 2011 has yet to be implemented as a national scheme. The consultation RIS provides a number of specific options for a national single scheme however as borne out by state responses such schemes may be implemented in different ways across the states and territories either as some states will choose to possibly extend their existing schemes e.g. the ACT, some abandon an existing scheme such as Queensland without moving to any new scheme or as in the case of Victoria now in 2016 move to develop a new Residential Efficiency non mandatory tool. Whilst it is beyond the scope of this paper to provide very detailed critical

analysis of each possible variation to home energy disclosure schemes and tools and examine such impacts of the macro-economic modelling of costs and benefits, the regulation impact statement released back in 2011 has provided a basis for a broad comparison of likely schemes and elicited stakeholder comment as a valuable contribution to any assessment of likely outcomes for a national scheme.

Mandatory disclosure tools that exist for new housing and regulation of standards for new housing exist both nationally and internationally however how they might be adapted for rating existing housing stock or whether it is fact desirable to use such existing tools and what the benefits are to their use is still ill-defined. There is not a great deal evident in either the regulation impact statement or policy development processes of much in the way of learning from overseas models of mandatory disclosure and it can be argued that the federated system of states and territories in Australia each controlling their own building sale and lease regulations has not assisted the implementation of a national scheme.

Whatever National or individual State(s) based model developed for residential building mandatory disclosure, it appears likely it would need to report on both the fabric of the building as well as the appliances (especially heating/cooling), because this data will influence the veracity and usefulness of the final assessment report. Options that require a full thermal assessment of the building appear the more costly however have the advantage of being tailored to specific measures that allow either the vendor or future owner to undertake cost effective improvements in performance.

Self-assessment or checklist type options requiring no independent assessment provide less accurate data on the actual energy performance and there is evidence is of un-willingness of purchasers to either engage with or understand the information that is presented. Billing data as used in some overseas schemes does not appear to be part of the options outlined in the RBMD RIS, whilst there appears to be a case that using billing data is useful as a voluntary feedback mechanism it is fundamentally flawed as a measure of building energy performance capacity due to wide variation in occupant behaviour.

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Mike B Roberts

# Using PV to help meet Common Property Energy Demand in Residential Apartment Buildings

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## Abstract

14% of Australians live in apartments, predominantly in urban centres, yet few of these have PV systems, despite high levels of PV deployment on separate and semi-detached residential buildings. Increased PV deployment on apartment buildings represents a valuable market opportunity for the PV industry, which would allow apartment dwellers to obtain the financial benefits of using PV to offset electricity bills. PV on apartment buildings could also help relieve network congestion, as it is a good fit with commercial loads commonly found in urban areas, and might therefore benefit network operators as well as households.

Some recent high-density residential developments incorporate a PV system for each residential unit, or an embedded network serving all units. However, in existing apartment buildings, as well as physical and other barriers to PV installation [1], legal arrangements can create additional difficulties for individual rooftop PV systems and there may be specific technical and economic barriers to the installation of embedded networks. In these cases, installing PV to supply common property demand (sometimes a high proportion of total building demand) may present a simpler retrofitting opportunity.

Common property load varies significantly between apartment buildings and may include lighting for common areas, and carparks; lifts; water heating and pumping for centralised hot water and pools; air conditioning and ventilation. Its characteristics and diversity are not well understood, with a 2008 DEWHA report identifying the need for further research into communal area energy use in high and medium density housing. Common property energy is typically purchased on behalf of all unit owners by the Owners Corporation, often on commercial tariffs with high ratios of demand to volumetric charges.

We present preliminary findings from a study that utilises the 30-minute common property electricity demand data for 25 apartment buildings in the Sydney metropolitan area. Daily and annual demand profiles are examined and PV systems modelled for each building, sized both for available roofspace and to ensure high levels of on-site consumption. The economic viability of these PV systems is explored using existing retail tariff structures. The findings highlight the potential opportunity for PV to assist in meeting common property load in medium- and hi-rise apartment buildings, and the additional opportunity to supply individual unit loads or sell energy to third parties in medium-rise buildings.

## Introduction

Although Australia has PV penetration reaching 40% of separate and semi detached residential housing in some Australian cities [2], few of the 1.3 million Australians who live in apartments [3] have access to on-site renewable energy. PV can be deployed on-site to supply individual unit loads, either using independent PV systems for each unit or shared systems distributed through embedded networks or virtual net metering [1]. However, the simplest and most common retrofitted arrangement utilises PV to supply common property (CP) loads only.

There is a limited amount of published data regarding energy loads in Australian apartment buildings. A 2005 report from Energy Australia [4] is often cited in comparisons of energy use as evidence that per-capita energy emissions are highest in high-rise apartment buildings and higher in mid- and low rise apartment buildings than in detached houses, although it is unclear whether these emissions calculations are based solely on total energy use or consider the energy sources utilised. Conversely, a 2010 IPART study [5] suggests that apartments use less energy than detached dwellings, but significantly the comparison does not include common property load in calculations of apartment energy use.

The Energy Australia report identifies some of its own limitations (disproportionate representation of high rise buildings in its sample despite 72% of apartments being in buildings of 3 storeys or less [3], reliance on ‘walk through’ energy audits, etc.), and highlights the difficulty of comparisons across the diverse range of existing multi-occupancy buildings in Australia. In view of this diversity, load data from a significant sample of buildings would be required to statistically capture the variability of load profiles. While it has not been possible to obtain data from large numbers of buildings for this study, using a modest sample of 25 apartment buildings in the Sydney metropolitan region, it has been possible to undertake an initial exploration of the nature and variability of CP loads, and a preliminary analysis of the ability and cost-effectiveness of PV systems to supply common property demand for apartment buildings in the Sydney metropolitan area.

## Common Property Loads in Sydney Apartment Buildings

Existing Australian multi-occupancy housing stock is very diverse in terms of height, construction and facilities. Consequently, common property (CP) loads are highly variable in total energy use and in their daily and monthly profiles. CP demand may include lighting for common areas, stairwells and carparks; lifts; water heating and pumping for centralised hot water and/or for pools; heating, ventilation and air conditioning (HVAC) for common areas and sometimes centralised HVAC for all units. Although CP energy demand can be relatively low in low-rise walk-up apartment buildings, it can account for a large proportion of the total building energy usage in high and medium rise buildings where vertical transportation and communal service area requirements increase markedly.

This study utilises 15- and 30- minute CP load data (initially obtained for the purpose of energy audits) for 25 apartment buildings in the Sydney metropolitan area. Ten of these sites have (ground floor) commercial as well as residential units, but the common property loads do not include any commercial services (with the possible exception of Site 36 where the metering of air-conditioning for the commercial units is unclear). Table 1 shows some characteristics of the sites. (Note that the 25 sites were selected from a larger set on the basis of availability of interval data - hence the non-sequential numbering of the site identifiers.)

**Table 1- Summary of Site Characteristics**

Site Identifier	No. storeys	Total Units (Commercial)	Centralised A/C	Pool	Number of Lifts	Interval Data Available (Days)	Building Footprint (m <sup>2</sup> )
1	12	208 (0)	No	No	3	485	1530
28	4	35 (6)	No	No	2	819	1070
29	5	35 (2)	No	No	2	395	1220
30	8	104 (0)	No	No	3	394	2090
31	4	34 (0)	No	No	2	862	1380
33	3	43 (0)	No	No	4	210	1490
34	4	44 (16)	No	No	2	181	1041
35	5	33 (6)	No	No	4	365	1740
36	5	116 (2)	No	No	2	883	2510
37	6	102 (15)	No	No	4	365	2400
38	9	138 (0)	No	Yes	4	731	3660
40	18	110 (0)	Yes	No	4	156	1040
41	7	161 (0)	No	Yes	6	365	4930
44	5	20 (0)	No	No	1	730	1500
45	7	121 (42)	Yes	No	3	268	2260
47	5	42 (1)	No	No	1	357	1200
48	4	44 (0)	No	No	0	365	2250
50	4	58 (0)	No	No	1	170	1930
51	3	52 (0)	No	No	3	365	3330
52	4	48 (0)	No	No	0	365	2620
53	4	26 (0)	No	Yes	3	607	1160
54	5	20 (0)	No	No	2	668	11290
55	8	40 (1)	Yes	No	4	1156	2650
56	20	80 (0)	Yes	Yes	2	548	3850
57	20	154 (4)	Yes	Yes	2	365	4000

Figure 1 shows the weekday daily common property load profiles averaged over the period of available data for each site, while Figure 2 shows the weekend profiles, which are similar in most cases to the weekday data.

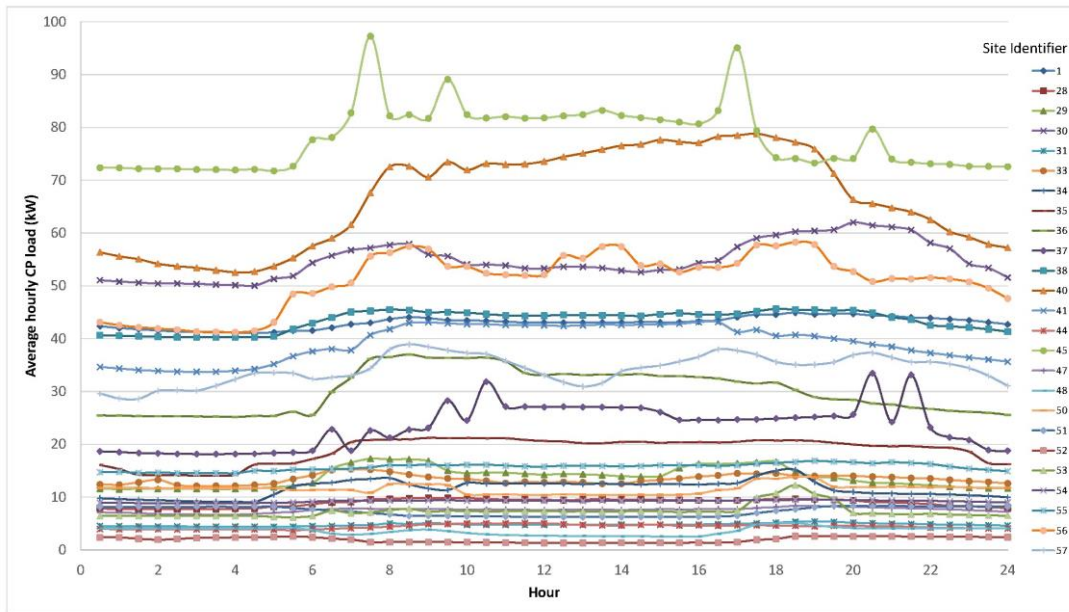


Figure 1 – Average weekday CP load profiles

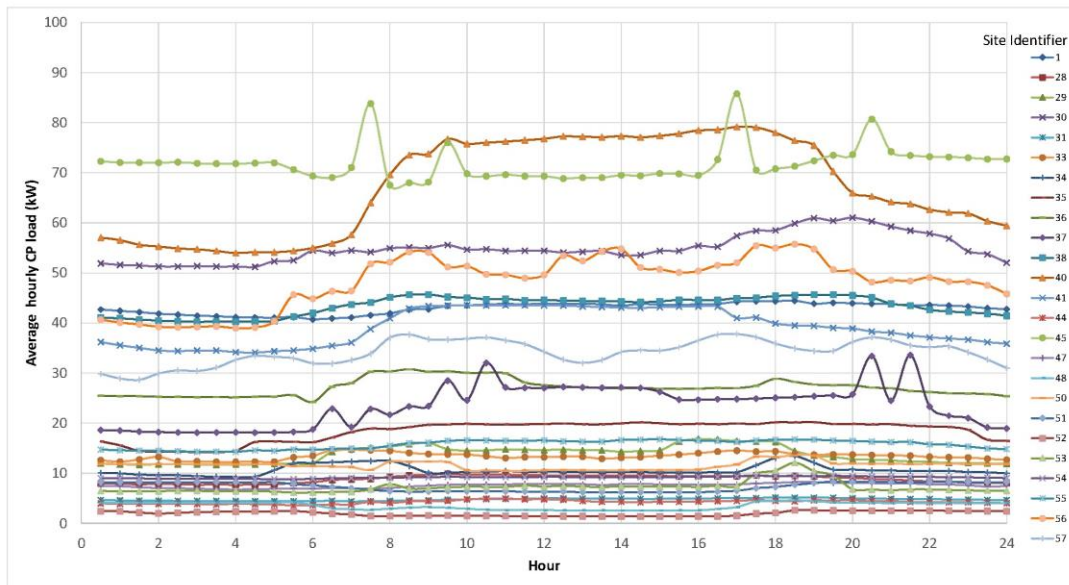


Figure 2 – Average weekend load profiles

As is the case for residential building loads in general, daily CP demand is likely to have morning and evening peaks, reflecting increased consumption as residents prepare to leave for, and return from, their daily activities. However, many of the buildings in this study have significant continuous and near constant CP loads that result in relatively flat demand profiles. Figure 3 shows the same profiles for all days normalised for the number of units (residential and commercial) in each building, indicative of the significant variability in common property energy usage beyond that due to the wide range of building sizes.

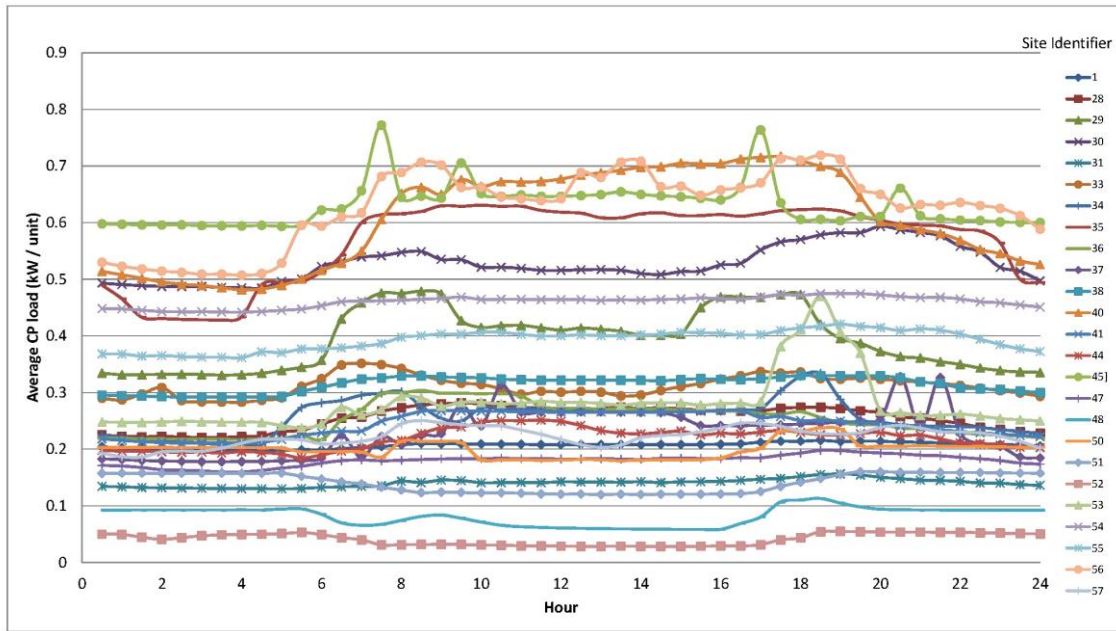


Figure 3 – Average daily load per unit

To provide a basis for the analysis of the suitability of PV systems to meet CP load in Australian apartment buildings, and to add to the thus far limited amount of Australian CP load analysis in the public domain, the remainder of this section explores some of the factors influencing the variability of load profiles in the base dataset. Figures 4 to 10 show the available 30-minute demand data for the common property load at some of the sites. The figures also show the variation in period over which data has been made available for the study.

The seasonal variation shown in Site 56 (Figure 4) is somewhat typical of sites with air-conditioning (A/C) and a pool, while site 45 (Figure 5) shows an increase in demand from February onwards due to ducted heating in the building.

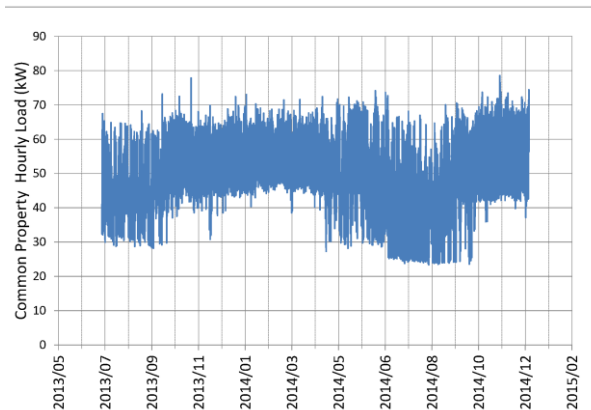


Figure 4 - CP Load for Site 56

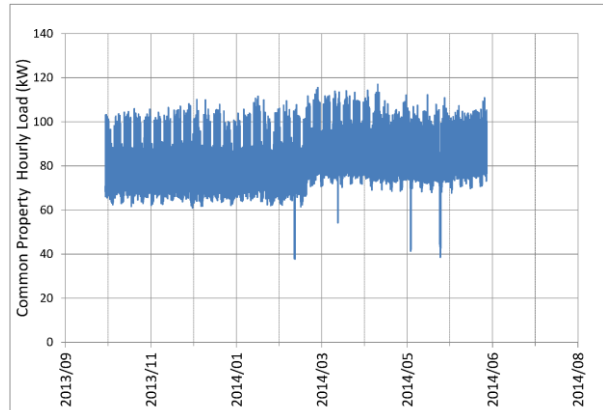


Figure 5 - CP Load for Site 45

The size of the summer spikes for site 35 (Figure 6) is largely due to carpark ventilation fans which are used heavily in summer to vent the heat produced by heat exchangers (located in the underground carpark) for A/C in the common lobby areas, while Site 38 (Figure 7) has minimal seasonal variation, but exhibits sporadic spikes all year round as the carpark fans are used for prolonged periods during procedures to unblock sewage pipes.

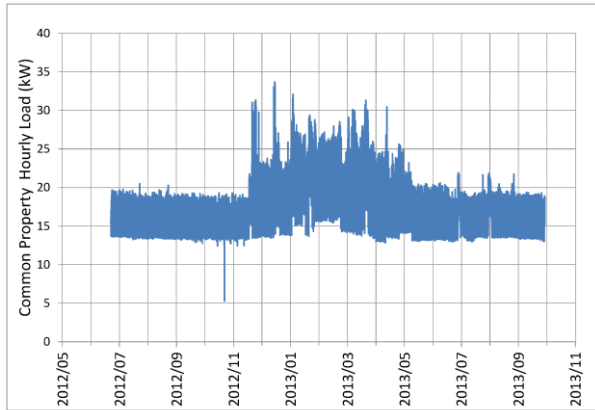


Figure 6 – CP Load for Site 35

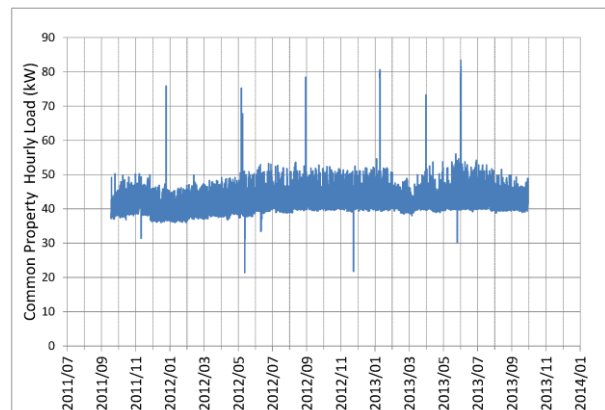


Figure 7 – CP Load for Site 38

Similar control issues with major equipment (often high power ventilation fans and pumps) are evident in many of the sites. For example, sites 1 and 50 (Figure 8 and Figure 9) show increased demand for periods due to faulty timeclocks, also controlling carpark fans. With many sites on tariffs with high demand charges and relatively low supply charges, such control issues can have a major impact on common property energy charges, which are typically passed onto unit owners by the Owners Corporation.

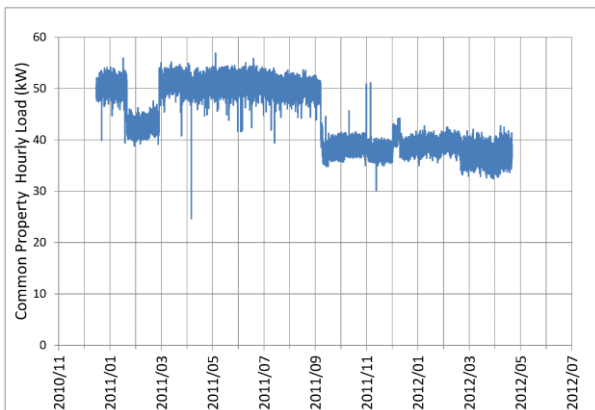


Figure 8 - CP Load for Site 1

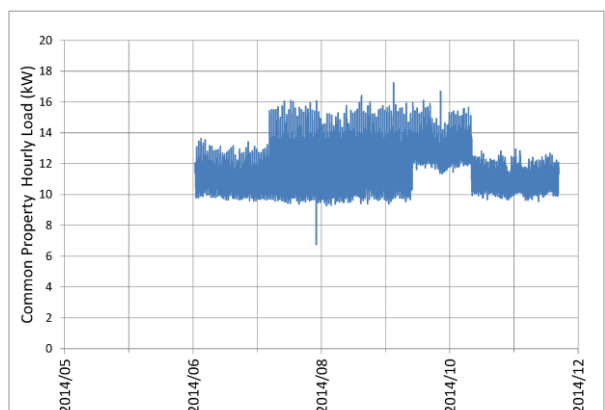


Figure 9 – CP Load for Site 50

For those sites with underground car parks, carpark lighting accounted for between 11% and 51% of total annual load, with an average of 23%. Figure 10 shows the impact on common property demand of introducing simple energy efficiency measures (LED lighting, motion sensors) at site 31. Total common property load reductions of 40% or higher through these low cost retrofitted solutions are not uncommon.

This section has explored the variability of CP load profiles in different buildings, depending on the equipment installed and the design and operation of the building. Because of this variability, general conclusions about the use of PV to meet CP loads are hard to reach and further assessment of the opportunities requires specific analysis of generation and load data for case study buildings. The remainder of the paper will present the method and results of a preliminary assessment of the ability of PV to offset CP loads and its cost-effectiveness for this application.

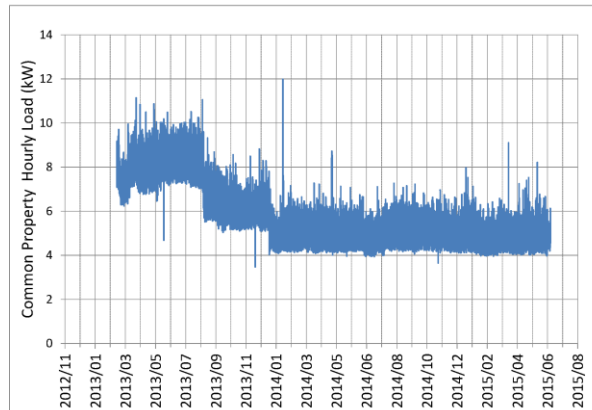


Figure 10 - CP Load for Site 1

## Method

Of the 25 sites in the study, 18 had a full year of load data supplied for a period when hourly weather data was also available. For each of these buildings, two potential PV systems are considered. The first “Full Roof” system approximates to the maximum amount of PV that could be installed on the rooftop of the building. For each building, this system has been designed using Nearthmap [6] to fit generic PV modules (250W 1600mm x 1000mm) to the usable roof area. To assess the useable roof area, oblique images of the rooftops were used to estimate the height of projections and a simple geometric model used to calculate shading. In accordance with previous studies [7] and typical calculations used to determine array spacing [8], the arrays have been arranged to avoid shading between 10am and 2pm on the winter solstice (the extent of this shading is shown by dark blue lines in Figure 11). Using these criteria, Copper et al [7] calculated that to avoid self-shading, 50% - 60% of a horizontal roof surface is usable for mounting latitude-tilted arrays, while arrays flush mounted on a flat roof in Sydney can obtain solar yields of up to 90% [9]. For this study, therefore, the arrays are mounted flush to the roof surface (or at 2° to flat roofs) to bypass the need to provide space between modules to avoid self-shading and hence maximise output from the available roof area, although, in the case of large arrays, pathways have been left clear to facilitate access for maintenance. For sloping roofs, sub-systems are arranged with different orientations, flush to each roof surface.

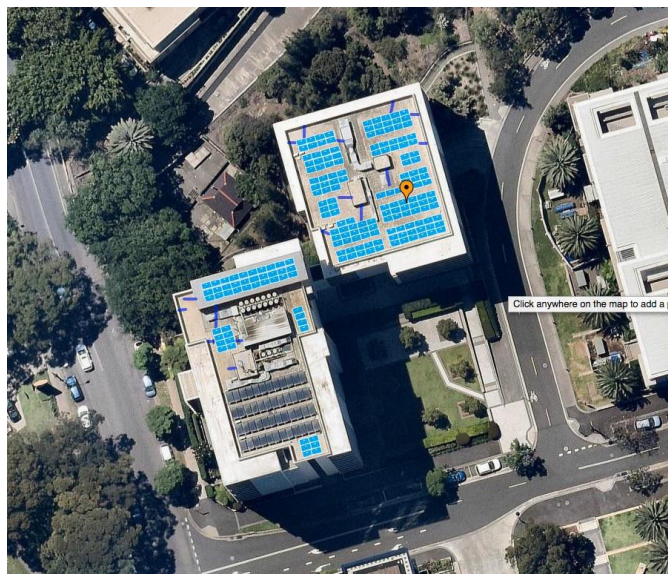


Figure 11 – Example “Full Roof” PV system

The second “Zero Export” system for each building has been sized ignoring building constraints, and matched to the common property load profile to avoid export of more than 0.1% of PV generated over the year. Although sizing a system for close to 100% self-consumption may not be financially optimal in many circumstances, this

arrangement is often used for strata buildings under current regulatory and economic conditions [1] to avoid complexities concerning taxation of export revenue, particularly since export tariffs for PV are typically very low compared to retail tariffs. As an example, the export tariff used for this study is 5.1c/kWh, compared to peak consumption tariffs that vary between 19.6c/kWh and 47.7c/kWh.

The “Viable” system for each site is the smaller of the two systems modelled. i.e. sized for zero export but constrained by the available unshaded roof area.

The output of each PV system was modelled over a year using the PV Watts model (pvwatts5[10]) in NREL’s System Advisor Model (SAM) [11]. The default values in SAM for system efficiency, degradation, etc. were used. As many of the buildings have some degree of HVAC (whether for common areas or serving units centrally) and / or pools, their common property load can be affected by weather as well as seasonal factors. A real year weather file was created for each site for the same year as the available demand data, utilising Bureau of Meteorology (BOM) gridded satellite-derived irradiance data and weather data from the nearest BOM weather station. Emissions abatement for the largest possible PV (“Full Roof”) system at each site was calculated, based on the total annual generation and using an average electricity emissions intensity value of 0.84 tonnes CO<sub>2</sub>-e /MWh for New South Wales[12]. Only scope 2 emissions are considered (i.e. emissions physically produced by burning of fuels), not scope 3 emissions (those due to the extraction and transportation of the fuel or transmission and distribution of the electricity). Nor has account been made for embodied energy, either of the PV installation or of the power generator and distribution network.

For each site, the 2013 / 2014 published tariff rates (with actual negotiated % discounts applied as appropriate) were used to calculate financial savings to the Owners Corporation due to reduced energy import and energy export (if any) for the PV systems sized to maximise self-consumption. A simplified analysis of potential demand charge savings was also included although the irregular distribution of large peaks in many of the load profiles makes it difficult to attach any degree of certainty to these estimates. The combined annual savings were used to calculate simple payback periods for the systems, using average \$/W capital costs for NSW [13] (ranging from \$1.24/W for systems above 50kWp to \$2.41/W for the smallest 1.5kW system) and the current CP load tariffs for each building, assuming no tariff changes going forward.

## Results

For the 18 sites modelled over a full year, the available roofspace had the capacity to generate an average of 74% of the common property load, with some of the 3, 4 and 5-storey sites having total PV capacity in excess of (and as high as 3 times) annual CP demand (Figure 12).

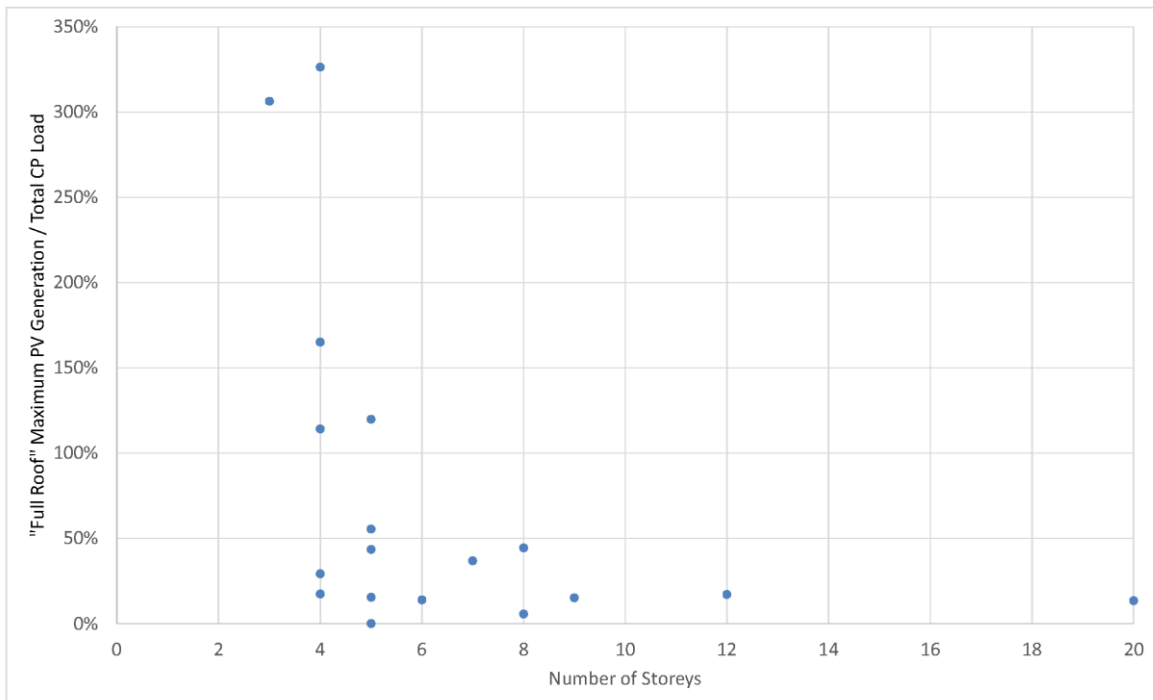


Figure 12 – Maximum potential annual generation as proportion of CP load

Figure 13 shows the CO<sub>2</sub>-equivalent GHG emissions that could be avoided each year by installation of the “full roof” PV system for each site (on average 23kg CO<sub>2</sub>-e/m<sup>2</sup>/year) and demonstrates the variability in the proportion of the building footprint that can be utilised for PV deployment. Figure 14 shows the potential reductions per unit, which have an average value of 1120kg CO<sub>2</sub>-e / unit, with significantly higher reductions possible for some of the medium-rise buildings. This represents 14% of the (8 tonne) average annual household GHG emissions reported in the Energy Australia study. [4]

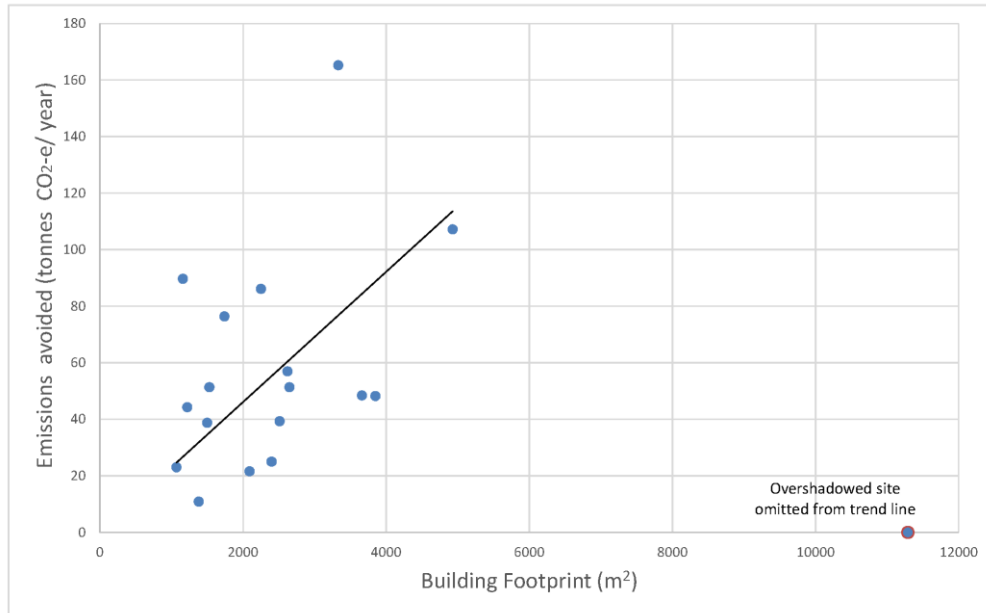


Figure 13 – Potential whole building emissions reductions

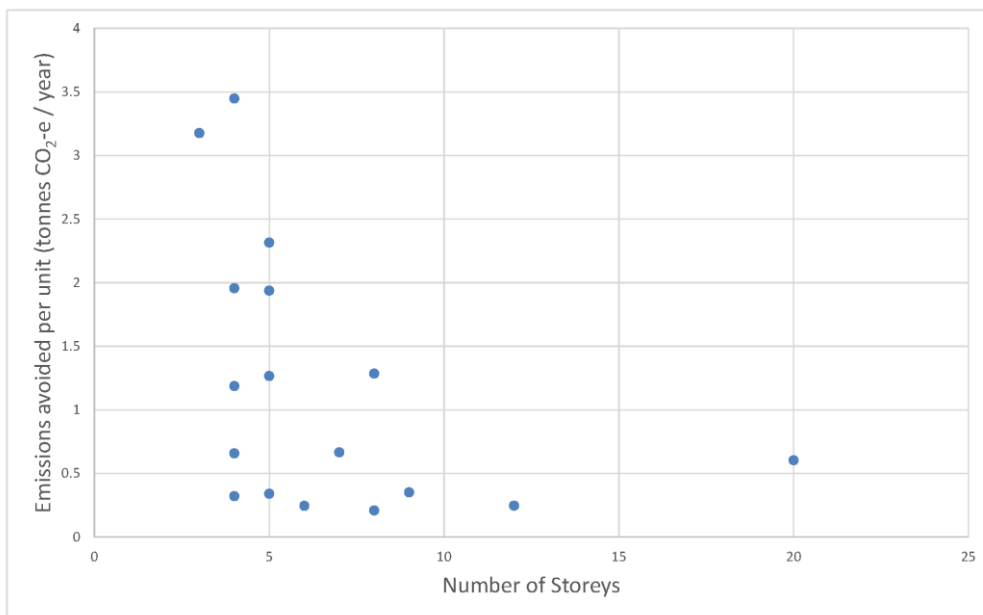


Figure 14 – Potential emissions reductions per unit

In 7 of the 18 sites examined in the study, the “Zero Export” PV system sized to meet CP load without export was larger than the “Full Roof” PV system. However, for the remaining systems, the available roof area was at least sufficient to site a “Zero Export” system, with many medium-rise buildings having a large surplus of potential generation (Figure 15). The latter may be suitable sites for deploying PV to serve loads of individual units in addition to common property, or for deploying storage to offset evening demand.



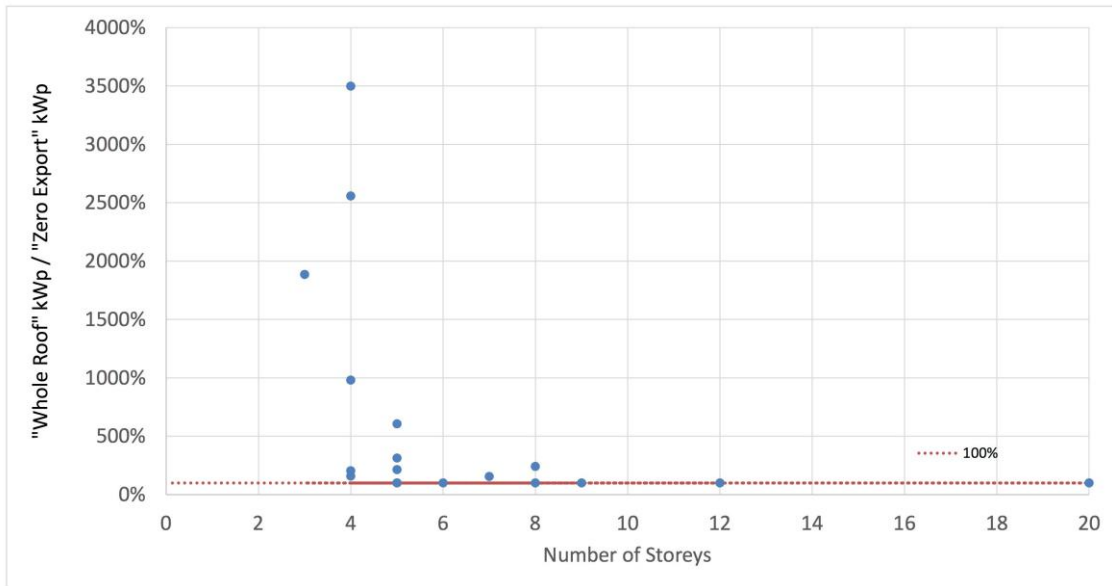


Figure 15 – Ratio of “Full Roof” to “Zero Export” system sizes

The annual electricity bill savings per apartment for installing the “viable” system range from zero (for an overshadowed site) to \$180 with an average value of \$77. On average, the non-discounted payback period for the “viable” PV systems would be 5.0 years (but see the discussion below). Although the shortest payback periods were for buildings with 5 storeys or less (Figure 16), no clear relationship was found between payback and building height or building footprint, once again highlighting the diversity of apartment building types and suitability for PV.

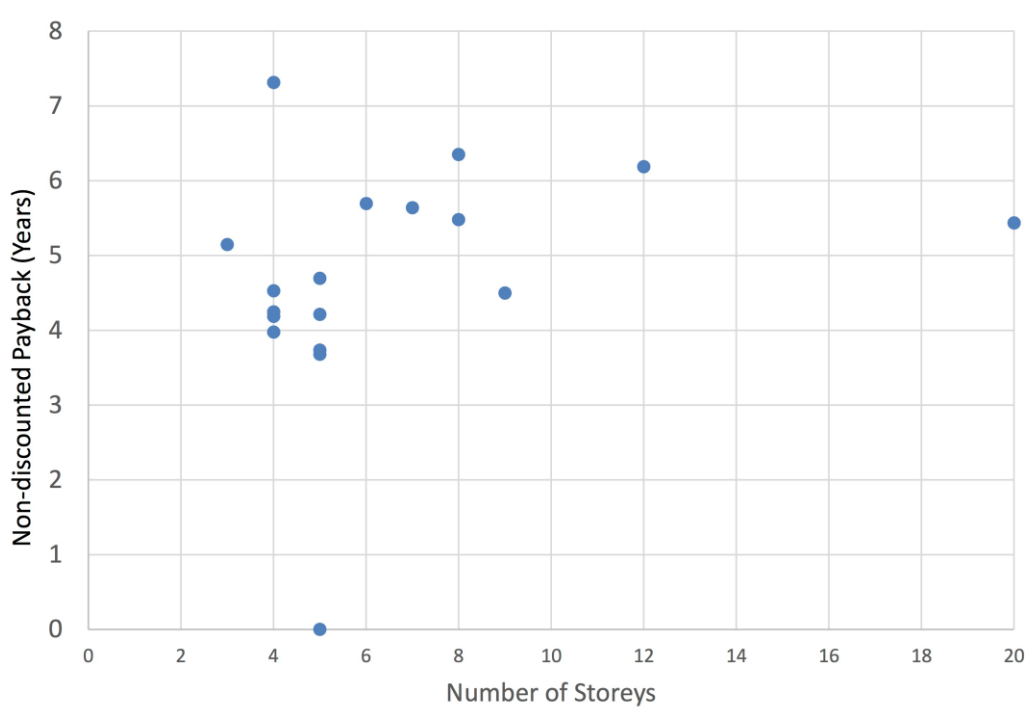


Figure 16 – Simple payback for “Viable” systems

Figure 17 suggests that, as would be expected, non-discounted payback periods are lower for PV systems serving CP loads in buildings with higher average supply tariffs, but a bigger sample would be required to establish any relationship.

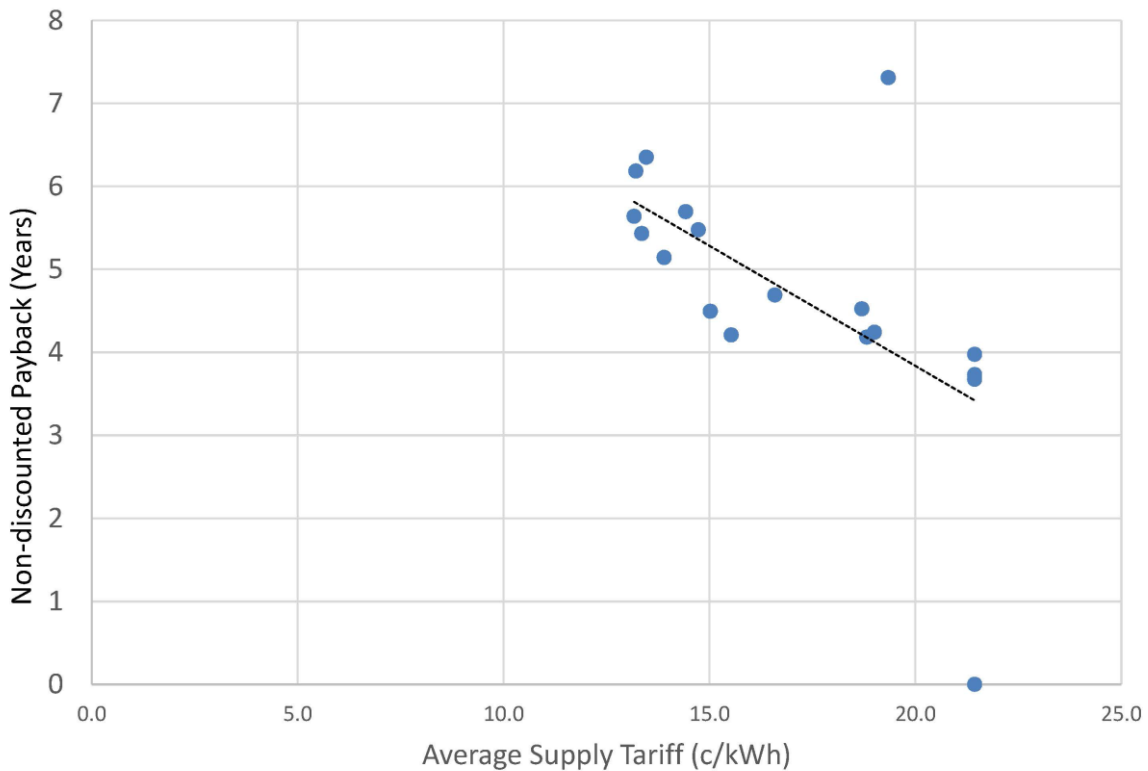


Figure 17- Simple payback for a range of supply tariffs

### Discussion & Further Research

The results presented here are from a small sample of buildings which is diverse in height, age and type of building stock. A larger sample, with significant numbers in specific subgroups (3 storey walk-ups, medium-rise, high-rise, etc.) is needed for any meaningful statistical analysis. It would also be useful to examine the impact of other building characteristics such as CP floor area and facilities, and to extend the study to include other climatic zones within Australia.

The criteria used for assessing the maximum possible PV system for each site are deliberately intolerant of shading and allow significant roof area for access; as a result they may be overly conservative. As an extreme example, site 33 is completely overshadowed by a neighbouring building at the winter solstice and so has been identified as unsuitable for PV deployment, whilst, in fact, there is a (10kW approx.) PV system installed on this roof (although it is not known whether the neighbouring building existed at the time of the installation). It would be useful to further develop and evaluate the procedure for assessing maximum PV potential, using 3-D building models to calculate shading effects in detail.

On average, the buildings in the study have the potential to generate 74% of their CP load from that available rooftop area (Table 2). However, the inclusion of a criteria of 99.9% self-consumption in the definition of a “viable” PV system results in systems that all generate less than 23% of annual CP load. This highlights the combined impact of low FiTs and tax rulings IT 2505 [14] / TR 2015[15] as barriers to PV deployment [1], which leads to undersizing of PV installations relative to the potential capacity of many sites.

Table 2 – Percentage of CP load met by PV output

	Average	Max	Min
Maximum “Whole Roof”	74%	326%	0%
“Zero Export”	16%	22%	3%
“Viable”	14%	22%	0%

Although modelling of flush-mounted PV systems is useful for assessing the maximum generation potential for each site, in practice, PV systems are more commonly tilt mounted (particularly on flat roofs) to maximise energy generation per kWp installed. Modelling tilted arrays (with appropriate array spacing to minimise self-shading) may reduce calculated payback periods and this option should be considered when assessing the economic benefits of PV at each site.

On average, 97% of estimated annual savings from PV systems installed to offset CP electricity bills are due to reductions in supply charges, although for one small site 13% of the savings are from reduced peak demand. For those sites which show large variability in hourly and daily demand due to high power equipment such as exhaust fans, any reduction in demand charges due to PV is likely to be small in comparison to potential reductions from improved control strategies. Analysis of a significant sample of buildings would be required to appreciate the impact of PV on CP peak loads, particularly given the variability in size and timing of the peak loads.

Although the rudimentary economic analysis (using non-discounted payback) utilised in the study does facilitate a comparison of sites with different characteristics, it has limited use in assessing the real economic benefits of PV deployment. A more sophisticated economic analysis – including a rigorous assessment of the potential impact of PV peak demand charges, a more detailed cost of installation model, and the use of discounted payback or Net Present Value to assess the economic case - would add value to the study.

## **Conclusion**

The preliminary data from the study suggests that many apartment buildings have the potential for deployment of PV systems that can make a significant contribution to reducing common property energy demand and carbon emissions; and that many of these systems have simple payback periods of 8 years or less. The study also highlights the impact of apartment building energy efficiency and demand management measures on energy costs. However, for some low- and medium- rise buildings, the potential PV generation is larger than can be utilised to meet CP loads economically under existing tariff arrangements. Further study is needed to assess the economic potential of diverting excess generation to storage or to meet unit loads, as well as exploring appropriate deployment models and regulatory arrangements. Estimates of the contribution and value of PV can also be improved in future work by using a larger sample of buildings across a range of Australian climates, more detailed modelling of shading at the site and a more detailed economic analysis.

## **Acknowledgement**

The authors are grateful to Dr Jessie Copper for assistance in sourcing hourly weather data as well as advice on shading calculations and the use of SAM.

## Glossary

A/C	Air conditioning
BOM	Bureau of Meteorology
CP	Common Property
FiT	Feed-in Tariff
HVAC	Heating, Ventilation, Air Conditioning
IPART	Independent Pricing and Regulatory Tribunal
kWp	Kilowatt peak
OC	Owners' Corporation (or Body Corporate)
PV	Photovoltaic
SAM	System Advisor Model

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Paul Ryan

# Residential Energy Productivity: Is 40% improvement possible?

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## Abstract

Energy consumption in the residential sector has been decreasing in Australia since 2009 but the causes of this decline have not been adequately identified. Energy use per household has also been declining at a greater rate, with total energy use per household reducing by 16% over the period 2004 – 2014. A new, comprehensive energy end-use model for Australia and New Zealand has recently been developed and it provided insights into the energy and demand impacts of various appliance programs, and changes to market characteristics, over the last 15 years. It assesses the contribution of solar generation and provides scenario projections of future consumption and demand.

The 2015 Australia Residential Baseline Study (RBS) examines the historical energy end-use trends and makes projections to 2030. Research on the market factors, appliance attributes, building efficiency and use of equipment in the residential sector has provided deep insights into the potential causes of the now declining energy use. The research has utilised up to 20 years of sales matched appliance attribute information (efficiency, size, etc.) of appliances, lighting and building thermal efficiency, to produce a stock and linked energy model of Australia.

Many of the appliance and equipment used in households have been subject to MEPS and labelling programs, with significant increases in scope and stringency since 2000. These programs are now impacting on the overall energy use in Australia, with dramatic effects that were not considered in earlier forecasts or the planning by energy authorities. We examine the factors contributing to the improvement of energy productivity at the household level, provide projections of the overall energy use per household to 2030, the contribution of solar generation, and potentially what changes might be required to reach a 40% residential productivity goal. BAU projections show an improvement in energy productivity of 20% under BAU (without PV) by 2030 from 2015 base year.

## Introduction

### *Exploring residential energy productivity measures*

What is residential energy productivity in the context of the national and business productivity measures? Examples of national and business energy productivity are typically measured in the form of value of output (\$) per energy use (GJ) with the national value of output being GDP and the business output being company revenue (A2SE 2015). Although the residential sector does contribute to the use of energy, it is much harder to quantify the value of output, as the residential or household sector is generally a consumer of goods and services, rather than a producer. The national accounts can be used to determine the final consumption expenditure by households and this could be used to provide the value of output numerator in the energy productivity equation. However, this is a perverse measure as it effectively relates increasing consumer expenditure with increasing energy productivity, which does not relate to the productivity of the household sector. The value of output from the household sector could be determined from compensation of employees, but again, many households could be relying on government financial assistance or business profits or investments, which would again not capture the effective contribution of the household sector to the economy.

The most realistic and measurable indicator of residential productivity in relation to the national energy productivity measure is energy use per household. The energy use per household (HH) measure does effectively capture efficiency of energy use, behaviour changes, household energy generation (if appropriate) and is normalised on a per household basis. Another measure could be residential energy use per population. Both these measures can be used to show changes over time and improvements (or reductions in energy/HH) that result from efficiency improvement, renewable energy generation and changes in the usage of energy services in the residential sector. Final energy use (where the energy consumption is related to the actual energy used by the

household) is typically used to measure energy use per household. The primary energy use per household would be a more appropriate measure of energy productivity as this would capture the changes in the efficiency of the energy conversion and production processes. However, again it is difficult to attribute the primary energy consumption for electricity used by households (final energy consumption), due to the range of energy generation sources, timing of their output to the grid and demand that is attributed to the residential sector.

Therefore this paper uses final energy consumption per household as the measure of energy productivity in the residential sector, because of the simplicity and data availability, and reliability of the measure over time. It also captures many of the factors that contribute to improvements in national energy productivity, such as efficiency and usage, but does not include the generation of renewable energy by the household. If we subtract PV generation from the final energy consumption, the total energy use per household would be substantially lower, but accounting for the proportion of PV generation used by the household is difficult. The gross PV energy generation is subtracted from the total final household energy use in the following sections to illustrate the impact of distributed generation on energy use per household.

The Federal Government released its Energy White Paper (DoIS 2015) in April 2015 which included a desire to establish a National Energy Productivity Plan. The Energy White Paper states that:

*“A national improvement target of up to 40 per cent by 2030 is achievable, but will require contributions from a broad range of sectors and actions, both regulated and voluntary”*

The base year for measuring this improvement in energy productivity is critical to the target. The USA has a target of doubling energy productivity by 2030 from 2010 and the Australian COAG Energy Council has supported the recently announced national improvement target of up to 40 per cent between 2015 and 2030 (COAG 2015). To be consistent with the national improvement target, we have chosen 2015 as the base year to measure improvement.

### ***Australian residential energy productivity***

The 2015 Australia and New Zealand Residential Baseline Study (RBS) examines the historical energy end use trends up to 2013 and makes projections from 2014 to 2030 (DIS 2015a). This study was funded by the Department of Industry, Innovation and Science on behalf of the Equipment Energy Efficiency Committee (E3). Two similar studies were conducted, in 1999 (AGO 1999) and 2008 (DEWHA 2008). The RBS utilises a ‘bottom up’ energy end-use model of the residential energy sector, divided into major end-uses (i.e., appliances, hot water, etc.), categories of equipment (i.e., televisions, electric water heaters, etc.) and products (i.e., plasma TV, small water heater, etc.). The recent 2014 update of the RBS expands on earlier studies by including additional products and utilises a slightly different approach to the stock modelling. This 2014 study uses updated information and research derived from several projects undertaken since the 2008 study commenced (the 2008 study used data available up until 2005).

The overall electricity use in the residential sector in Australia (excluding solar electric PV self-consumption) has declined by almost 3% in 2012-13 compared to 2010-11 financial year (BREE 2014). This is the first time in Australia’s recent history that electricity use has declined over two subsequent years. There are probably many factors contributing to this decline in overall electricity use, including the improvement in efficiency of appliances, improvements in the thermal efficiency of buildings and fuel switching (including to gas appliances or solar hot water). Decline in usage is also attributed to reductions in the services supplied (such as more efficient shower heads reducing hot water usage and behavioural changes in response to increased electricity prices. When examined on a per household basis, the reduction in electricity use is even more pronounced (see in Figure 5).

In comparison, total gas usage has shown only a small decline in energy consumption over the last five years (DIS 2015a), plus there has not been a substantial upgrade to the standards, labelling or efficiency of gas appliances. Therefore, further analysis of the drivers of gas consumption trends will not be undertaken in this paper.

The focus of this paper is on electricity energy use and the drivers of changes in residential consumption of electricity. The paper provides an overview of the methodology, research and data used to develop the RBS and then analyses the BAU trends in consumption for each end use. Several policy scenarios are then explored to investigate the possibility of achieving a 40% reduction in energy use per household.

## Methodology and research

### Methodology overview

A BAU scenario and increased residential productivity scenarios were explored using the residential energy end-use model developed for the RBS. The underlying methodology on which the residential energy end-use model and study is based is classified as a bottom-up engineering model (Yuning Ou 2012). It involves calculating the energy end-use consumption at the individual level and aggregating these consumptions to estimate the total locality or network consumption.

At the heart of this approach is the calculation that for each energy end use:

$$\text{Total Energy Consumed} = \text{Stock Numbers} * \text{Unit Energy Consumption (UEC)}.$$

Determining the stock number of energy end-use equipment is undertaken by stock models which are effectively databases that keep a running tally of the number of equipment installed on a year by year basis. The stock in any year will be the sum of all past stock sales, less retirements of equipment.

The next aspect of the energy modelling is determining the value of the Unit Energy Consumption (UEC) for each end-use to be used in the residential energy end-use model. At its most basic level, UEC is determined by:

$$\text{UEC} = \text{Hours of usage} * \text{Unit Energy Input,} \quad \text{or}$$

$$\text{UEC} = \text{Hours of usage} * \text{Unit Capacity} * \text{Unit Efficiency.}$$

The energy use of residential equipment is calculated from these formulae, or from a variation of these formulae for more complex products operating in different modes or different measurement and usage metrics (such as wet appliances where UEC is a function of the usage per cycle). For products with multiple modes (e.g., products which have a standby energy consumption element), energy consumption while in operating mode must be separately calculated and added to obtain the total energy consumption in all modes. Although there are several different modes of operation found in appliances these have been condensed to the modes shown in Table 1.

Table 1: Modes of operation used in the RBS

Mode	Description
Operation 1	Main operation mode - heating mode in space conditioning equipment.
Operation 2	Main operation mode - cooling mode in space conditioning equipment
Auxiliary	Auxiliary mode used by some appliances such as energy use by fans in gas heaters
Standby	The modes that are non-operating (standby/off), but consuming power.

Space conditioning energy use requires special attention due to the impact of climate on usage and equipment efficiency, and the interaction of the thermal efficiency of the building shell with the usage of the equipment. There are many methods for estimating space conditioning energy use and demand. Broadly they can be divided into the measurement/metering based approaches (billing, metered data, hours of usage analysis), building thermal modelling, and engineering algorithm approach as identified by Stern (Stern 2013). ). In Australia there is insufficient data to use measurement/metering based approaches so a mixed engineering/building thermal modelling, using AccuRate software developed by CSIRO (AccuRate ), which has previously been used to predict energy use, is used in this study. The impact of annual variation in climate conditions has not been included in the modelled energy use, as the purpose of the modelling was to examine medium to long term energy use trends rather than to examine annual variations, but climate variation by household location is accounted for in the RBS model as these have an ongoing impact.

A systematic approach to the model development was used to ensure all end-uses were considered and the model was developed by focusing on products in each end use. The end-uses and their categories (where appropriate) are listed as follows:

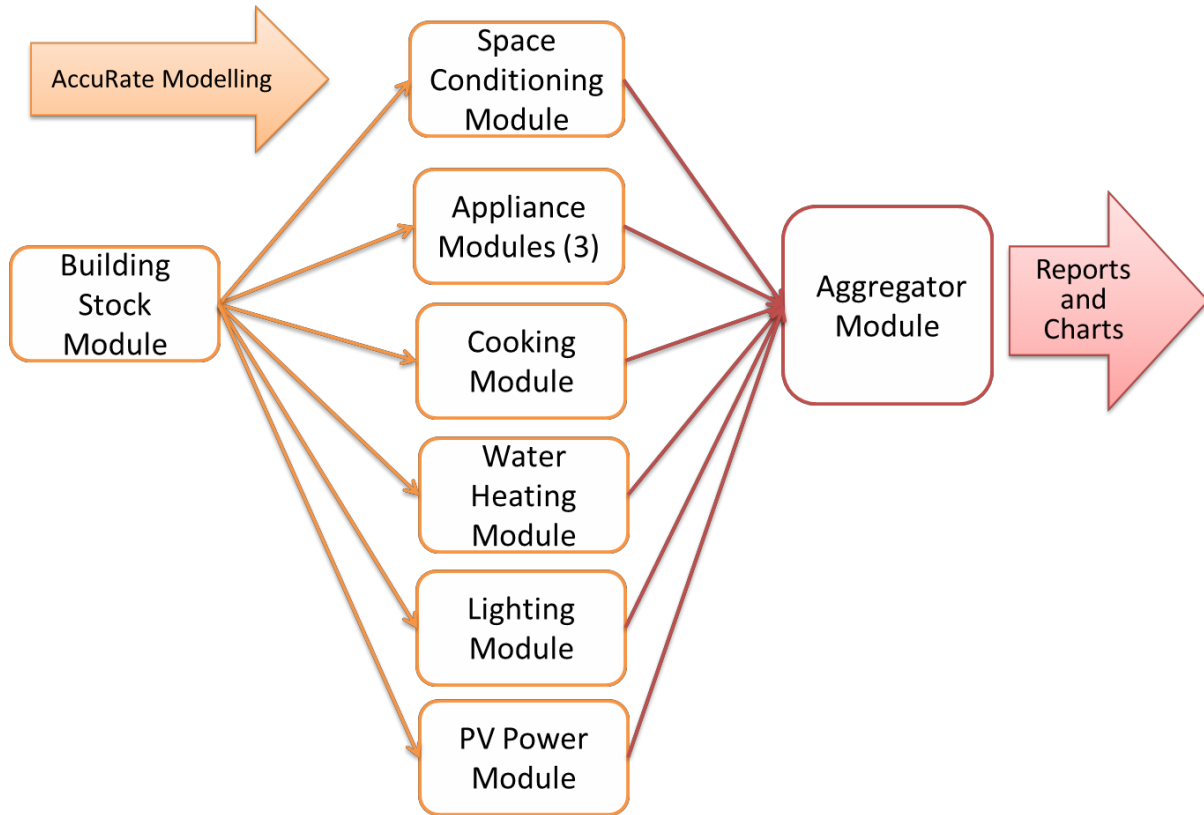
- Water heating
- Space conditioning
- Appliances
  - White Goods
  - IT and Home Entertainment
  - Other Equipment
- Cooking
- Lighting.

Common functions, which will supply data to or accept data in, regarding the products are:

- Building Stock (including thermal demand requirements)
- Energy usage aggregator
- Peak demand calculator (not discussed in this paper)
- User Interfaces for data input/scenario testing.

A schematic of the end-use model is provided in Figure 1.

Figure 1: Schematic of energy end-use model modules and linkages (DIS 2015a)



The end-uses and categories, along with the typical equipment included in the model are shown in Table 2. The model calculates the impact of over 110 separate products.

Table 2: End-uses and categories with examples of typical equipment used in the RBS

End-use & category	Equipment/Products included
Space Conditioning	Air conditioning (heating and cooling), fans, resistive electric heating, gas space heating, wood heaters
Water Heating	Electric and gas storage, gas instantaneous, solar boosted electric and gas, heat pump water heaters
Cooking	Gas and electric cook-tops, oven, microwave oven
Lighting	Incandescent, halogen, LED, CFL
Appliances - White goods	Refrigerators, freezers clothes washers clothes dryers dishwashers
Appliances – IT&HE*	PCs, laptops, network equipment, printers, TVs, game consoles, set top boxes, DVD/BluRay, etc.
Appliances – other equipment	Pool pumps and pool heaters, spas, battery charging systems, other miscellaneous (cleaning appliances, irons, etc.), other misc. standby

**BAU scenario and Assumptions for projections**

The methodology assumes a BAU scenario based on no additional regulatory or program interventions to improve the efficiency of appliances and equipment will be introduced. The model inputs for the each of the products take into account the current programs that are affecting future energy use (i.e., Minimum Efficiency Performance Standards – MEPS & Energy Rating Labels – ERL) and those that are scheduled to be implemented (where a Decision Regulatory Impact Statement/RIS has been approved by the Government), but assumed no



additional new regulation or programs. However, market trends in take up of energy efficiency technologies, such as LED lighting, are considered in the forecasting of product sales and of future changes in product efficiency.

**Research and data sources**

Usage by households of many products is derived from Australian Bureau of Statistics (ABS) surveys, including a recent survey of 12,000 households in 2012 (ABS 2014). Household projections from the ABS have also been utilised.

The key attributes of the majority of significant equipment installed in households by year, including the average of their size and efficiency, was obtained from analysis of the sales data by model and from MEPS/ERL registration data. Sales of products were estimated from this same data or derived from penetration data, such as that obtained from ABS surveys. Research on the impact of the building thermal performance and the proportion of the building stock with improved thermal performance was also undertaken as part of this study.

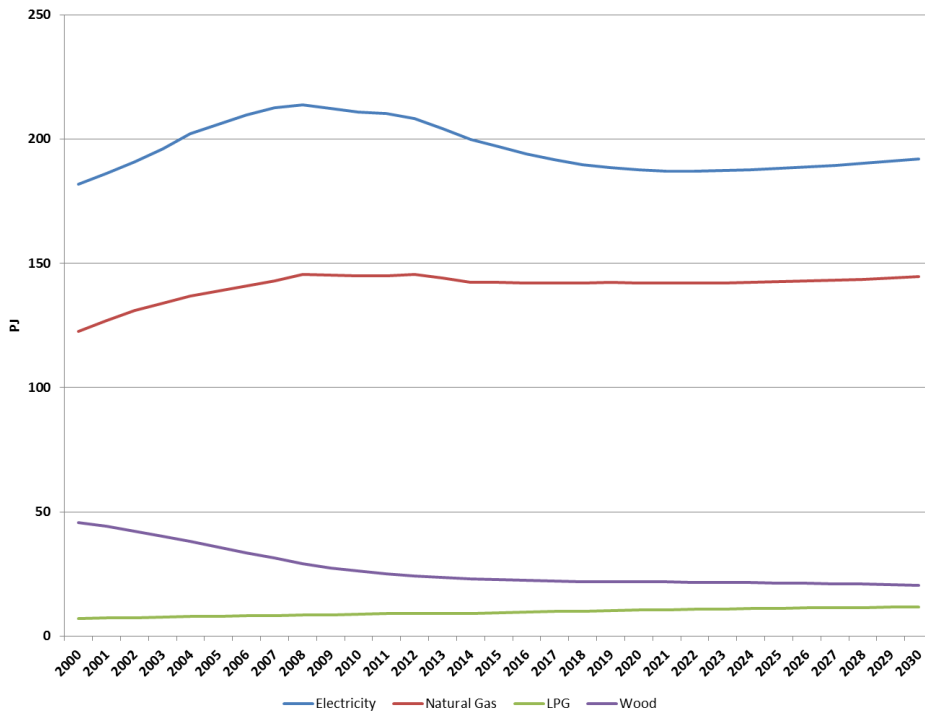
**Validation of RBS model**

The RBS and ESAA estimates of national residential electricity use were compared for the period 2004-2013, and there was an acceptable difference of less than 5% in the estimates, and for most years a difference of 2% or less was found. For residential gas use over the same period, a maximum difference of 10% was found, which is acceptable considering the RBS model does not account for annual weather variation and the impacts of weather are much greater with natural gas used mostly for heating.

**Residential energy use by fuel and end-use 2000 to 2030**

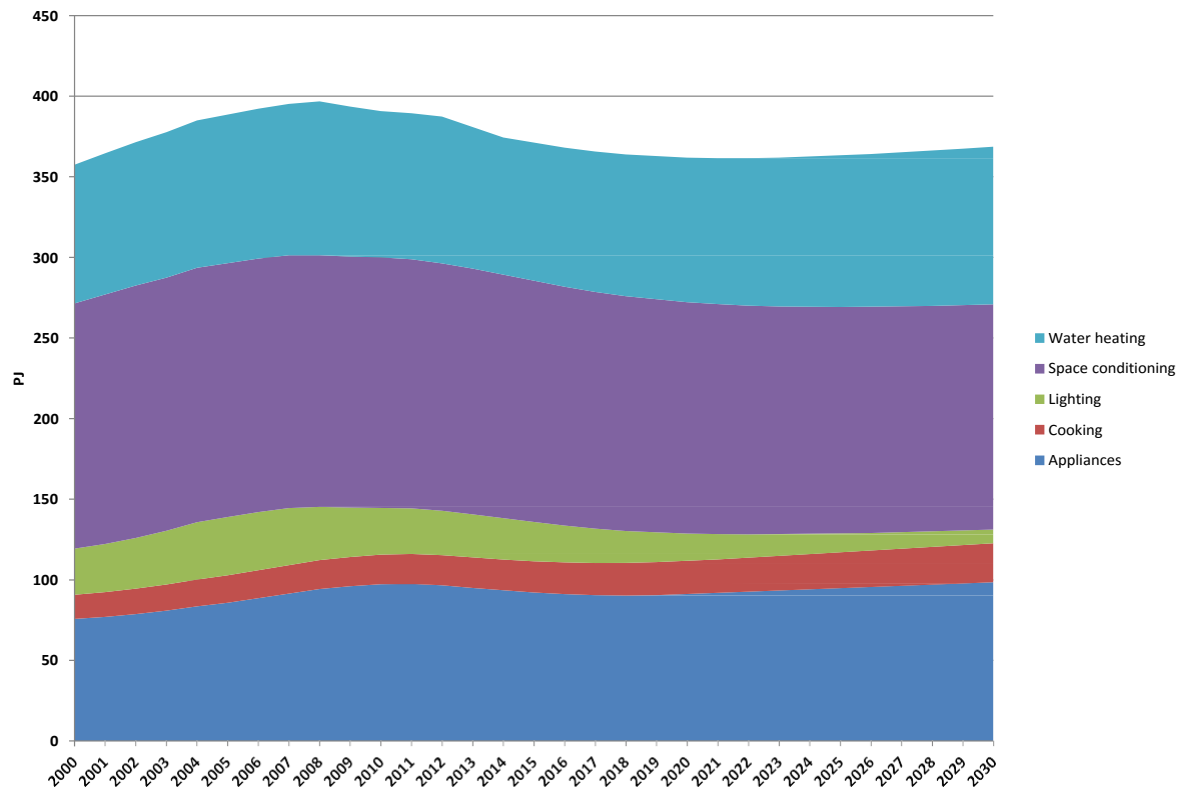
Figure 2 shows the total residential energy consumption by fuel type from 2000 and projected to 2030.

Figure 2: Trend Lines for Residential Consumption by Fuel (DIS 2015a)



These trend lines show that the total energy use trend (i.e. peaking in 2008, declining then gradual increase in the 2020s) is largely the result of the underlying trend in electricity consumption, as electricity consumption follows a similar but slightly more exaggerated trend. Electricity use peaked in 2008, is currently in decline and is not expected to increase until after 2021. In comparison, natural gas use is expected to remain relatively stable post 2008, while wood use has declined and will continue to do so. LPG use is the only fuel expected to increase throughout the study period.

Figure 3: Total Residential Consumption by End Use (DIS 2015a)



In 2014 the largest share of total energy consumed is by space conditioning (40%), while roughly a quarter is used by water heating (23%) and appliances (25%). The remainder is used by Lighting (7%) and Cooking (5%).

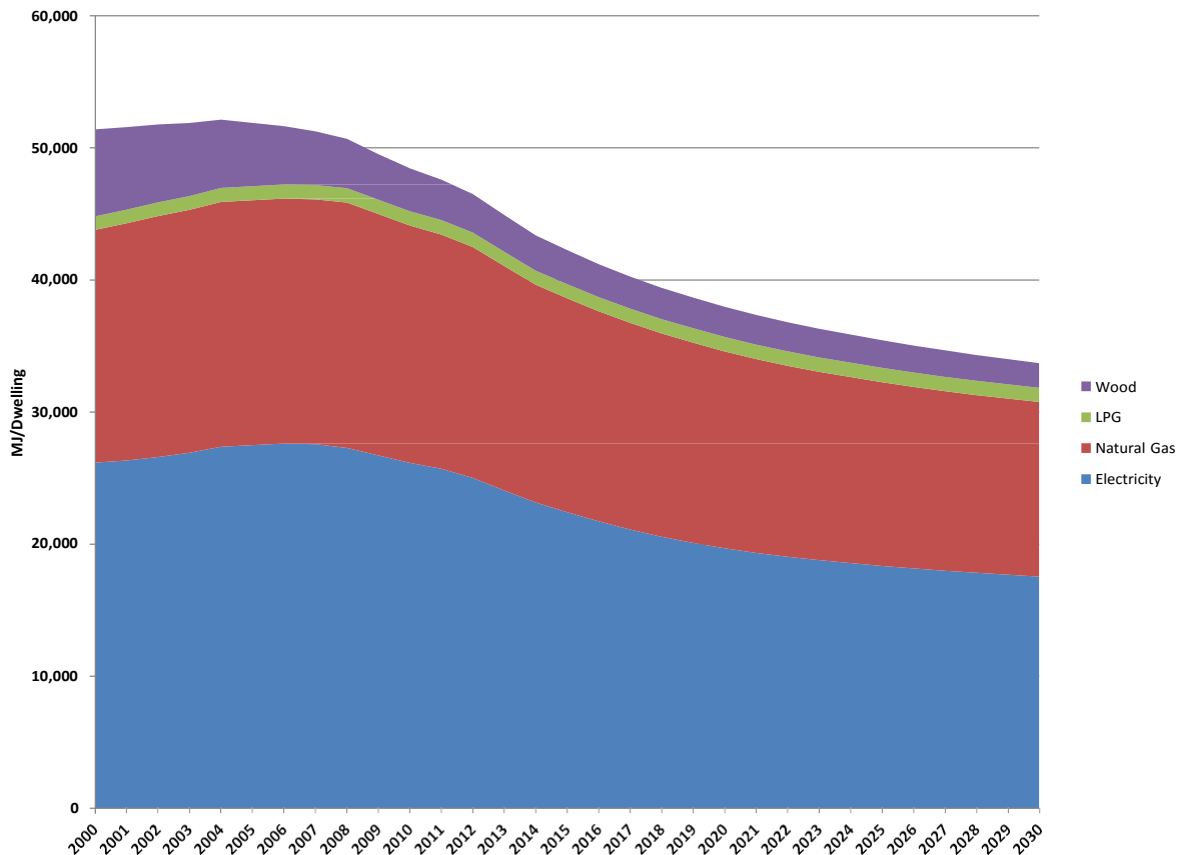
The dominance of space conditioning to energy consumption is again clearly shown in Figure 3, as is the large contributions made by water heating and appliances to total energy use. However, this chart also shows the trend for the energy use of water heating and appliances to make up an increasing proportion of the overall energy consumption. The decline in energy use by lighting since 2005 has also added significantly to the overall decline in total energy use and is expected to continue to do so throughout the projection period.

Energy consumption by space conditioning has been in decline since 2004, and is expected to continue to decline throughout the projection period. Energy use by water heating has also been in decline since 2008, but is expected to increase from 2014 onwards. A similar trend is expected for appliances, with appliance energy use declining since 2010 but is expected to start to increase from 2020. Only cooking is expected to increase uninterrupted throughout the study period, but at a relatively low rate of increase.

### **Background and Causes of Trends**

The main reason for the rises and falls in total energy consumption over the study period is due to changes in energy use per dwelling. Average energy use per dwelling, as shown in Figure 4 has been falling since 2004 and the energy efficiency of the average dwelling is expected to continue to improve to 2030, based on projected trends. The average energy use was 51 GJ in 2000 but in 2014 was 43 GJ.

Figure 4: Total Residential Consumption per Dwelling by Fuel (DIS 2015a)

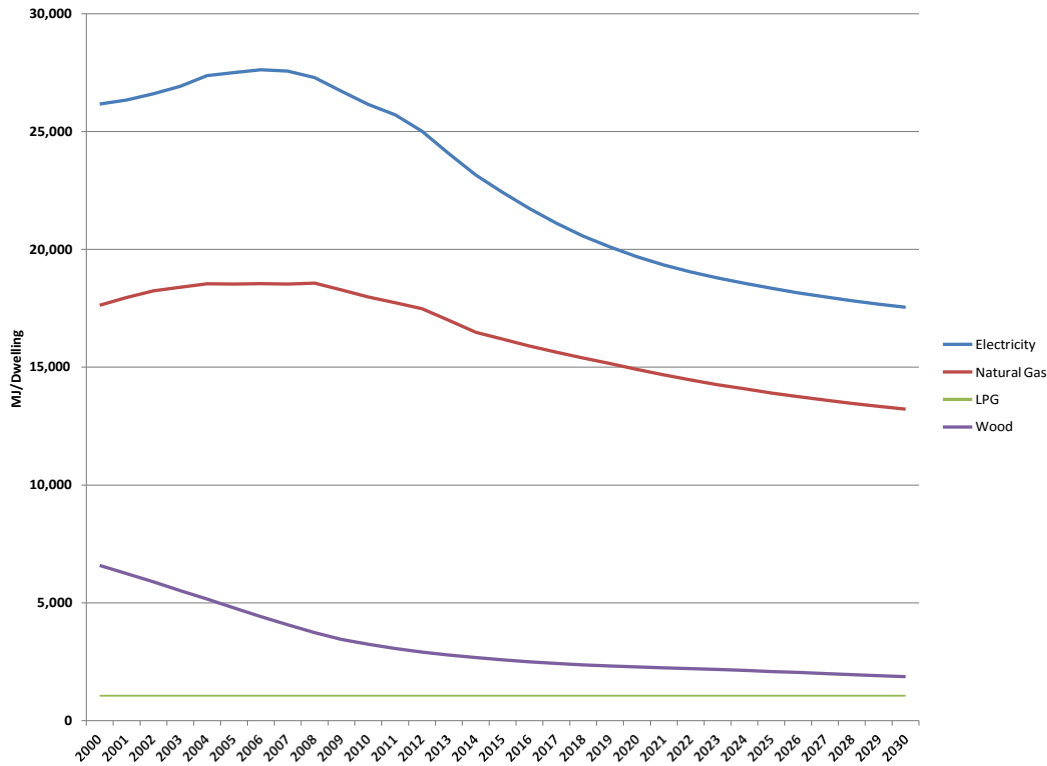


Initially the rate of decline in consumption in the early 2000s was less than the rate that dwelling numbers increased, so total energy consumption increased, but by 2009 the pace of decline in energy consumption per dwelling started to exceed the increase in dwelling numbers, so total consumption began to fall. Only when the rate of decline in average energy use starts to slow in the 2020s is it predicted that increases in dwelling numbers will lead to a new increase in total energy consumption. These efficiency trends, and the growth in dwelling numbers, are expected to be the trends that drive energy consumption in the near future.

It should be noted that these predictions of future energy use are based both on sales of future products leading to the integration of more efficient product into the appliance stock, and on there being some ongoing improvement in the efficiency of most products. However, these predictions are conservative in so far as they do not anticipate the introduction of any further energy efficiency regulatory requirements or energy efficiency programs being introduced, unless the regulation has already been announced. If further energy efficiency initiatives are introduced, then the energy use per dwelling may further decline and the projected growth in energy use during the 2020s may not occur.

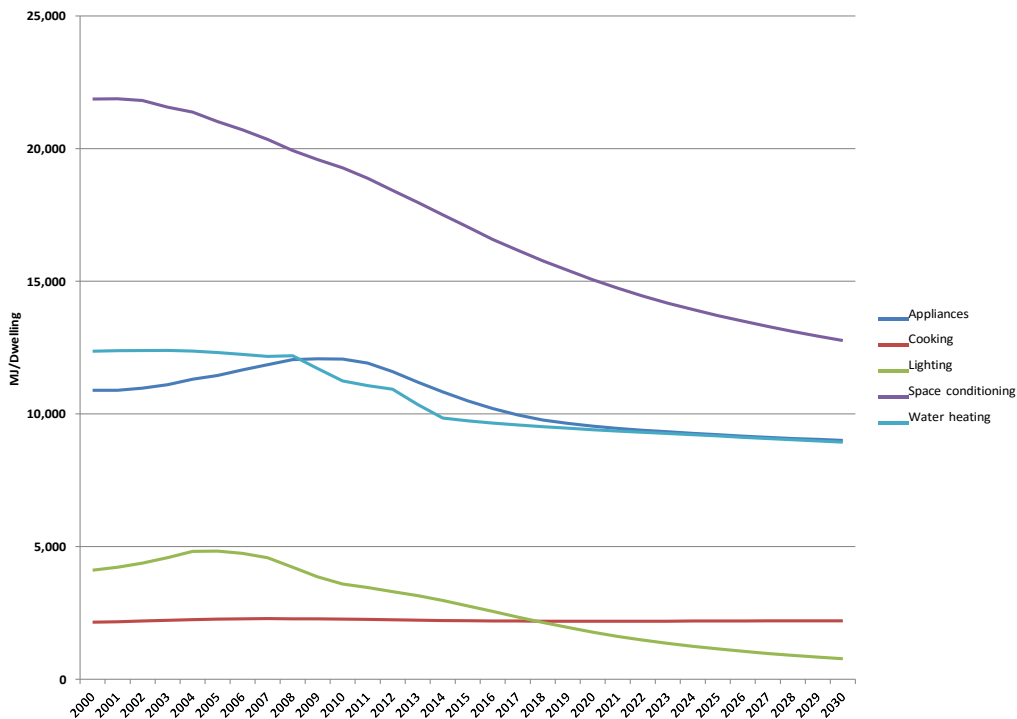
An examination of the trend lines for energy consumption by fuel per dwelling, shown in Figure 5, reveals that the decline in energy use is driven by a decline in the average use of all fuels, except LPG use which remains constant. The decline is most pronounced in electricity, but also strong in natural gas and wood use. The decline in total energy use per dwelling has accelerated since 2008 as the use of electricity stopped growing and then started to quite rapidly decline. Projections suggest this trend in electricity use will be one of the main drivers of future decreases in total energy use.

Figure 5: Trend Lines for Total Residential Consumption per Dwelling by Fuel (DIS 2015a)



Further insight into the drivers of the current reduction in total energy use can be obtained by examining the energy consumption per dwelling for the individual end-uses, as shown in Figure 6. This chart shows that the energy used by each end-use, for the average dwelling, started declining from the mid to late 2000s and continues to decline throughout the study period. Space conditioning contributes the greatest amount to the decline in total energy use per dwelling, followed by lighting and then appliances and water heating. Cooking energy use also declines but only very slightly. The reasons for the declines in energy consumption for each end use are discussed later in this paper, but are largely due to appliance efficiency improvements, changes in the technologies being used and fuel switching.

Figure 6: Trend Lines for Total Residential Consumption per Dwelling by End Use (DIS 2015a)



## **Factors contributing to energy use trends**

### ***Space conditioning***

Space conditioning electricity use by category displays an overall increase in energy consumption, but is then relatively stable from 2013 to 2030

Space conditioning equipment has shown a rapid increase in energy consumption from 2000 to 2012, which largely reflects the increase in ownership of air conditioners in Australian homes which has increased from 0.52 to 0.94 per household. The main reasons why space conditioning electric energy consumption has not increased further since 2012 are:

- the shift from electric resistive heating to use of reverse cycle air conditioners as heaters,
- an increase in the efficiency of air conditioners, from an average EER of 2.5 to 3.9 by 2013
- the impact of building thermal improvements due to the building code (in 2005 and again in 2010), and the federal governments home insulation program (EES 2011) during 2009-10 that insulated 1.2 million households (15% of total Australian households).

### ***Hot Water***

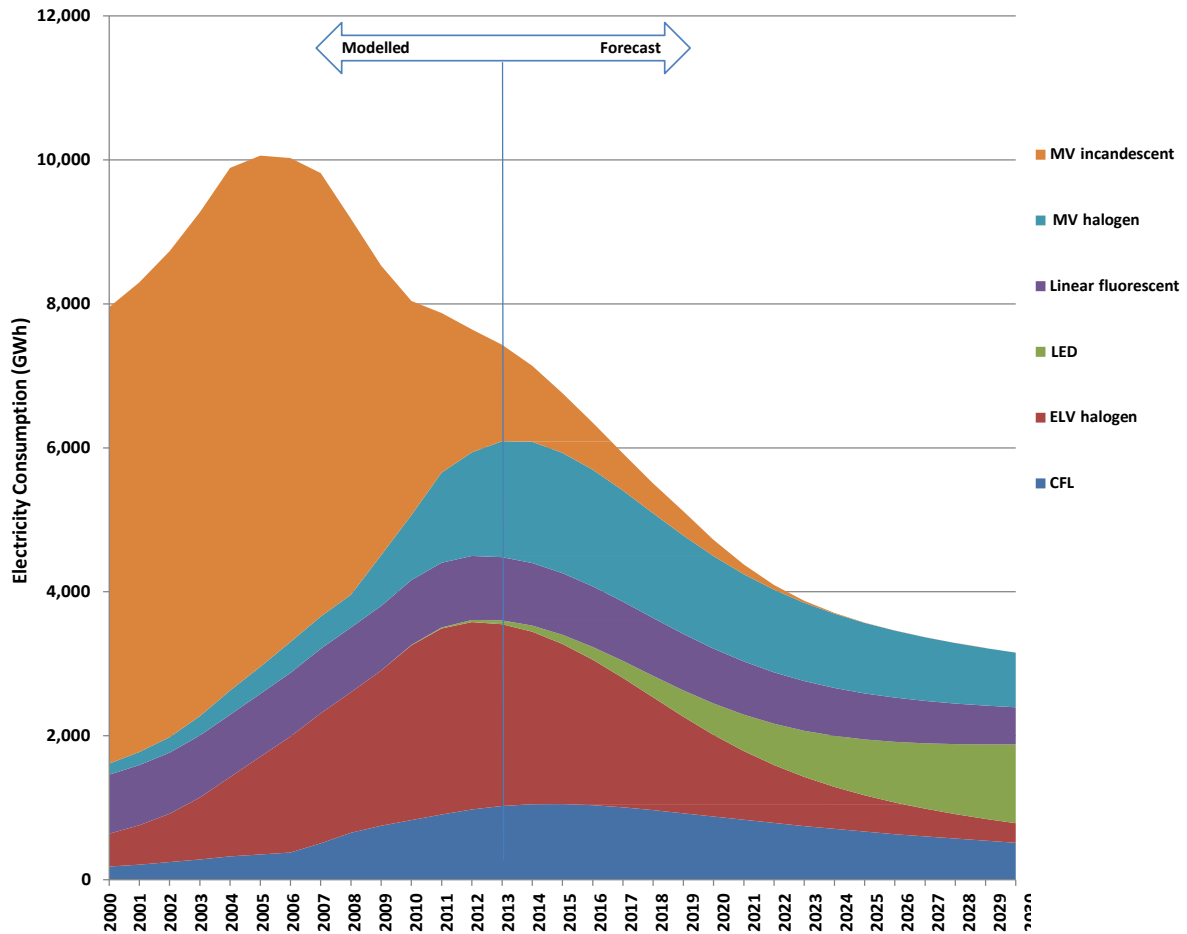
Hot water energy consumption was relatively stable to 2005 and then declined by over 20% to 2013. It is forecast to remain at this level till 2020, and then increase. A major factor contributing to the reduction in energy use in hot water, in the second half of the 2000s is the switching by consumers to gas, solar and heat pump water heaters, encouraged by incentives from state and federal governments and regulations that required new homes to install solar and heat pump water heaters. Average ownership of electric water heaters declined from 0.62 in 2000 to 0.46 in 2013. In addition, the introduction of a MEPS that reduced the heat losses from new electric storage water heaters by 30% in 1999, behavioural changes due to an extended drought and rapid take up of water efficient showers have also contributed to significant reductions in energy use per water heater. Research conducted for the RBS, utilising electricity distributor data on off-peak and controlled load water heaters, has found that the a decline in hot water use from water efficiency measures and changes in behaviour has contributed to approx. 10% of the reduction in total hot water electricity consumption in Australia.

The energy use by electric water heaters is forecast to increase slightly, as the fuel switching rate declines and no other MEPS or water efficiency measures are planned to be implemented. The financial incentives for solar and heat pump water heaters have also been significantly reduced resulting in sales reducing to pre-2007 levels. In one Australian state, the requirement to install solar or heat pump water heaters in new dwellings has also been rescinded, and the planned national regulatory measures to phase out electric water heaters have not been implemented.

### ***Lighting***

Lighting demonstrates a rapid increase in energy consumption to 2006 and then is forecast to decline by over 60% to 2030, as shown in Figure 7.

Figure 7: Estimated and forecast electricity consumption of lighting end-use in Australia (DIS 2015a)



Lighting energy use increased in the first half of the 2000s due to the increasing number of lights per household, especially of halogen downlights. However the national phase out of incandescent lamps and the state government based white certificate programs caused a market transformation and increased use of more efficient CFLs over the last decade. Now, total energy consumption for lighting is forecast to continue to decline as CFLs and LEDs slowly replace halogen lamps.

### ***Appliances – White goods***

White goods electricity use by category shows a slow increase in energy consumption to 2010, then stabilises and is forecast to increase again from 2018 to 2030. Energy use by white goods has been impacted by a number of factors, some causing decreases in energy and others increasing energy use. Refrigerators and freezers have been subject to MEPS (1999 and 2005) and energy labelling (since 1986, with updated scales in 2000 and 2010). The overall energy use of new refrigerators has declined by over 35% from 1996 to 2005, which has had a significant impact on the total refrigerator energy use, although ownership has increased to almost 1.4 refrigerators per household by 2010. The combined impact of these two factors means that energy use by refrigerators has increased by 7% from 2000 to 2010. Further MEPS are planned; however details are not yet published. The other major factor contributing to the increase in energy use by white goods is the shift from top loading to front loading clothes washers, which uses more energy as they generally heat water to a minimum temperature to enhance washing performance while lowering total water use. Clothes washer energy use has increased by a factor of three from 2000 to 2014. Forecast energy use by white goods shows an increase in energy use over the period 2020 to 2030, as current impacts of MEPS diminish and total energy use increases with the projected increase in the number of households.

### ***Appliances – IT&HE***

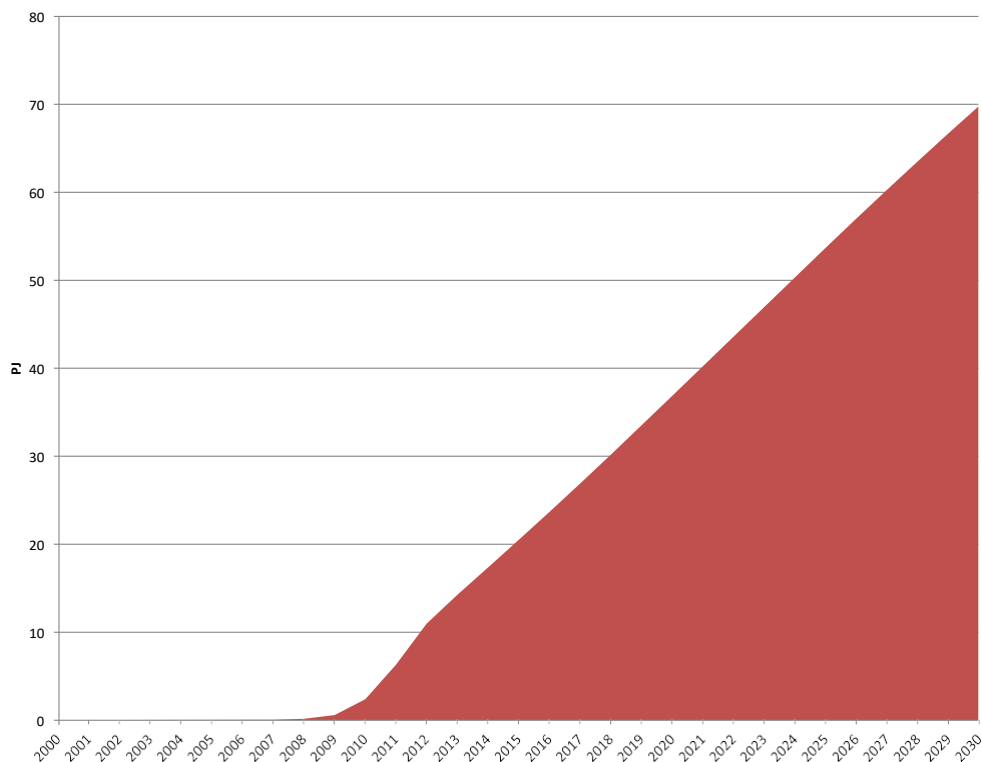
The total energy use of Information Technology & Home Entertainment (IT&HE) increased by almost 100% from 2000 to 2010. It is then forecast to decline to 2020 and a slow increase to 2030. The main factor contributing to the rapid increase in IT&HE energy use to 2011 was from the increase in TV ownership (from 1.7 in 2000 to 2.2 in 2011) and purchase of larger flat screen TVs. At the same time, energy use of new TVs

increased by over 50% from 2000 to 2008. However, due to the technological improvements in the efficiency of new TVs and the introduction of MEPS and labelling in Australia in 2009, the energy use per new TV has now declined to levels below those of the old screen technology used in the last century. Ownership of TVs has also declined to less than 2 per household in 2014 and is forecast to decline further with the change to portable devices for viewing of video by consumers. The forecast increase in energy consumption by TVs from 2020 is due to the increase in average size and number of higher energy consuming TVs, such as ultra-high definition. Another factor reducing energy use is the increased use of laptop/notebook PCs and tablets which has led to the decline in total energy use by all computers in households. Network devices (which are always connected and using power) are forecast to further increase their share of total IT&HE energy consumption as their numbers increase.

## Distributed electricity generation in the residential sector

Photovoltaics (PV) generation is also not an energy end-use, but is presented here as it will increasingly impact on the net energy consumption of Australian homes. The chart below shows generation was immaterial before 2009, after which it has rapidly grown to around 3,600 megawatts (MW) in 2014. Projections in the RBS indicate PV generation capacity will grow to over 14,000 MW by 2030. Figure 8 above shows that annual gross PV energy generation output has grown and by 2014 was 17.3 PJ (4,800 gigawatt hours (GWh) p.a. and is expected to increase to over 69 PJ (19,000 GWh) p.a. by 2030.

Figure 8: National PV: Gross Annual Energy Output (DIS 2015a)



The projected growth in generation capacity and energy output is based on the growth in sales and stock of PV systems. Using these stock projections, ownership rates were estimated. 14% of households own PV systems in 2014 and that ownership is expected to increase to 33% by 2030. Generation output is expected to grow faster than ownership as households are expected to install PV systems which are larger on average in the future.

## Scenarios of residential energy use to achieve a 40% increase in energy productivity

If we interpret the national improvement target of a 40% increase in energy productivity as a 40% decrease in energy use per household by 2030, it will be a substantial task. Some of the options available to policy makers that would contribute to achieving this goal are regulatory actions (MEPS and building codes), incentives (such as state based Energy Saving Schemes) and information programs (Energy Rating Labels, Endorsement labels).

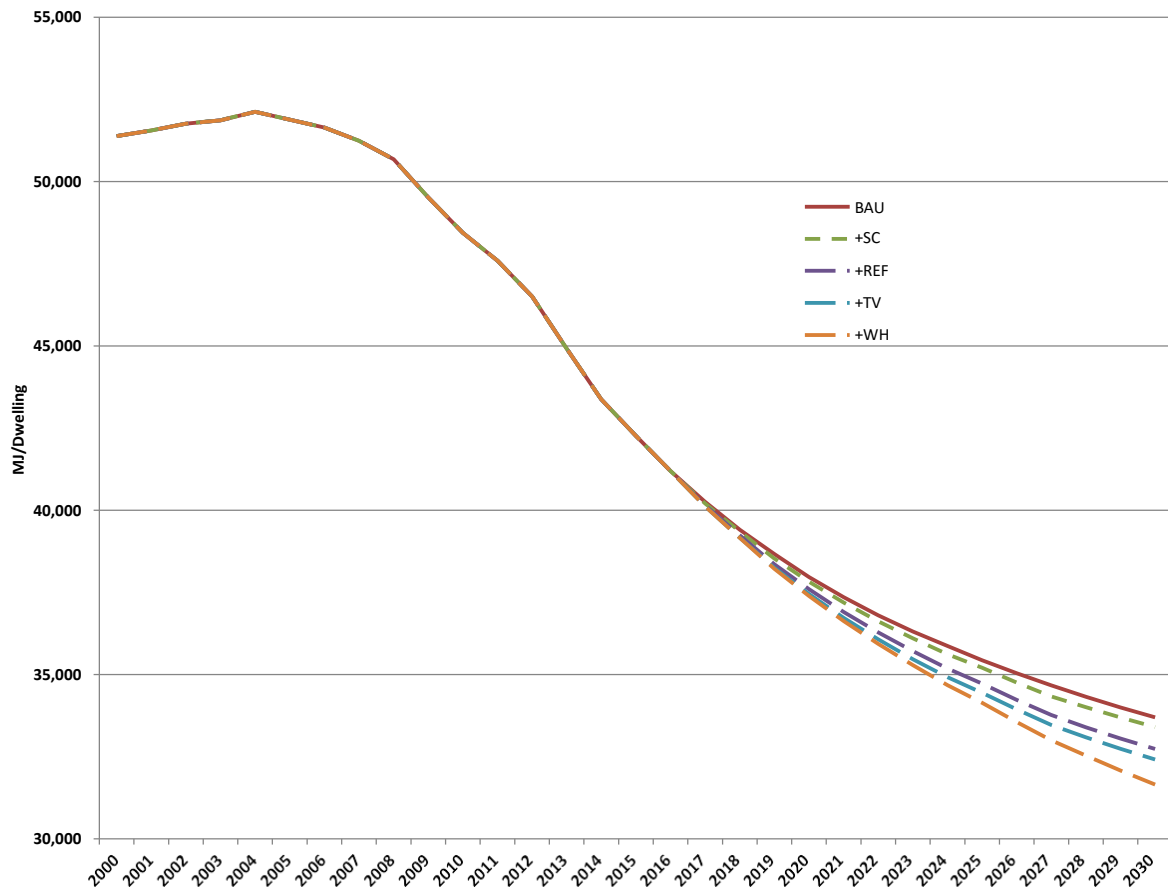
If we consider that under BAU, energy use per household is projected to decrease by 20% by 2030 compared to 2015, another 20% would be required.

To illustrate the potential of regulatory measures (such as MEPS) on top of the BAU improvement of 20%, a number of potential options are explored. These are:

- Space Conditioning – Increase the thermal efficiency of new buildings by increasing the national building code energy performance requirements to 7 stars in 2017 (Shown as +SC in the following figures)
- Refrigeration – increase the MEPS for new domestic refrigerators and freezers that is equivalent to a 30% efficiency improvement (similar to the USA standards) in 2017 (+REF)
- TVs – increase the MEPS for new TVs to be equivalent to a 30% efficiency improvement above BAU (similar to the USA Energy Star Specifications) in 2017 (+TV)
- Water heaters – phase out the installation of new medium and large electric storage water heaters in Australian households, beginning in 2017. This would increase sales of solar electric, heat pump, solar gas and gas instantaneous water heaters, while it is assumed that sales of electric storage water heaters would reduce by 80% (+WH)

The impact of these policy options were modelled and compared to the BAU, and are illustrated to cumulatively reduce the energy use per household in Figure 9. The total contribution of these measures is a reduction of 2 GJ per household by 2030 bringing the total reduction in energy use per household from 2015 to 2030 to 25%. The largest contribution is from water heater measures, followed by refrigerators/freezers, TVs and finally space conditioning. The low impact of the increase in building performance to 7 stars is a result of the smaller impact increases in the star rating have on the building stock considering 6 stars is already modelled in the BAU, and the proportion of new housing of the building stock. Also, the model does not account for the impact on renovations and additions to existing houses. Of course measures targeting the existing building stock would have greater impacts in the short term.

Figure 9: Cumulative impact of various policy measures on energy use per household

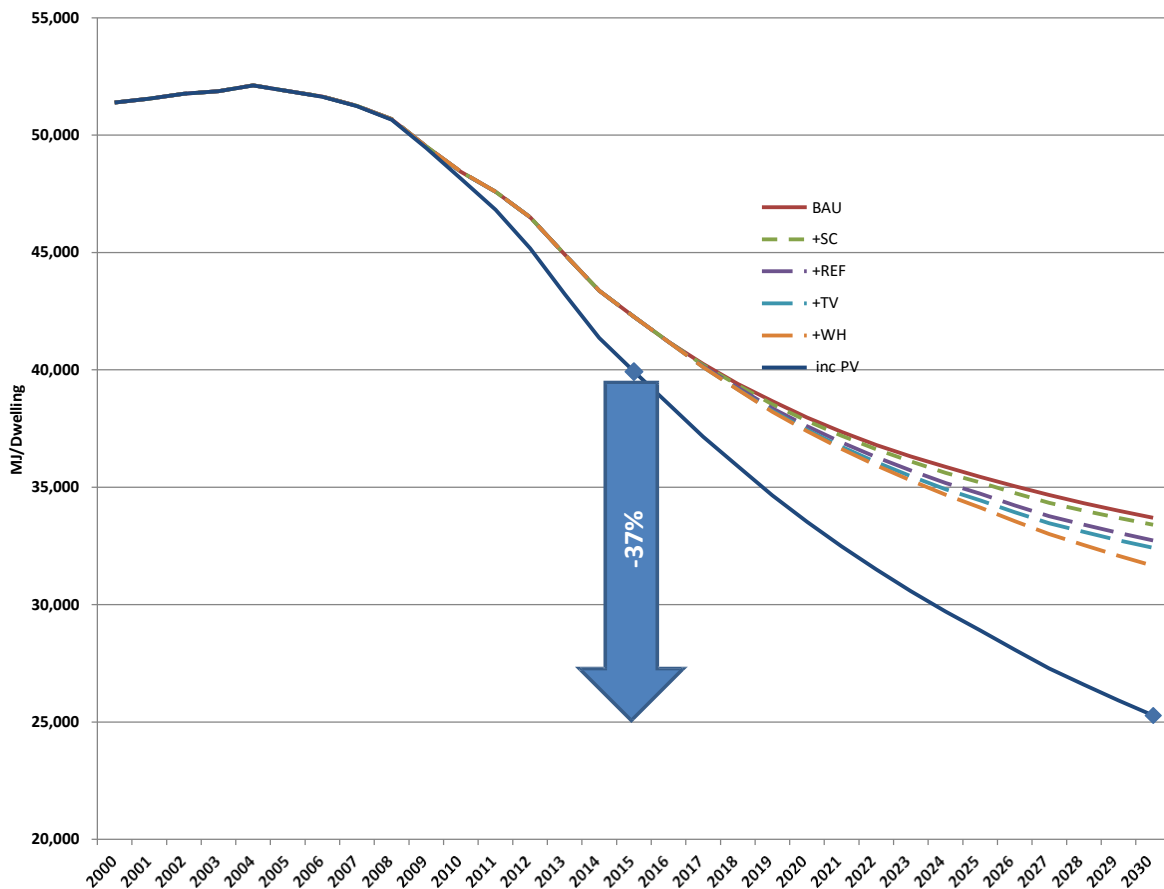




Subtracting gross solar (PV) generation from the final energy use by households in both the BAU and the above scenario, the energy use per household would reduce by 37% from 2015 to 2030, as shown in Figure 10. As the PV generation is included in both the BAU and the scenario, the reduction in energy use per household is based on the net average energy use per household of 40 GJ pa in 2015 to 25.3 GJ pa in 2030.

Therefore, with concerted government action, such as increasing the stringency of MEPS programs and building efficiency requirements, the goal of a 40% reduction in household energy use is achievable if measured as final net energy use by Australian households (by including the solar energy generation).

Figure 10: Cumulative impact of various policy measures on energy use per household including gross solar generation



## Conclusions

Residential energy use in Australia increased during the 2000s but has declined in recent years since 2008. Average energy use per dwelling has been falling since 2004 and the energy productivity of the average dwelling is expected to continue to improve to 2030, based on projected trends. The modelling reported in this paper explains the major factors contributing to the changes in energy use in the residential sector and explores the impacts of these trends on forecast energy use. There have been dramatic declines in the last five years in the energy consumption in some end-uses, such as hot water, IT&HE and lighting, but these have been masked by the increase in energy use of space conditioning and white goods. With continued changes in types of equipment installed in households, and the improvements in efficiency being realised in the stock of equipment, total energy use is now declining and forecast to continue to decline till 2020. With increasing population and hence households, total energy consumption is then forecast to increase from 2020.

The efficiency measures introduced by governments during the period 1999 to 2012 have contributed significantly to the decline in total residential energy use seen in the last few years. The largest regulatory impacts have been from MEPS for heat losses of electric storage hot water heaters, MEPS for lighting, and

MEPS and Labelling for TVs, refrigerators/freezer and air conditioners. Significant impacts have also occurred due to state and federal government programs that encouraged the installation of efficient showers, solar/heat pump water heaters and efficient lighting.

Energy productivity in the residential sector is defined in this paper as energy use per household. The total contribution of the measures modelled for this paper is a reduction of 2 GJ per household by 2030 bringing the total reduction in energy use per household from 2015 to 2030 to 25%. If solar energy generation is included in the total net final energy consumption by households, a 37% reduction is found. This would come close to the national productivity improvement of 40%.

However, the energy use forecast also shows that without further regulated improvements in the efficiency of electric water heaters, refrigeration and TVs in Australia, there is likely to be increasing energy use over the period 2020 to 2030. The continual refreshment of MEPS and energy labelling programs will be essential to the achievement of the national energy productivity goal in the residential sector. Also, contributions by state based energy saving schemes and other market incentives will be required to ensure that the residential sector effectively contributes to national energy productivity.

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# The need for a new approach in NEBs classification

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## Abstract

Industrial energy efficiency has been widely recognized as a major contributor for the reduction of green-house gases emissions and the improvement of industrial competitiveness. Nevertheless, a broad set of studies have pointed out the existence of barriers limiting the adoption of promising Energy Efficiency Measures (EEMs). Recently, authors have shown the relevance of the so-called “non-energy benefits” (NEBs) coming from the adoption of EEMs. Still, the existence of such benefits has been pointed out from specific studies and manuals for practitioners, but an overall framework describing them in terms of savings and benefits, as well as technical and management implications, cannot be found yet. Furthermore, the focus on an industrial decision-making perspective seems to be lacking. Hence, starting from a thorough literature review of scientific as well as practitioners studies, the present study aims at shedding the light on NEBs features, implementation issues and management implications coming from the adoption of EEMs. In summary, the study reveals major elements to be taken into consideration for a novel framework to properly address NEBs (and losses) in the implementation and service phases of an EEM from an industrial decision-making perspective, with consequent implications and suggestions for the stakeholders involved into an EEM supply chain. Additionally, the study sketches several opportunities for further researches into the topic for both industrial decision-making as well as policy-making purposes.

## Introduction

According to the International Energy Outlook 2014 from EIA (2014), by 2035 the world energy consumption is expected to increase by more than 50%, overcoming the value of 791.000 PJ, because of the robust economic progression and the sensible population growth. The sectors considered responsible for this situation are mainly four: the major one is the industrial (52% of the overall energy consumption), that includes agriculture, mining, manufacturing and construction, followed by the transportation sector (27%), the residential (accounting for the 14%) and, finally, the commercial sector (7%). On the other hand, green-house gases emissions (GHG) in general terms are generated for the 65% by the production and use of energy. When considering CO<sub>2</sub> emissions, the production and use of energy is responsible for 84% of the emissions, and 40% are generated from the industrial sector, with sensible increases along with the energy consumption (EIA 2011), in particular in developing countries.

Based on those evidences, the European policy makers developed multiple agreements and, among these, in more recent years the Europe 20-20-20 program (European Council 2012). It is a long-term European strategy to deal with energy and environmental issues, aiming by 2020 at reducing GHG emissions by 20% or more, increasing the energy efficiency at least by 20% and, finally, increasing the share of renewable energy in final energy consumption to 20%. The revision of Directive in 2012 has shown a worrying perspective: indeed, despite the targets of increase of renewable energy and GHG emissions level are going to be reached, the 20% increase in energy efficiency is far to be achieved. Therefore, much additional efforts should be paid in the near future towards this objective. For this reason, it is apparent that attention should be devoted to the industrial sector, due to its relevant energy consumption. To increase industrial energy efficiency, it is really crucial to foster the adoption of the so-called Energy Efficiency Measures (EEMs). Indeed, as Palm and Thollander (2010) note, EEMs must be diffused to reduce the existing energy efficiency gap, in combination with other policy instruments such as proper thresholds on the emissions level and adequate incentives, in a proper blend of engineering and social sciences approaches.

However, existence of an energy efficiency gap reflects that the implementation rate of EEMs is low because of the existence of several barriers that prevent the decision makers to accomplish such measures. In the field of barriers to industrial energy efficiency, scholars and practitioners have offered contributions at multiple levels. Indeed, as for example, empirical studies have distinguished between market-related or behavioral and organizational-related barriers (Thollander and Ottosson 2008). Sorrell et al. (2004; 2010) have offered a thorough review of studies on barriers to industrial efficiency, coming up with a classification of six barriers, namely: *i*) risk; *ii*) imperfect information; *iii*) hidden costs; *iv*) access to capital; *v*) split incentives; and *vi*) and bounded rationality. More recently, Cagno et al. (2013) in their taxonomy have classified barriers according to seven categories, namely: *i*) technology-related; *ii*) informative; *iii*) economic; *iv*) behavioral; *v*) organizational; *vi*) competence-related; and *vii*) awareness. Additionally, they have paid attention to characterize barriers according either to the most affected phase of the decision-making process or the specificity of a barrier (thus making a distinction between general barriers from intervention-dependent ones).

Nevertheless, empirical studies have revealed that EEMs are perceived as not relevant for the core process of industrial activities (Fleiter et al. 2012), thus being considered as marginal or with low priority (Trianni et al. 2013). Other relevant contribution in the discussion have been recently offered by Cooremans (2007; 2011), that has pointed out the need to go beyond a “mere” investment logic, thus considering EEMs possibly as strategic.

A quick overview of the literature contributions on barriers to energy efficiency allows gathering an interesting picture: scholars and industry have so far paid little attention to increase the knowledge on how to overcome such barriers and, in particular, there is a little discourse on the so-called Non-Energy Benefits (NEBs), that have been presented to the industrial decision makers as positive effects arisen because of the EEMs in the service phase of the measure. Heffner and Campbell (2011) recognized that they are able to modify the perception of the decision maker about the EEMs. Nevertheless, they have been so far considered with scattered examples almost exclusively focused on the service phase of an EEM, without really considering the huge amount of possible positive and negative implications either at the implementation and service phases. In short, a structured framework to thoroughly describe and analyze NEBs is missing.

For this reason, in the present study we aim at offering a contribution to fulfill this research gap, by identifying some major features for a new framework through which analyze EEMs defining their impact. In addition, a new classification for the benefits should be developed with a top-down approach and proposed in order to provide a higher level of knowledge to the industrial decision makers as well as to the policy makers, who can really benefit from the novel approach proposed in the present study.

## Literature Review

Non-Energy benefits (NEBs) from the adoption of EEMs have been mostly presented and described without any structured analysis of their characteristics, but just with the inclusion of a few properties. In addition, despite in some cases attempts to evaluate the impact on the payback time have been provided, the considerations have been offered without a comprehensive approach, thus resulting inadequate for a structured analysis needed for generalization purposes.

An example able to provide the perspective so far adopted on the NEBs is the study by Lung et al. (2005). In that case, the authors presented a model for the evaluation of the magnitude of the benefits, in monetary units. The approach also includes the existence of additional benefits to be considered when deciding to perform an investment in a EEM. Indeed, authors have pointed out the capability of EEMs to offer an opportunity to gain a competitive advantage in the long-term. In this regard, Bunse et al (2011) offer an interesting contribution, defining three macro-categories of benefits based on the aspects involved: economic, environmental and societal. For each of these classes of impact, a list of benefits has been defined. Nevertheless, they tend to recognize all positive consequences occurring in the plant and including the production, or core process, as well as other ancillary processes with limited interest for the negative ones. This may happen because highlighting the potential of such type of investments and the wide range of positive effects for the organization undertaking an investment in EEMs was deemed as most important. A further confirmation has been provided by Mills and Rosenfeld (1996), who concluded their study with the indication of a higher interest, from an industrial manager perspective, for several non-energy benefits, thus pointing out the need to go beyond energy savings.

In the past, NEBs have been considered as benefits perceived as a consequence to the adoption of an EEM, but that cannot always easily be quantified in monetary terms. Indeed, as authors note, “a benefit may be deemed ‘non-quantifiable’. For example, adopting a technology may enhance a firm’s reputation as an innovator and leader, but this is too intangible to quantify” (Worrell et al. 2003). Nevertheless, regardless of the capability to quantify benefits (and monetize them), the interest for describing NEBs has been differentiated. In fact, the focus from

scholars and practitioners was directed toward the indication of possible areas within an organization where the benefit was going to be experienced or, alternatively, towards the definition of their nature indicating e.g., whether the benefit is internal or not, direct or not, economic or not.

Contemporary to the increasing knowledge about their existence, the level of detail used for the description of NEBs has been enriched with further attributes. Here Elliott et al. (1997) have offered an interesting contribution to the discussion. In particular, even if benefits are considered just based on the area where they can be experienced, some additional progresses have been reached. In particular, it has been highlighted the need to add a “project” or intervention-related perspective. For this reason, benefits in their study are defined as project benefits (stemming from the label used for the EEMs, i.e. Energy Efficiency Projects). With regard to this, the areas used for clustering the benefits have been defined considering the areas of a company where the benefits could be appreciated, including: *i*) reduced costs of environmental compliance; *ii*) improved worker safety; *iii*) reduced production costs; *iv*) improved product quality; *v*) improved capacity utilization; and *vi*) improved reliability. Hence, it has been possible to overcome the idea of almost exclusively considering energy savings, thus admitting that those benefits may go over the energy savings provided through the EEMs analyzed. Furthermore, Lilly and Pearson (1999), who have proposed an economical evaluation of the benefits deriving from the implementation of the EEMs in the industrial context, pointed out the need to evaluate such impacts in the decision-making process. This first attempt reveals the need to encompass (in some way) NEBs into the decision-making process of adopting an EEM.

Piette and Nordman (1996) propose several areas where to experience a benefit, such as: *i*) improved indoor environmental quality and comfort; *ii*) improved controls and zoning; *iii*) reduced operations and maintenance costs; *iv*) improved equipment life; and *v*) reduced EEM dollars. Additionally, the benefits accounted into such areas tend to reduce the total costs paid for adopting an EEM. As a consequence, the authors offer an approach to evaluate the cost-effectiveness for the measures taken into account, by comparing the energy costs savings with the total costs paid for an EEM commissioning. Furthermore, the study by Piette and Norman (1996) is notable for their first attempt of considering in the investment analysis also the so-called “deficiencies”, intended as operational problems existing in the plant before the EEM completion. Such deficiencies could be directly related to the EEM, indirectly related to the EEM – as in case of a deficiency that could have been found even without the implementation of the measure considered – and, finally, unrelated to EEM.

Another important contribution has been provided by Worrell et al. (2003) and Laitner et al. (2001), who focus their attention on the definition of the productivity benefits, highlighting the possible distance from the core process of the benefits arisen and indicating the areas where the impact is perceived. The six areas for the productivity benefits are as follows: *i*) waste reduction; *ii*) emissions reduction; *iii*) operation and maintenance; *iv*) production; *v*) working environment; and *vi*) other. In addition, the definition of such productivity benefits points out the possibility to include them in strategic evaluations and, consequently, trying to suggest the industrial decision makers that EEMs themselves can be perceived as further possibilities to build a competitive advantage. Notably, to evaluate the cost-effectiveness of EEMs complemented with additional benefits, the authors propose the Conservation Supply Curves (CSCs). CSCs represent a useful tool based on discounted cash flow techniques where all benefits (energy and non-energy) and costs related to the service phase of an EEM, being aware of different capital recovery factors as well as EEM lifetime, have to be accounted and compared to a given energy cost threshold (typically, the current average energy price). Based on the approach proposed by Worrell et al. (2003) and Laitner et al. (2001), Finman and Laitner (2001) have conducted a study of the impacts of NEBs through 77 different case studies available in literature, even if only 52 of them have been thoroughly evaluated, because of missing information.

Considering, in addition, the contribution by Pye and McKane (2000), the definition of the profitability of the benefits has been pointed out through the introduction of a different perspective. In fact, a stronger interest towards the NEBs is demonstrated with the indication of the impacts attributable to a certain measure accomplished in order to increase the *efficiency*, and not merely the *energy efficiency*. This shift shows indeed the need to identify and characterize the benefits as able to increase and build (or strengthen) the firm’s competitive advantage on the long-term. Again, other scholars have offered an attempt to look at other than energy-related performance affected by the adoption of EEMs. In the study proposed by Finster and Hernke (2014), the perspective adopted changes sensibly, moving the focus from the quantification in monetary units to the consideration of gaining a competitive advantage from the implementation of the EEMs. Seven domains have been identified, namely: *i*) markets and products; *ii*) reputation; *iii*) risk; *iv*) human resources; *v*) sourcing; *vi*) collaboration; and *vii*) strategic direction. In addition, for each of them, there is the proposal of different benefits.

More recently, an interesting proposal has been offered by Ryan and Campbell (2012); in particular, there is a wider analysis of the socio-economic outcomes arising from an EEM different from the energy savings. Even in this case, it has been taken into account on the one hand that different perspectives on NEBs exist; on the other

hand, that benefits from the adoption of EEMs may be either direct or indirect. In particular, they are defined as direct if they are a consequence of the having implemented an EEM, while they are indirect if they can be experienced as consequences (or evolutions) of the direct benefits. In addition, the categorization of the benefits has been accomplished considering the economic level (individual, sectorial, national and international levels), even if other hints are provided. Among these, they have proposed to look at the beneficiary, the nature of the impact, the temporal scale and the character of the impact.

Scholars have stressed the need to consider multiple perspectives on benefits for energy efficiency, moving beyond those experienced exclusively by a single company. In particular, Skumatz and Gardner (2005) define several co-existing perspectives when considering the EEMs, individuating three opportunities: the utility, the societal and the participant benefits. For each benefit, in order to provide satisfying estimates, the evaluation of the net effect has to be accomplished considering the type of impact (positive or negative), defined in relation to the non-efficient equipment available, instead of that included in the EEM and accomplished exclusively considering the benefits attributable to an energy efficiency program, and not to the technology. According to the authors, a deeper knowledge of the NEBs – relevant for the stakeholders where the efficiency program has to be implemented – reduces the existing barriers and improves the awareness of a company regarding the EEM that suits the most its needs. In short, a thorough knowledge of NEBs allows a more accurate choice of the EEMs, e.g., thus understanding which of them is closer with respect to a company energy strategy or which one is most effective. This represents a driver for improved energy efficiency. Indeed, combining this enhanced opportunity with the need for a more detailed EEMs description, the benefits have been initially indicated as Net Non-Energy Benefits. The “net” concept here seems to underline the existence of both positive and negative impacts, as previously mentioned.

In 2014, the IEA (2014) has published a report on capturing the multiple benefits of energy efficiency, where the benefits are analyzed to demonstrate the correlation existing between EEMs and strategy as well as core processes of the organization, contrary to what happens to policy makers. Nevertheless, the report is pretty vague in describing how to account for both the full costs and benefits of the EEMs and to the way known aspects are communicated to the decision maker. The first aspect provided relates to the area where benefits can be experienced, similarly to what proposed from other authors (see, e.g., (Worrell et al. 2003) and (Lung et al. 2005)). Consequently, the time axis is considered, in order to distinguish the benefits easy to be quantified and defined, so to give them a higher priority, with consideration expressed on the base of previous studies, interviews and collaborations. In a recent publication on policy pathways for energy efficiency in Small and Medium-Sized Enterprises (SMEs) by IEA (2015), benefits are presented as opportunities to improve the profitability of the EEM in SMEs. Nevertheless, the considerations of the extension of the real impact of the measure is not proposed. In addition, the classification and characterization of the benefits, in this phase, is something not considered. This happens because the interest at this stage is still focused on the definition of the advantages proper of the EEMs for strengthening their diffusion.

## **General considerations on the existing classifications**

What emerges from the literature review is the existence of a narrow interest focused almost exclusively on the benefits with a positive impact that arise in the service phase, i.e. after the adoption of the measure has been completed. However, as some authors pointed out, the effects are not all positive – considering, for example, negative benefits (Skumatz e Gardner 2005), (IEA 2005), or deficiencies) – and do not manifest just in the service phase (as for the deficiencies encountered in the implementation phase (Piette and Nordman 1996)). A full set of literature review has been reported in Table A.1 (in Appendix). To summarize the main information analyzed, in *Figure 1* we have exploited a graph characterized from two axes: on the one hand, we have reported the time, which covers all the EEM lifetime, thus with a clear distinction between implementation phase (installation, start up, etc.) from the service phase of an EEM. On the other hand, we have distinguished between the type of impact of the benefit.

The picture clearly shows that almost the whole literature has been focused on benefits (25 out of 38 studies considered on the topic) for the service phase: this is reasonably due to the fact that a strong boost has come from EEMs manufacturers, suppliers and policy-makers, thus tending to show as much positive impacts as possible in the description of the EEMs, so to improve the diffusion of such measures. However, according to the perspective of an industrial decision maker, it is important to perform a frank and complete analysis of the EEMs, including the effects of each phase in the previously mentioned description as well as possible negative impacts (here called “losses”) both in the implementation as well as in the service phase. The need to highlight both negative as well as positive impacts is related to the need of overcoming the informational barriers related to the lack of knowledge (as briefly reported in the introduction), mostly about the interaction of the EEMs with the context where they are

applied, and also regarding the impact that the adoption of an EEM has on the organization's strategy. Last, but not least, it is really interesting that no study has been so far focused on addressing losses in the implementation phase: indeed, the so-called "disturbance" has been recognized as a possible crucial element when dealing with implementation of EEMs, and assumes great relevance especially in case of EEMs with possible effect on core production activities.

Consequently, in order to address the viewpoint of an industrial decision maker, it is important to provide first a new framework to describe the attributes of the impacts proper of each EEM and, consequently, a new characterization of the benefits, in order to precisely define the dynamics within a plant where EEMs are implemented, the core process and the ancillary ones. The characterization of the benefits would for sure take advantage from the previous literature contributions, thus aiming at including the most relevant properties proposed by previous scholars.

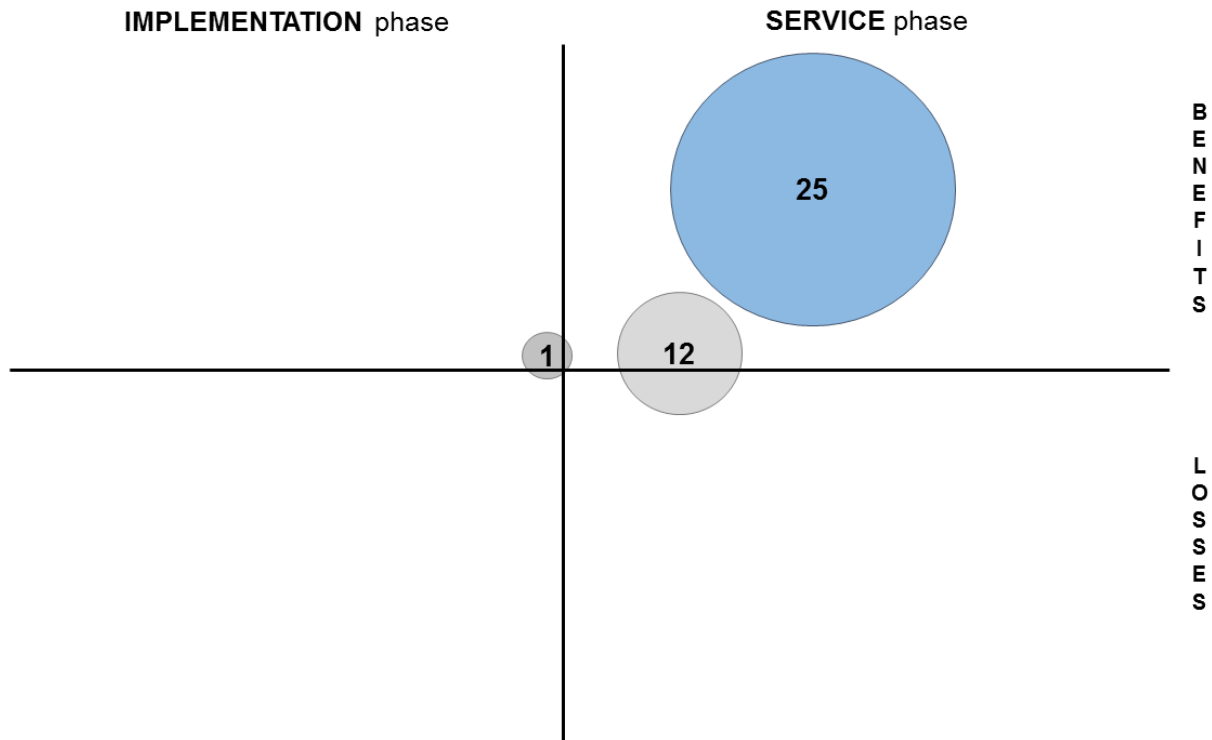


Figure 1 - Focus of the existing literature studies on Non-Energy Benefits

### The need of a novel model for NEBs

Considering the previous literature review and keeping the perspective of an industrial decision maker, it is really crucial to re-design the set of attributes needed to entirely describe the impact that EEMs have on the whole organization. This indeed calls for a brand novel approach much more oriented towards investment decision support from a manager perspective, as Sandeberg and Söderström (2003) note. To do so, on the one hand it is important to encompass a set of characteristics so far missing, or barely integrated; on the other hand, it would be needed to develop a tool able to measure (with appropriate scales) both benefits and losses of EEMs.

Having a proper instrument for decision-making purposes has been recognized as important since the whole supply chain where the organization is placed may have different performance, technologies, demand and regulations, that may also vary over time (e.g. due to regulatory issues). The industrial decision makers responsible for the investments must therefore be able to understand the widest spectrum of consequences of each decision accomplished, in order to establish the investment chain that supports the most the company strategy and enables an enterprise to build a long-lasting competitive advantage.

As it can be noticed from *Figure 1*, the focus has some missing attributes that relates both the phase in which the benefit can be appreciated and the type of impact of the benefit itself, i.e. positive or negative. The first terminological aspect must relate to the definition of a new framework that should account for the type of impact, defining how the benefits and the organization relate one with the others. This is partially what can be observed from the extant literature, where a distinction among positive and negative impacts has been considered to some

extent (although unclear). For this reason, it is important to modify the terminology adopted: the indication of the benefits must suit the different perspectives about the perception of the positivity of the benefits themselves, defining the NEBs and other categories of benefits.

According to Sandeberg and Söderström (2003), an investment is the consequence of a trade-off between quality and time; consequently, many effects must be considered in the decision making process regarding the impact of the investment itself on several aspects of the company. These include environmental and quality issues but, mostly, it is important that even an EEM has advantages and opportunities, disadvantages and alternatives pointed out in the early decision-making phase, that, without being clearly identified, may jeopardize the whole EEM implementation. Indeed, the need to account for several alternatives calls for a more detailed evaluation of the phases that define the lifetime of an EEM, as happened in case of a detailed *feasibility study*. In fact, in a feasibility study it is really important to properly define and respect the boundary conditions and thresholds (both technical and environmental ones), and to evaluate the possible change in some performance due to the implementation of the measures. In short, industrial decision makers need a detailed objective picture of the EEM to be undertaken with a broader perspective according to its lifetime, including possible implications in terms of relevant economic and environmental performance. In doing so, a crucial element is to offer fair and unbiased information about the real performance, so to limit as much as possible the inertia of decision makers.

Therefore, and quite new with respect to previous literature, it would be important to include in a framework of NEBs the time window in which the impact is going to be perceived and, thus, defining the implementation phase and the service one, including a detailed analysis of the EEMs and their impacts on the plant. These are important if considering the perspective of the industrial decision maker, who is strongly interested in the definition of the effects deriving from the adoption of the EEM considered in both phases. In particular, these effects are so important since they strongly influence the opinion of a decision maker about the measures since they include, among the other effects, production disruption and discomfort in production departments. The possible benefits and, mostly, the losses perceived in the implementation phase should be objectively described and remarked, as well as evaluated in an unbiased manner. What is reputed as a fundamental aspect to be considered is the dynamic evolution of the conditions inside the plant during the intervention, defining possible consequences of this specific phase on the surrounding environment. Considering all these aspects, the first of the two phases proposed, that is the implementation one, is defined as the time interval that includes the decommissioning of the existing non-efficient equipment, the installation, the testing and the start up of the efficient one. The second phase, i.e. the service one, is the time window in which the best energy-efficient equipment installed is exploited and the energy savings forecasted occur. Combining both the phases, the whole lifetime of the measure is obtained.

With respect to the above mentioned opportunities, it would be interesting to identify those impacts (not necessarily positive benefits, but a general impact involving the organization) that may be obtained in cooperation with the considered EEM. Following Ryan and Campbell (2012), this means that the focus should not be just given towards the identification of the impacts directly related to the EEMs, but also on the indirect ones, i.e. of the set of events and consequences triggered by the implementation of the EEM itself (as an effect from direct benefits or losses).

On the other hand, it would be interesting to have a thorough definition of the indirect effects during the implementation phase, in the sake of what proposed by Ryan and Campbell (2012), although having a slightly different meaning. Indeed, the definition of the indirect benefits should be done in order to define the dynamic behavior of an EEM in a plant, positioning it into an industrial context and considering the possible existence of either several operators, production systems and other investments (or measures in general) under accomplishment in the same time window, not necessarily specifically addressed for increased energy efficiency.

Considering the scheme reported in *Figure 1*, it is possible to notice how the contents introduced and suggested in this section would improve the knowledge of the benefits, properly defining the way they are obtained and can be perceived, other than the need to describe the impact of the benefits and defining when they arise in the organization. A description obtained in this way could suit the perspective of an industrial decision maker: in fact, as first objective, we aim at defining a novel approach to consider and analyze EEMs and their consequences on the whole organization. As second objective, we would like to offer a new perspective also for policy making purposes, so to increase the effectiveness of their choices and actions.

Additionally, a crucial element that has been partially suggested from previous literature is the distinction between benefits stemming from a reduced energy flow, with respect to those depending on the implementation of the given EEMs. Indeed, in many cases, authors seemed to have mixed up between these two categories of benefits, that should be kept separate, in particular related to GHG emissions (that are typically energy-flow related).

Moreover, based on the empirical evidence as well as existing contributions, it would be really useful to include in a framework describing Non-Energy Benefits (NEBs) Losses (negative impacts deriving from the adoption of



such measures) who, within a company, is going to experience a benefit, as well as whether a benefit could be persistent over time and how long it would be possible to experience it. Finally, in a proper framework to describe the effects, it would be interesting to describe which effects may have a relevant effect in the relationship with external company's stakeholders, from those that may be appreciated exclusively within the company. This enhanced knowledge on NEBs would support on the one hand industrial decision makers to properly give a higher priority to selected EEMs on the basis of those with most interesting effects. On the other hand, it would support the set of stakeholders in promoting EEMs, since it would be clearer who (and to what extent) is going to effectively benefit from the adoption of the considered EEMs within and outside a company.

## Concluding remarks and further research

In conclusion, the present study has offered a thorough review of the set of studies concerning the whole set of effects, both benefits and losses, deriving from the EEMs adopted in the industrial sector, in production plants. In particular, we have highlighted the need to develop a novel approach to characterize and analyze such effects, based on an industrial decision-making perspective. If yet most of the work has been accomplished to point out benefits in the service phase for an EEM, much greater attention should be paid to clearly point out the existence of benefits since the implementation phase of an EEM as well as to describe the negative consequences (losses) brought by the adoption of EEMs. Additionally, several attributes would still need to be described in detail, getting benefits from the extant literature. Furthermore, in detailing attributes, proper attention should be paid in offering adequate scales for measuring the characteristics. Finally, to validate the novel approach and guarantee to have developed a really useful tool for industrial decision-making purposes, a thorough investigation of the framework with respect to different EEMs would be needed. This phase would be really crucial to test the capability of the framework to thoroughly describe the set of relevant attributes of an EEM as well as its benefits (and losses) according to the implementation as well as the service phase.

As further research opportunities, the development of such framework could be exploited for additional empirical research through the following research streams: firstly, it would be interesting to apply the framework in selected cluster of enterprises, so to understand common needs and opportunities (as well as difficulties and barriers to the adoption of EEMs). Secondly, it would be possible to apply the framework in analyzing several stakeholders within the same supply chain of an EEM, so to point out different perspectives and analyze existing mismatches (that lead an EEM to not being implemented by a final user). Thirdly, it would be possible to analyze a single company with respect to several different EEMs, so to understand which might be the possible existing synergies (either positive or negative) coming from the adoption of a set of EEMs. Fourthly, it would be quite interesting and challenging to seek whether the framework would perform out of the context for which it has been specifically developed, i.e. industrial energy efficiency. Indeed, it would be quite relevant to point out existing energy efficiency benefits from the adoption of measures not designed for energy efficiency purposes. Finally, from a policy making perspective, it would be possible to use the developed framework to describe a set of different companies with respect to the same EEM, so to develop the most appropriate means to foster the adoption of such measures.

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## Appendix

Table A.1 Overview of literature contribution on Non-Energy Benefits for industrial energy efficiency measures

Authors	Year	Type	Focus	Implementation/Service phase	Benefits/Losses
Benemnt and Skumatz	2007	Conference proceedings	Commercial and Industrial sector	Service phase	Benefits and Losses
Boyd and Pang	2000	Journal - Energy policy	Industrial sector	Service phase	Benefits
Bozorgi	2015	Journal - Energy Efficiency	Real estate	Service phase	Benefits and Losses
Bunse et al.	2011	Journal of Cleaner Production	Industrial sector	Service phase	Benefits
Cooremans	2011	Journal - Energy efficiency	Industrial sector	Service phase	Benefits
Elliott et al.	1997	Conference proceedings	Industrial sector	Service phase	Benefits
Finman and Laitner	2001	Conference proceedings	Industrial sector	Service phase	Benefits
Finster and Hernke	2014	Journal of Industrial Ecology	Industrial sector	Service phase	Benefits
Fleiter et al.	2012	Journal - Energy policy	Industrial sector and policy makers	Service phase	Benefits and Losses
Giannantoni	2009	Conference proceedings	Policy makers	Service phase	Benefits and Losses
Gillingham et al.	2004	Report	Policy makers	Service phase	Benefits
Hall and Roth	2004	Conference proceedings	Commercial and Industrial sector	Service phase	Benefits
Hall and Roth	2003	Report	Policy makers	Service phase	Benefits
Heffner and Campbell	2012	Report	Policy makers	Service phase	Benefits and Losses
IEA	2015	Report	Policy makers	Service phase	Benefits
IEA	2014	Report	Policy makers	Service phase	Benefits
Imbierowicz and Skumatz	2004	Conference proceedings	Policy makers	Service phase	Benefits and Losses
Laitner et al.	2001	Conference proceedings	Industrial sector	Service phase	Benefits
Lilly and Pearson	1999	Report	Industrial sector	Service phase	Benefits
Lung et al.	2005	Conference proceedings	Industrial sector	Service phase	Benefits
Worrell et al.	2002	Report	Industrial sector	Service phase	Benefits
Mills and Rosenfelds	1996	Journal - Energy	Industrial sector	Service phase	Benefits
Pearson and Skumatz	2002	Report	Commercial sector	Service phase	Benefits and Losses
Piette and Nordman	1996	Conference proceedings	Commercial and Industrial sector	Service phase / Implementation phase	Benefits and Losses
Pye and McKane	1999	Conference proceedings	Industrial sector	Service phase	Benefits

Pye and McKane	2000	Journal - Resources, Conservation and Recycling	Industrial sector	Service phase	Benefits
Ryan and Campbell	2012	Report	Policy makers	Service phase	Benefits and Losses
Skumatz and Gardner	1997	Report	Industrial sector	Service phase	Benefits and Losses
Skumatz and Dickerson	1998	Conference proceedings	Industrial sector	Service phase	Benefits
Skumatz and Gardner	2005	Conference proceedings	Commercial and Industrial sector	Service phase	Benefits and Losses
Skumatz et al.	2000	Conference proceedings	Residential sector	Service phase	Benefits
Smith-McClain et al.	2006	Conference proceedings	Residential and commercial sector	Service phase	Benefits and Losses
Trianni et al.	2014	Journal	Industrial sector	Service phase	Benefits and Losses
Vine	2011	Report	Policy makers	Service phase	Benefits
Vine et al.	2000	Journal - Energy	Insurance, industrial sector, policy makers	Service phase	Benefits
Worrell et al.	2003	Journal - Energy	Industrial sector	Service phase	Benefits
Zhang et al.	2015	Journal - Applied Energy	Industrial sector	Service phase	Benefits
Zhang et al.	2014	Journal - Energy	Industrial sector	Service phase	Benefits

Daniel L. Waters

# Case Study: The advancement of energy and carbon management at Gosford City Council.

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## **Abstract**

There are various approaches to energy and carbon management and the most appropriate approach is likely to change over time. Selecting the appropriate approach is pivotal in determining how successful an organisation will be in achieving its energy and carbon management objectives. Over the last fifteen years, Gosford City Council has undergone numerous shifts in its approach to the management of energy and carbon across its operations.

Council initially focused on reducing its carbon footprint, firstly by setting aspirational targets and followed by the setting of evidence based targets. In response to rising energy costs, Council shifted from a “carbon abatement” to an “energy management” focus in 2012. At this time, the sophistication of Council’s energy management program was vastly improved with the introduction of a corporate energy management information system and a revolving energy fund. In 2014, Council’s energy management program focused on “use less” and “pay less” levers. The first lever “use less” covered much the same ground as previous carbon abatement approaches, however, the second energy management lever, “pay less” unlocked significant additional value to Council. Payless initiatives, such as energy procurement, load shifting, energy account management and bill validation resulted in energy cost savings of hundreds of thousands of dollars for Council.

Council is now shifting from a tactical to a more strategic approach to energy management. An Energy Management Strategy is under development. The Energy Management Strategy will introduce an Energy Productivity Improvement Objective. This objective will focus on recognising the complete economic value of improved energy and carbon management. This should yield organisational productivity improvements and economic value in the local community. The strategy also introduces advanced energy metrics such as an energy cost index and asset class energy intensity metrics.

The appropriate approach for Gosford City Council’s energy and carbon management has advanced in line with wider organisation objectives, values and maturity of its energy management systems.

## **Introduction**

Over the last fifteen years Gosford City Council has achieved several milestones in its approach to energy and carbon management. Whilst Council has undertaken community carbon abatement initiatives through its plans and education programs, this paper focuses on Gosford City Council’s approach to carbon and energy management from its own operations. The paper will cover key energy and carbon milestones, outline Council’s carbon footprint, discuss the advancement of Council’s carbon and energy management and how the concept of energy productivity is guiding the current strategy under development.

## **Energy & Carbon Management Milestones**

There have been five key milestones associated with the advancement of Council’s carbon and energy management since 1999. Each milestone continues to build on the achievements of the previous milestone. The Cities for Climate Protection Program was designed to improve carbon management. The climate change policy formalised Council’s commitment and integrated carbon management with climate change adaption risks. The Climate Change Mitigation Strategy provided more information and evidence to support cost effective carbon abatement. The introduction of a revolving energy fund was designed to address the capital funding project

implementation barrier. The carbon & energy management system improved the carbon and energy performance of Council. The energy management strategy currently under development introduces energy productivity as an additional benefit. The following timeline shows a shift from a carbon abatement focus to an energy management focus (Table 1).

*Table 1 Energy & Carbon Management Timeline*

1999-2009	2010	2011-2012	2012	2012-2014	2015
Cities for Climate Protection	Climate Change Policy	Climate Change Mitigation Strategy	Revolving Energy Fund	Carbon & Energy Management System Improvements	Energy Management Strategy

### ***Cities for Climate Protection (1999-2009)***

The Cities for Climate Protection (CCP) program was an initiative of the International Council for Local Environmental Initiatives (ICLEI). Gosford City Council joined the CCP program in 1999. The CCP program involved five steps:

1. Inventory and Forecast
2. Setting a Reduction Goal
3. Developing a Local Action Plan
4. Implementation
5. Monitoring and Reporting

Council set two aspirational voluntary targets under the Cites for Climate Protection program:

50% reduction in per capita carbon emissions from Council operations by 2020, based on 2001 levels.

50% renewable energy by 2020.

The CCP was an important step in raising the profile and need for carbon abatement. The CCP was successful in gaining support at the political level and adopting aspirational targets. The main shortfall of the CCP was the lack of management buy-in and integration into corporate planning. This may have been a function of the bureaucratic structure with the responsibility of climate change sitting with the environment section and not seen as a responsibility of other sections of Council. There were also energy and carbon data quality and completeness issues. The information systems were insufficient to collect adequate data on energy consumption and carbon emissions. These barriers combined to result in an unwillingness to invest the resources into climate change mitigation strategies. Consequently the targets were treated as long term aspirational targets and failed to drive any significant change to the emissions from Council operations.

### ***Climate Change Policy (2010)***

Increasing regulatory reporting requirements and rising energy cost triggered senior management to renew efforts to improve energy and carbon management. This included the creation of a dedicated full time position and the development and adoption of a climate change policy in 2010. The policy provided a strategic framework for managing both climate change mitigation and adaptation risks. It included a high level hierarchy for removing the sources of carbon emissions and increasing carbon sinks (Figure 1). The policy formalised Council's commitment and provided a framework for Council's Climate Change Mitigation Strategy.

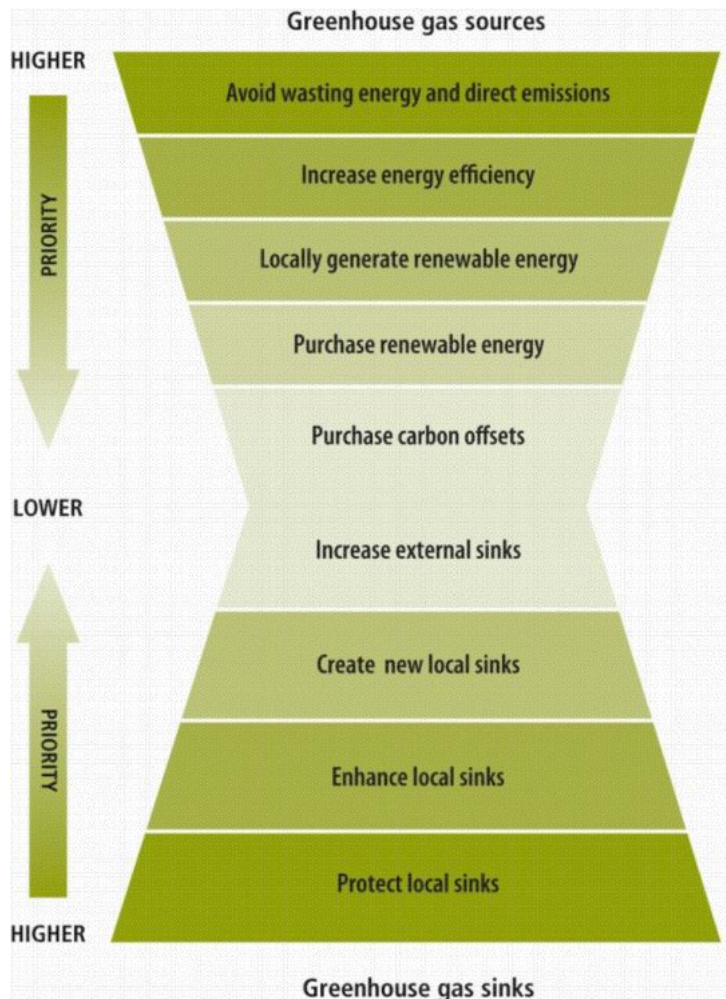


Figure 1 Climate change policy abatement hierarchy

### ***Climate Change Mitigation Strategy (2012)***

The overarching purpose of the Climate Change Mitigation Strategy (CCMS) project was to develop a sustainable climate change mitigation strategy for Council operations and the community, in alignment with Council's key policies and plans (Dowling et al, 2012). The key drivers behind the need for an updated carbon reduction strategy were lack of ownership and implementation of the existing CCP strategy, increasing energy costs and new technologies. The objective of the strategy was: "To reduce Gosford City Council's carbon footprint, and assist the community to reduce their footprint, in an achievable and sustainable manner" (Dowling et al, 2012).

The climate change mitigation strategy utilised a bottom up evidence based approach for setting the reduction target. It established an emissions baseline by calculating Council's carbon footprint, including a business as usual emissions forecast. It improved Council's understanding of the carbon abatement potential by identifying and evaluating carbon abatement opportunities based on a triple bottom line lifecycle costing approach.

The CCMS methodology combined robust data analysis with stakeholder engagement at each of the four development stages:

- 1) Project inception and objective setting
- 2) Development of carbon footprint inventory for GCC
- 3) Identification and assessment of carbon abatement opportunities
- 4) Development of strategic scenarios

The use of stakeholder engagement and robust data analysis in the methodology assisted with addressing the implementation barriers of the Cities for Climate Protection Program (i.e. lack of buy-in and perceived lack of robust evidence).



The strategy target was based on a selection of abatement opportunities comprising energy efficiency, renewable energy, carbon emissions capture and destruction, community abatement programs and demand management opportunities. The abatement opportunities identified in the marginal abatement cost curve were used to guide the level of abatement to be targeted by the strategy (Figure 2). Council adopted a carbon reduction target of 20% at 2025 based on 2010 levels.

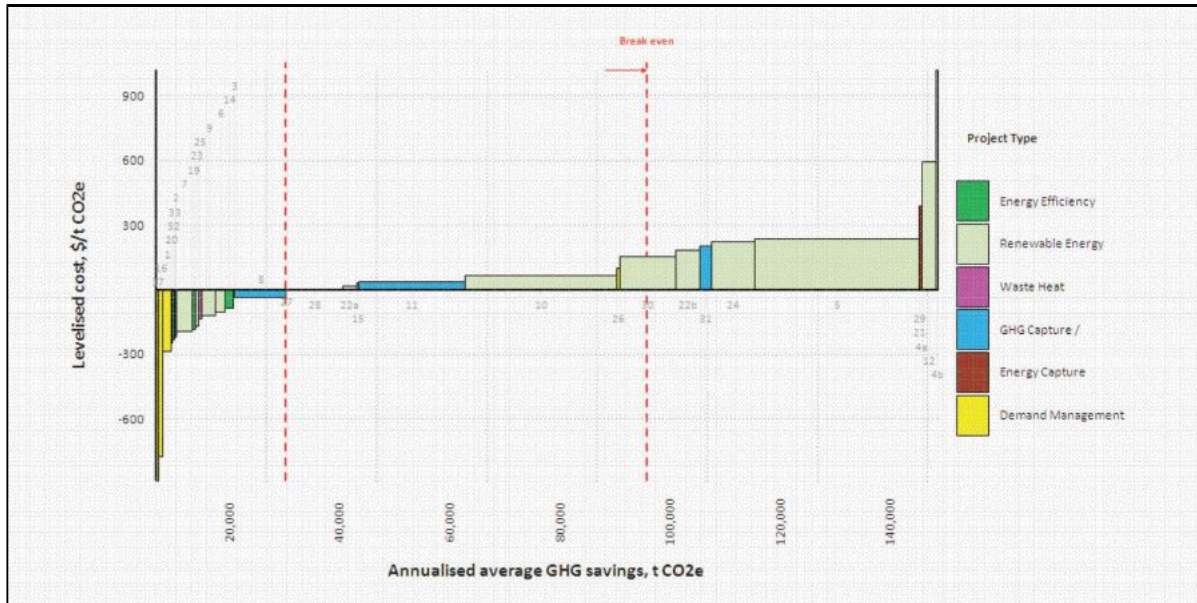


Figure 2 Gosford City Council Carbon Abatement Marginal Cost Curve

Since adopting the carbon reduction target, the emissions from landfills and wastewater treatment plants have been most variable with significant increases and reductions from year to year (Figure 3). The decomposition of waste in landfills creates carbon emissions. Council has a landfill gas extraction system at its landfills which capture the landfill gas more than halving the landfills' carbon footprint. The captured landfill gas is used to fuel engines which generate enough electricity to power over 2050 local homes.

Carbon emissions from electricity use have remained relatively stable with growth and energy efficiency improvements balancing each other out. The emissions from transport fuels have dropped by 10% over the last year primarily from reductions in usage and efficiency improvements (Figure 3). The continued implementation of the Climate Change Mitigation Strategy the carbon gas reduction target is achievable. The 2015 carbon inventory highlights the importance further reducing landfill, wastewater treatment and electricity emissions. Council is on track to meeting the target by 2025 with major projects underway such as the roll out of over 1,600 solar photovoltaic panels, landfill gas capture and other energy efficiency improvements.

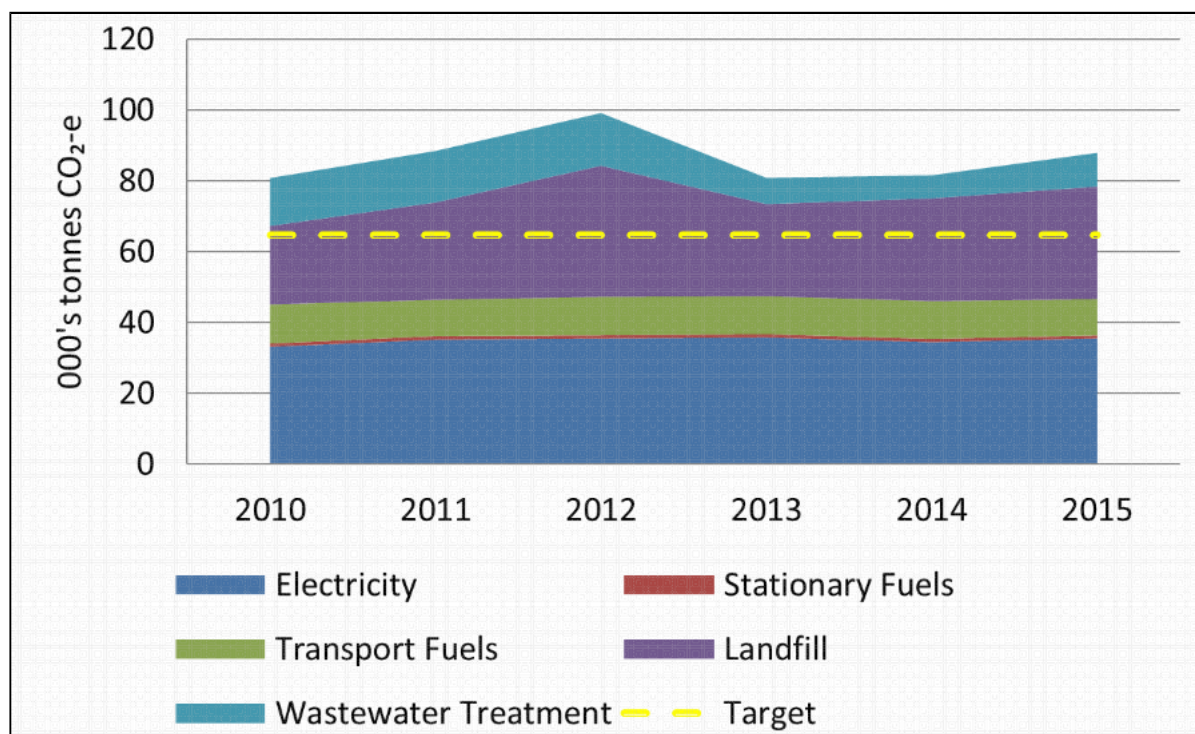


Figure 3 Gosford City Council Carbon footprint (000's t CO<sub>2</sub>-e)

### ***Revolving Energy Fund***

The revolving energy fund is designed to be a financially sustainable source of capital to fund cost effective energy and carbon projects. Energy cost savings from energy projects and other energy management initiatives were identified to be captured by the revolving energy fund. For example, the revolving energy fund recently invested in a project that installed 1,600 solar panels (434kW) on Council facilities with an internal rate of return over 10%.

### ***Carbon & Energy Management System Improvements (2012-2014)***

The development of the Climate Change Mitigation Strategy highlighted the need to further improve carbon and energy management systems. The sophistication of Council's carbon and energy management program was vastly improved following the introduction of an organisational carbon and energy management information system in 2012. The information system provided carbon, energy and cost data.

Improvements to Council's energy management systems have led to improved energy consumption and cost performance. Reliable and timely energy and carbon data is necessary for the design, implementation and measurement of system improvements. The improved energy information system allowed the identification and verification of ways to reduce Council's energy consumption, such as avoiding unnecessary energy use, improving energy efficiency and generating energy on site. It also gave Council the data to identify ways to pay less for energy.

Traditionally there have been three broad reduction objectives for Council's carbon and energy management activities; carbon footprint, energy cost and energy consumption. Each of the three objectives can be thought of as a different lens through which to view Council's operations. Each lens highlights a different asset class as the most important in terms of their relative contribution (Figure 4). For example, the landfills are the largest source of carbon emissions, but have very little energy use and energy cost. If the primary objective is to reduce Council's carbon footprint, the landfills, wastewater treatment and pumping would be the asset classes to focus attention on. Energy cost and consumption are more closely aligned with some exceptions due to relative differences in the unit cost of energy sources. For example, transport is the largest asset class in terms of energy consumption, whereas wastewater pumping and treatment has the largest energy costs. This is because the unit cost of energy from liquid fuels (\$31.9/GJ) is 35% less than the unit cost of electricity (\$49.3/GJ).

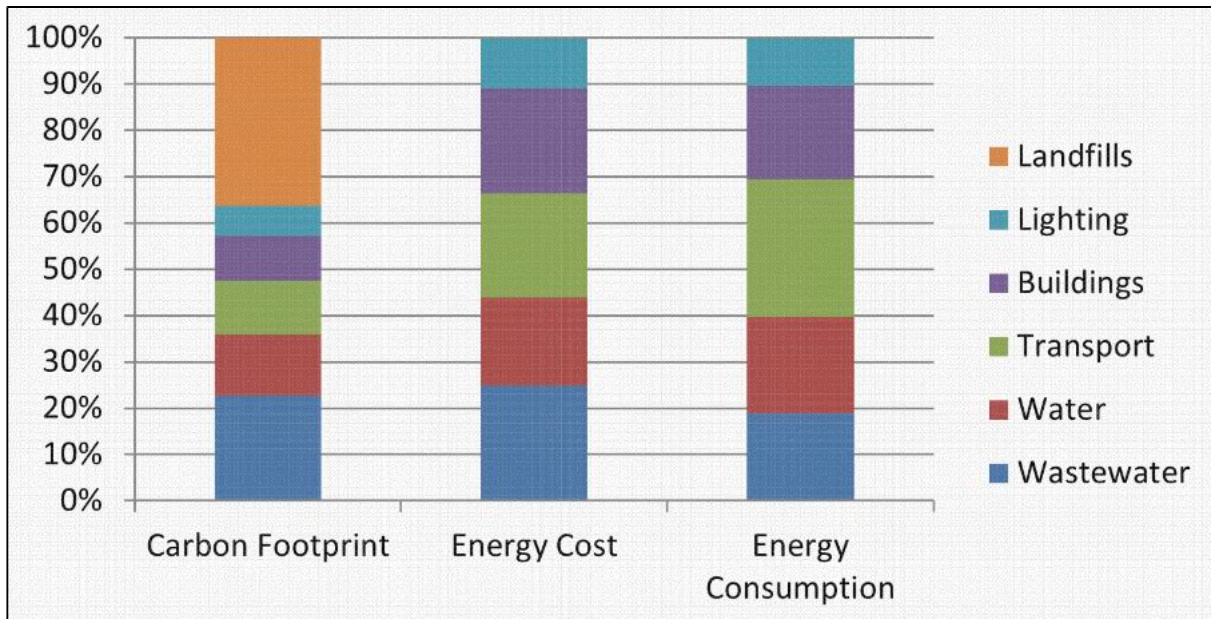


Figure 4 Council 2014/15 carbon footprint, energy cost and consumption by asset class

In the four years to 2013, Council’s energy cost increased by 61% (Figure 5). This dramatic increase was not due to increased energy consumption which remained steady (Figure 6), but was almost entirely due to increased electricity prices. In response, Council expanded its “pay less” energy management initiatives. Energy cost savings over \$822,000 were achieved by initiatives such as improved electricity procurement practices, bill validation, load shifting, electricity account management and tariff optimisation. The cost of transport fuels also dropped by 24% compared to last year driven primarily by reductions in usage and price. These improvements along with external factors such the repeal of the *Clean Energy Act 2011* have reduced Council’s annual energy cost by \$2.2M from its peak in 2013 (Figure 5).

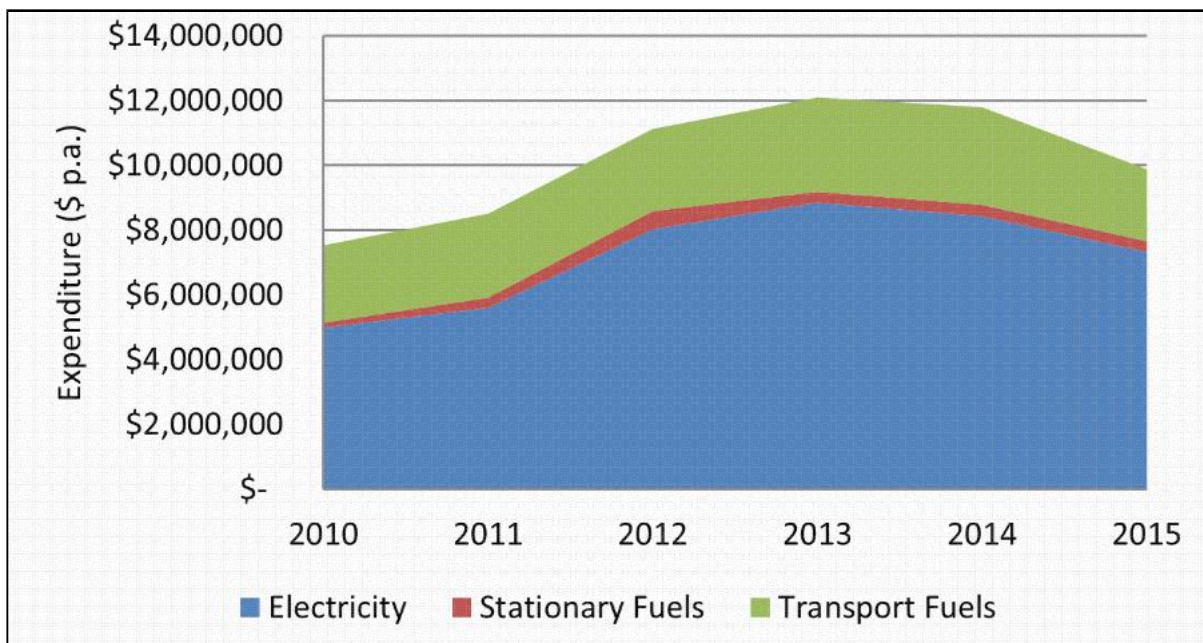


Figure 5 Gosford City Council nominal energy cost by source

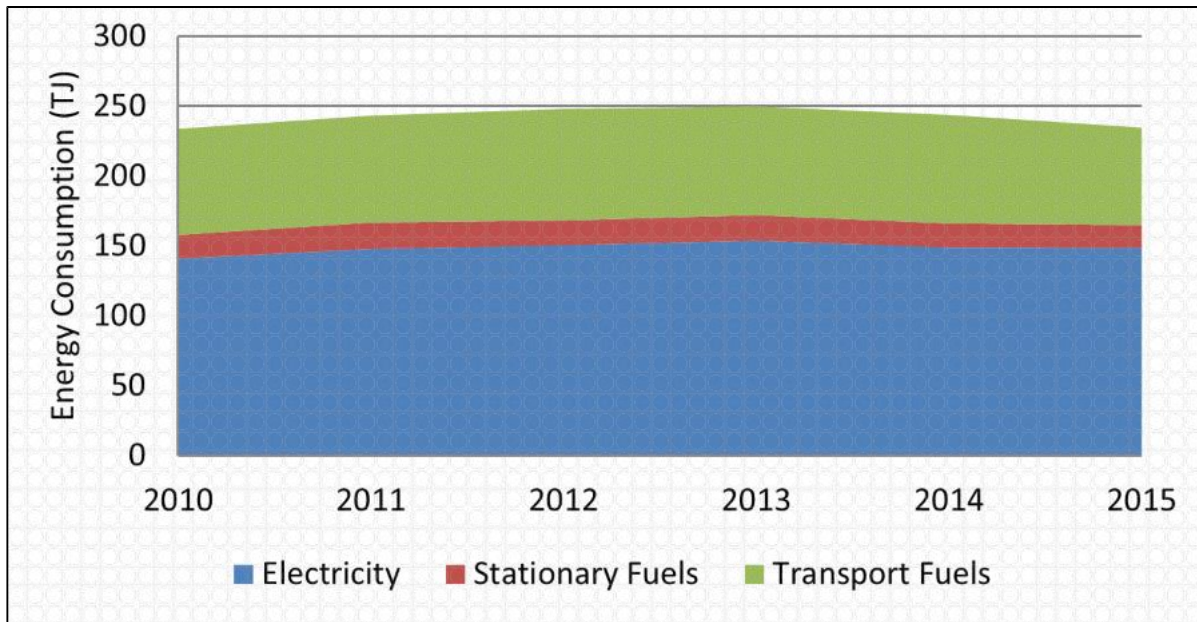


Figure 6 Gosford City Council energy consumption by source

**Energy Management Strategy (2015)**

Council is now building on the tactical carbon and energy management system improvements by developing an energy management strategy. The fundamental objective of the energy management strategy is to drive improvements in the energy productivity of Council’s operations. This approach is different to previous approaches which were focused on using less and paying less. The main difference is the energy productivity approach recognises that using less energy is not necessarily the optimal outcome. The energy productivity lens is expected to uncover previously overlooked opportunities by recognising the total economic value associated with Council’s energy use. This approach focuses on maximising the value Council generates from its energy use.

The energy strategy also introduces more advanced energy metrics such as asset class energy intensity metrics and an organisational energy index. The purposes of the asset class energy intensity metrics are to improve energy consumption benchmarking and identify high and low performing assets (Table 2). The energy intensity metrics have been used to develop an organisational energy index, designed to provide a high level indicator of Council’s energy performance through time. The Gosford City Council energy index is the geometric mean of the energy intensity of each major asset class (Equation 1).

Equation 1 
$$EI = \sqrt[k]{x_1 \times x_2 \times \dots \times x_n}$$

Where:  
 EI is energy index  
 k is number of asset classes  
 x<sub>n</sub> is the energy intensity of each asset class

Table 2 Energy Intensity Metrics for key asset classes

Asset Class	Asset sub class	Energy Intensity Metric	Units
Water	Raw Water Pumping	Energy per unit of water supplied	MJ/ML
	Water Treatment	Energy per unit of water treated	MJ/ML
	Water Distribution	Energy per unit of water supplied	MJ/ML
Sewerage	Sewerage Collected	Energy per unit of wastewater collected	MJ/ML
	Sewerage Treated	Energy per unit of COD treated	MJ/kgCOD
Buildings	Actively Heated/Cooled	Energy per degree day square meter of floor area	MJ/DD.m2
	Passive Heating/Cooling	Energy per square meter of floor area	MJ/m2
Lighting	Street Lighting	Energy per square meter of light space	MJ/m2
	Public Lighting		
	Sports Fields Lighting		

## Energy Productivity

Energy productivity is a fourth lens to add to the carbon emission, energy consumption and energy cost lenses. The energy productivity lens is expected to provide insights into the organisation's energy and carbon performance, driving improvements in Council's operational efficiency, manage its risks and ultimately improve the affordability of Council services for our community. Energy productivity aims to increase the total economic value the Council generates with the energy it uses. Put simply it aims to do more with the dollars Council spends on energy. Office lighting is a good example to highlight the benefits of factoring in productivity gains. Council assessed an energy saving opportunity to change office lights from tubular fluorescent (T5) to LED. The LEDs were estimated to provide marginal energy cost and maintenance cost reductions. However, the LED lights provide improved light quality. Romm & Browning (1998) reported staff productivity gains from improved office energy efficiency of 15%. Even if a 0.5% improvement in staff productivity was achieved the simple payback period was reduced from 20 years to less than 2 years. Factoring in productivity gains is expected to identify further energy saving opportunities for Council and the community.

## Conclusion

Clearly the appropriate approach to energy and carbon management can evolve in line with wider organisation objectives and maturity of its energy and carbon management systems. Over the last fifteen years Gosford City Council has advanced the management of energy and carbon emissions from Council's operations. Council has transitioned from an aspirational carbon reduction program through an evidence based carbon reduction program, to managing energy and carbon emissions through to the latest inclusion of energy productivity. The shift towards focusing on financial benefits has resulted in more change with associated improved environmental benefits. The latest shift to include the consideration of energy productivity benefits is likely to result in more energy performance improvement projects by recognising the wider economic value of energy management initiatives. However, the risk is it will ignore carbon & energy projects that would have large environmental benefits without financial or economic benefits.

Selecting the most appropriate approach to manage an organisation's energy use and carbon footprint should reflect the organisational values. Even with similar objectives the approach can significantly influence the success or failure of the energy and carbon management program.

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