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BASIX Post-Implementation Cost-Benefit Analysis

An Economic Evaluation of the State Environmental Planning Policy- Building Sustainability Index (BASIX)

NERA
Economic Consulting

A Report for the Department of Planning

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Executive Summary

The New South Wales State Environmental Planning Policy – Building Sustainability Index (BASIX) has been in operation since July 2004 and in that time has influenced the design and construction of over 120,000 new dwellings throughout New South Wales.[1] The policy provides a direct incentive to developers and builders to improve the energy and water efficiency of residential premises through the building's design and the selection of energy and water efficient technologies and practices.

The BASIX regulatory scheme requires all new dwellings in New South Wales to comply with water use and greenhouse gas emission reduction requirements, and to meet minimum performance levels for thermal comfort. Major alterations and additions must also meet energy and water reduction requirements, with the obligations varying according to the climatic zone of the premise. The scheme takes the form of an online tool that assesses a new house or unit design and compares the estimated water and energy use of the dwelling against a New South Wales average pre-BASIX benchmark. Compliance with BASIX is monitored through the development approval and certification process administered by local governments.

Overview of the study

NERA Economic Consulting (NERA) has been asked by the New South Wales Department of Planning (the Department) to undertake an economic evaluation of the performance of the BASIX policy since its inception, and estimate the expected future net benefits of the scheme out to 2050. This evaluation provides a timely opportunity to revisit the assumptions that were made as part of earlier evaluations of the net benefits of BASIX undertaken prior to its introduction, and so confirm whether BASIX has been delivering the benefits anticipated.[2]

The economic evaluation has been undertaken for seven case study dwellings and associated BASIX compliance pathways, which have been identified as being representative of a large proportion of the BASIX certificates generated to date. These case study results were then aggregated to obtain estimates of the state wide benefits and costs of BASIX.

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1 As per ABS 8731.0 – Building Approvals, Australia, November 2009.

2 See previous cost-benefit analysis:

- The Allen Consulting Group, 2003, *BASIX – Building Sustainability Index: An Economic Evaluation,* Report for NSW Department of Infrastructure, Planning and Natural Resources (DIPNR);
- Centre for International Economics, September 2005, *Benefits and costs of BASIX for multi-unit dwellings,* Prepared for DIPNR;
- Centre for International Economics, November 2005, *Benefits and costs of BASIX for three multi-unit developments,* Prepared for NSW Department of Planning;
- BMT & Associates Quantity Surveyors, 2005, *Indicative Elemental Estimate for Residential Development BASIX Analysis,* Prepared for the Centre of International Economics; and
- BMT & Associates Quantity Surveyors, 2006, *Indicative Elemental Estimate for BASIX Energy 40,* Prepared for Sustainability Unit, NSW Department of Planning.

BASIX has and will continue to deliver net benefits of between $294 million and $1.1 billion since 2005 (to 2050) to New South Wales

The net benefits (ie, total benefits less the cost of compliance) of BASIX are estimated to lie within a range of $255 million to $1.1 billion in net present value terms since its inception in July 2004 until 2050. Of these net benefits, approximately 46 per cent arise from dwellings that have complied with BASIX between inception and 2009, with the remainder attributed to anticipated future dwelling compliance. The range represents uncertainty surrounding the likely energy saving benefits that can be attributed to BASIX due to the lack of detailed data on changing end-use patterns and baseline household energy consumption over time (eg, the increased penetration of portable appliances such as personal computers or plasma televisions).

The lower bound therefore represents our estimate of the most likely ***minimum*** benefits from BASIX, due to the substitution of electric hot water systems with lower emission gas hot water systems. The BASIX certificate database confirms that a majority of dwellings now install a gas hot water system to comply with BASIX.[3]

The upper bound assumes that emission reductions of between 24 and 51 per cent per dwelling were achieved, in line with the estimates generated by the BASIX online tool for the actions undertaken to comply with BASIX. Unfortunately within the time available for this study as well as the lack of appropriate data and existing research, we have been unable to verify whether the savings that are assumed for a development by the BASIX tool for each compliance action remain valid.

That said we believe that the estimated lower bound of energy benefits is likely to be a reasonable and conservative estimate of the energy benefits (for the cost of a typical lower bound BASIX compliance path) that have occurred as a consequence of BASIX. Therefore, we are confident that overall the net benefits of the scheme lie within the estimated range, and are positive for New South Wales as a whole.

The cost of complying with BASIX ranges from between $1,114 and $21,902 per dwelling

To estimate the cost of complying with BASIX, BMT Quantity Surveyors undertook an elemental cost study for each of the identified case studies, and also estimated the cost of a business as usual case in the absence of BASIX for comparative purposes.

The results indicate that the cost of complying with BASIX ranges from between $1,114 and $21,902 per dwelling.[4] The higher cost of compliance reflects more expensive fittings and systems being required in order for the dwelling to comply with BASIX. For example, the large house case study required the installation of photovoltaic cells as an alternative energy

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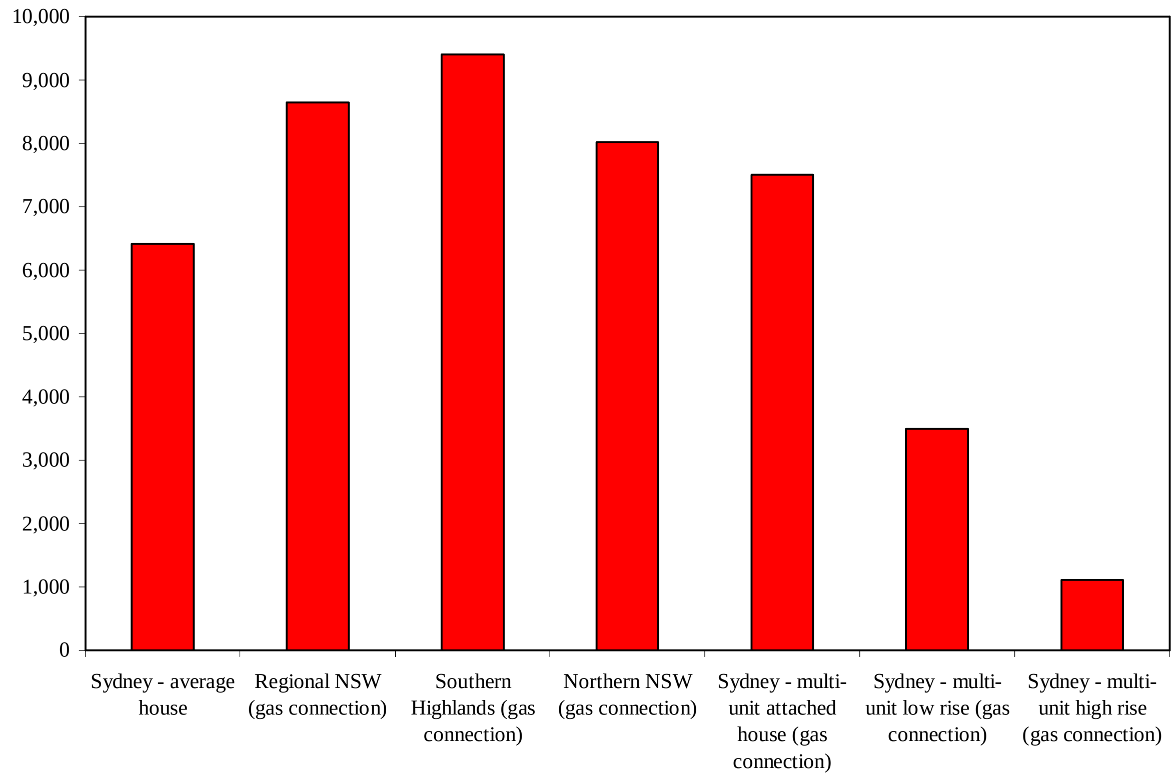
[3] 70 per cent of existing NSW dwellings preceding the introduction of BASIX used high-emission electric resistance or storage hot-water systems (Source: Commonwealth of Australia, *Energy Use in the Australian Residential Sector 1986-2020*, 2008).

[4] The estimated cost of compliance ranged from between $1,390 and $9,080 per unit (2005$) in the earlier studies for multi dwellings. This was to meet a 25 per cent reduction target (as opposed to a 40 per cent reduction which we are costing) (CIE, Benefits and costs of BASIX for multi dwellings, September 2005, p.28).

supply to meet the target in energy reductions (which is relatively costly when compared to energy saving actions of smaller dwellings). In contrast, the lower cost of compliance for unit dwellings reflects the advantages from greater economies of scale that allow costs of some compliance features, such as communal rainwater tanks, to be spread across a number of units in multi dwelling projects. The per dwelling cost of compliance was generally higher for single dwelling detached houses as compared to units in multi dwelling projects, reflecting mainly the higher cost of rainwater tanks per single dwelling to satisfy the potable water use reduction targets as compared to multi dwellings. Figure E.1 presents the cost of compliance per dwelling for each of the primary case studies investigated.

Figure E.1 Costs of compliance per dwelling ($)



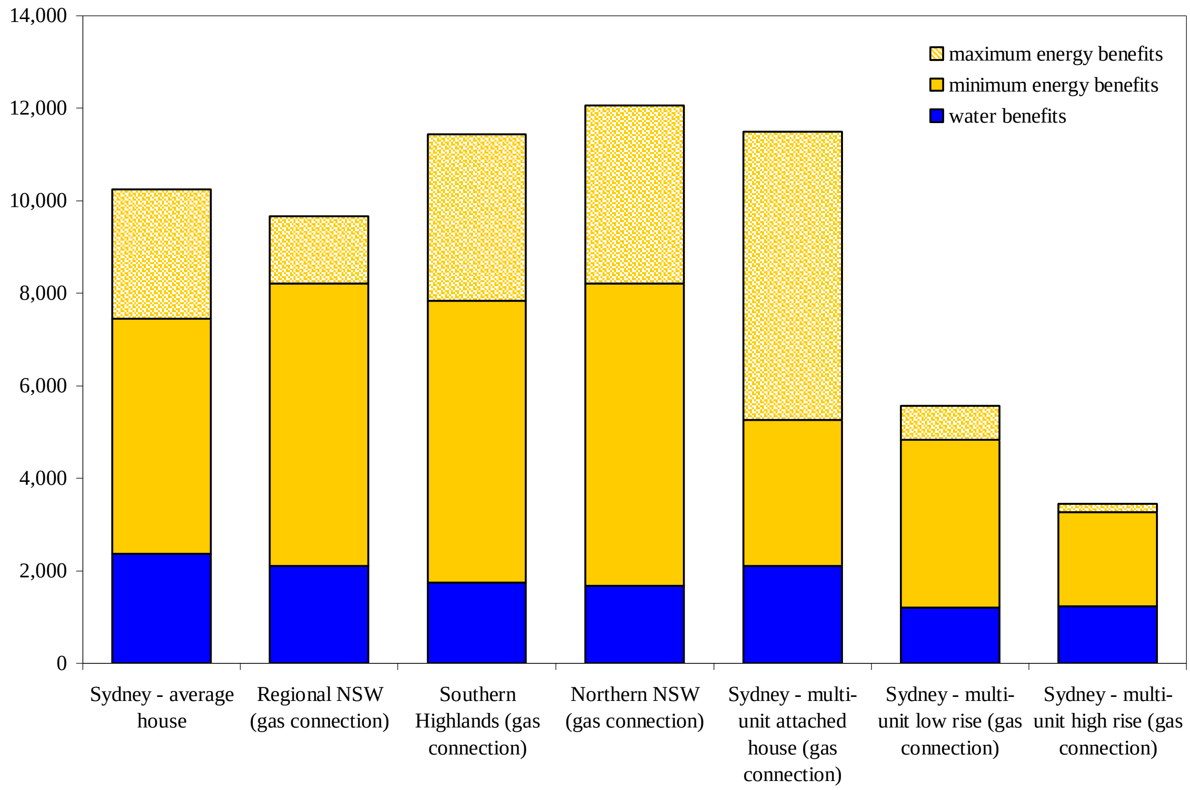
The estimates of the cost of compliance highlight the relatively higher cost of compliance in areas outside of Sydney – Regional NSW (approximately 35 per cent higher than an average house in Sydney), Southern Highlands (47 per cent) and Northern NSW (25 per cent higher). This reflects regional cost differences on the price of BASIX compliance actions, related to higher installation costs (both for materials and labour), as well as higher compliance costs associated with the different climatic zones in these areas. The lack of access to reticulated gas more generally means that the cost of compliance is higher because of the need to substitute a gas hot water system for a more expensive solar or heat pump hot water system in order to comply with the BASIX requirements.

Finally, the total cost of compliance with BASIX between July 2004 and June 2009 for dwellings certified to date is estimated to have been approximately $707 million. The anticipated future BASIX compliance costs for the period 2010 to 2050 are expected to be $1,215 million in net present value terms.

The majority of benefits of BASIX accrue to households

The principal benefits of BASIX are lower water and energy bills to households as a consequence of lower water and energy emissions compared to the absence of BASIX. In total the benefits are estimated to range between $3,273 and $14,661 per dwelling in net present value terms over the period to 2050 – Figure E.2.

Figure E.2 Benefit per dwelling NPV ($)



The total benefits of BASIX have been estimated to be between $2.2 and $3.1 billion in net present value terms since inception in July 2004 to 2050. The benefits for those dwellings who have already complied with BASIX are estimated to be between $843 million and $1.2 billion.

The largest benefit is the energy bill savings (approximately 69 per cent of total benefits), followed by water bill savings (22 per cent), environmental benefits (5 per cent) and avoided network augmentation (4 per cent). The direct household benefits therefore account for approximately four fifths of total benefits.

Finally, our results highlight that a high proportion of the water and energy benefits of BASIX are as a consequence of the use of an alternative water supply, such as rainwater tanks to substitute for the use of potable water, and the switching from electric hot water systems to a gas, solar or heat pump hot water system. The majority of BASIX certificates issued to date have included both of these actions to comply with the BASIX requirements. In particular, less than 0.1 per cent of all single and multi dwelling BASIX certificates selected a high emission electric resistance or storage hot water system.

The reductions in water and energy use as a consequence of BASIX have been significant across New South Wales

Our results demonstrate that the cost for reducing a tonne of carbon emissions through the BASIX scheme is $0, because in practice the household is generally better off through lower energy bills that more than offset the costs involved. The BASIX scheme ensures that these net beneficial energy saving actions are undertaken despite the incentive of developers to not undertake these actions because the benefits (through lower bills) are received by the household resident, while the higher costs are borne by the developer. Overall, we estimate that BASIX has reduced carbon emissions so far by an equivalent of driving 21,000 times from Sydney to Perth.

In terms of water reductions, we estimate that so far approximately 12,800 Olympic sized swimming pools of water have been saved as a consequence of the BASIX scheme. The average cost for each kilolitre of water saved (through BASIX compliance and administrative costs less water bill savings) has been approximately $2.09.

The BASIX scheme promotes innovation in the design of water and energy efficient technologies and practices

A key strength of the BASIX scheme is that it provides flexibility to developers and builders about the actions that are undertaken to comply with the energy and water use reduction benchmarks. Over time this results in the least cost combination of energy and water use efficient technologies and practices to achieve the benchmark targets being revealed. Importantly, and in contrast to alternate regulatory approaches (eg, banning the installation of electric hot water systems) it does not require governments to second guess what might be the most cost effective approach to achieving desired savings in water and energy use.

A consequence of the BASIX market-based approach is that to be most effective it requires continuous updating of the online tool to ensure that new and innovative energy and water use technologies are taken into account, and as new information on the effectiveness of existing measures becomes available. Indeed the scope for the tool to be updated in response to market changes is an additional strength of the BASIX approach.

There is a need to obtain an improved understanding of the impact of BASIX on energy use

Overall the results highlight that BASIX is achieving water and energy savings as compared to a counterfactual case in the absence of BASIX and that these benefits in aggregate are likely to outweigh the cost of complying with BASIX requirements, even when conservative assumptions are made about the likely energy savings that have been achieved as a consequence of BASIX. That said there remain considerable uncertainties about the energy benefits that have in practice been achieved.

It has been apparent in this study that the reason for these uncertainties is the difficulty of disentangling observed increases in energy use per capita in new dwellings that are a consequence of a large number of non-BASIX related factors (ie, increased quantity and size of household appliances eg, televisions), from the changes in energy use as a direct consequence of BASIX. In essence while we believe that energy consumption for these dwellings would have been even higher in the absence of BASIX, there is currently no strong reliable empirical evidence upon which this statement can be verified.

The results in this report therefore must be qualified by these uncertainties. We therefore believe that there is merit in undertaking a study of energy end-use demand for BASIX compliant dwellings to examine how BASIX is contributing to energy use change over time.[5] Such information could then be used to refine the online BASIX tool to ensure that BASIX continues to deliver the desired reductions in energy use for dwellings over time.

5 We note that Sydney Water has undertaken a water end-use study.

1. Introduction

NERA Economic Consulting (NERA) has been asked by the New South Wales Department of Planning (the Department) to undertake an economic evaluation of the performance of the State Environmental Planning Policy - Building Sustainability Index (BASIX), which was introduced in 2004. We understand that this economic evaluation will form the basis for an Independent Pricing and Regulatory Tribunal (IPART) review of BASIX five years after its implementation.

BASIX was introduced to provide incentives for improvements in water and energy efficiency as part of residential building construction and design, within a framework that provided flexibility on the specific mechanisms used to achieve the desired energy and water efficiency outcomes. This economic evaluation study provides the opportunity to assess the effectiveness of BASIX, by reviewing what BASIX has delivered in terms of changes in water and energy efficiency performance since its inception, and assessing the associated costs and benefits that have resulted.

It is important to recognise the role that BASIX has in addressing market failures and so ensuring 'optimal' investment in water and energy efficiency occurs. Candidate market failures that may act as barriers to water and energy efficiency — and that are often cited as justifications for government policy intervention to promote water and energy conservation — include the following:

- water and energy prices not including the cost of environmental and other externalities;
- a lack of information to allow consumers to make water or energy use decisions based on a proper understanding of the water or energy costs;
- a lack of access to finance to fund economic energy or water efficiency investments; and
- incentives for energy efficiency investments being split between parties, eg, landlords and tenants or mass market home builders and purchasers.

While introducing a Carbon Pollution Reduction Scheme (CPRS)[6] will provide a carbon emission price signal through energy prices it does not provide incentives to address environmental concerns arising from excessive water use or the split incentives problem, which can result in less than optimal investment in water and energy efficiency. This means that BASIX will likely continue to play an important role in the policy mix for Australia to address climate change in the future.

This study has involved two principal tasks, namely:

- an assessment of the direct costs and benefits of BASIX to households, by investigating a number of case studies drawing upon the most common compliance pathways observed to date; and
- an assessment of the state-wide costs and benefits of BASIX, focusing on the additional benefits from greenhouse gas emission reductions.

[6] There are considerable uncertainties about the timing for the introduction of the planned CPRS.

The remainder of this report is structured as follows:

- Chapter 2 describes the State Environmental Planning Policy - Building Sustainability Index (BASIX), and sets out the economic rationale underpinning BASIX;
- Chapter 3 sets out the methodology and approach used in the study including the scope of the analysis, a description of the case studies and key assumptions;
- Chapter 4 presents the results for households, including the implications for reductions in water and energy use on household bills and the costs of complying with BASIX requirements; and
- Chapter 5 presents the total benefits across New South Wales (NSW) of BASIX to date and the anticipated benefits in the future.

In addition, Appendix A sets out the key modelling assumptions, Appendix B sets out our approach to modelling the greenhouse gas emission reduction benefits resulting from BASIX, Appendix C provides the results of the sensitivity analysis and Appendix D presents the compliance pathways for each of the case studies.

2. Background and context

BASIX was introduced into New South Wales (NSW) amid concerns about growing water and energy demands for households resulting from continued growth of the population, as well as the level of fragmentation and duplication of council's sustainability policies. BASIX is seen as a way of providing direct incentives to developers of housing stock to invest in cost effective measures to lower household water and energy needs, as well as increasing information and awareness about water and energy efficiency.

This chapter briefly describes BASIX and its historical development before outlining the economic rationale for its introduction.

2.1. What is BASIX?

BASIX is a mandatory component of the development approval process for residential developments in NSW and is implemented through the *Environmental Planning and Assessment Amendment (Building Sustainability Index: BASIX) Regulation 2004* (and subsequent amendments); and the *State Environmental Planning Policy – Building Sustainability Index (BASIX) 2004* (and subsequent amendment). As a regulatory scheme this enables it to override any competing environmental provisions and development control plans, which ensures that BASIX is the only system of assessment in relation to certain aspects of sustainable residential design in NSW.

The *State Environmental Planning Policy - Building Sustainability Index (BASIX)* is a planning policy of the NSW Government and was introduced on 1 July 2004, with the aim of increasing the efficiency of both water and energy consumption. It takes the form of an online program to assess a new house or unit design and compares its performance against a number of sustainability targets. The sustainability targets are the reduction of potable water and greenhouse gas emissions (ie, energy consumption) by a stated percentage below NSW average benchmarks, as well as a requirement to meet minimum performance levels for thermal comfort.[7] The design of the house or unit must meet these targets before a BASIX Certificate can be obtained.[8]

In addition, major alterations and additions, including significant pool works are also required to satisfy BASIX requirements. The benefits and csots from this part of the BASIX scheme has not been considered as part of this study.

The objective of the BASIX policy is to ensure that:[9]

> "[A]pplications to carry out certain kinds of residential development will have to be accompanied by a list of commitments by the applicant as to the sustainability measures to be taken in relation to the development (that is, measures to improve the capacity of the development to reduce consumption of mains-supplied potable water, to reduce emissions of greenhouse gases and to perform in a thermally efficient manner)."

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7 Thermal comfort measures the ability to heat and cool the dwelling.

8 NSW Government Department of Planning (2006), *BASIX fact sheet.*

9 *Environmental Planning and Assessment Amendment (Building Sustainability Index: BASIX) Regulation* 2004 under the *Environmental Planning and Assessment Act* 1979, p1.

To obtain a BASIX Certificate, the online program assesses the anticipated water consumption and greenhouse gas emission levels and the expected thermal performance of the proposed development, based on data provided by the applicant. The assessments are made using comprehensive data sets relating to resource demand, occupation levels and market penetration rates of technologies provided by utility organisations, state agencies and the Australian Bureau of Statistics.[10] These benchmarks and targets are outlined in more detail below.

The BASIX certificate outlines the sustainability commitments that an applicant agrees to as part of the development.[11] Applicants then submit their development or complying development application to Council with the BASIX certificate attached. The Council assesses the application making sure that the building plans comply with the certificate. If approved, the development must be built in accordance with the BASIX commitments. BASIX certificates are also attached to the applications for construction and occupation certificates. Certificates will only be issued when the Certifying Authority is satisfied that the project has been built as described. Lastly, a completion receipt will be issued once the occupation certificate has been issued.

Since its inception in July 2004, the application of BASIX has been sequentially expanded. For example, initially only new single dwellings and dual occupancies, as well as guest accommodation under $300m^2$ in Sydney metropolitan local government areas were required to comply with BASIX, whereas now the scheme applies to any new residential construction in NSW as well as alterations and additions over a certain value.[12] A brief timeline of the development of BASIX since its inception is provided in Table 2.1.

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10 NSW Government Department of Planning BASIX website, available at www.basix.nsw.gov.au.

11 NSW Government Department of Planning (2006), *The development approval process.*

12 BASIX initially applied to all Sydney metropolitan local government areas except Blue Mountains, Hawkesbury and Wollondilly.

Table 2.1 Historical Development of BASIX

Date	Development of BASIX
1 July 2004	BASIX was introduced to new single dwellings and dual occupancy, as well as new boarding houses, guest houses, hotels, lodging-houses and backpacker accommodation under 300m^2 in the majority of Sydney's local government areas. This required compliance water savings of 40 per cent, and 25 per cent for energy.
1 July 2005	BASIX is extended to include all single detached dwellings throughout the rest of NSW.
1 October 2005	BASIX is extended to include all new residential dwellings, including single dwellings, villas, townhouses and low-rise, mid-rise and high-rise developments in NSW.
1 July 2006	The BASIX energy target is increased from a 25 per cent to a 40 per cent reduction in greenhouse gas emissions.
1 October 2006	BASIX is extended to include alterations and additions if: § the residential renovation work is estimated at $100,000 or more; or § a swimming pool (or pool and spa) is to be installed with a capacity of 40,000 litres or more.
1 July 2007	The residential renovation work threshold is reduced to $50,000 (with the same threshold applying to development proposals for a swimming pool ie, capacity of 40,000 litres or more).

2.1.1. BASIX benchmarks and targets

For new dwellings, compliance with BASIX requires undertaking water and energy saving actions that are assumed in aggregate to achieve water and energy reduction targets, and meeting minimum performance standards for thermal comfort. These compliance requirements are outlined in more detail below.

2.1.1.1. BASIX compliance for new dwellings

Water and energy reduction targets

The likely water and energy use performance of new dwellings is modelled and compared against water and energy reduction targets. These targets are based on consumption being reduced to below an average NSW benchmark measure for the residential sector on a per capita basis. The benchmark measures were originally determined using data collected by the NSW Department of Energy, Utilities and Sustainability (DEUS) from state-wide water and energy utilities in 2002 and 2003. These per capita benchmarks are multiplied by Australian Bureau of Statistics (ABS) average occupancy rates for dwelling size and location to obtain the benchmarks for a proposed dwelling. Applications for compliance with BASIX are scored using these targets, according to their potential to consume less potable water and energy than an average existing dwelling.[13]

The benchmark for water use is the average pre-BASIX NSW annual potable water consumption from the residential sector on a per capita basis, which is 247.5 litres of water

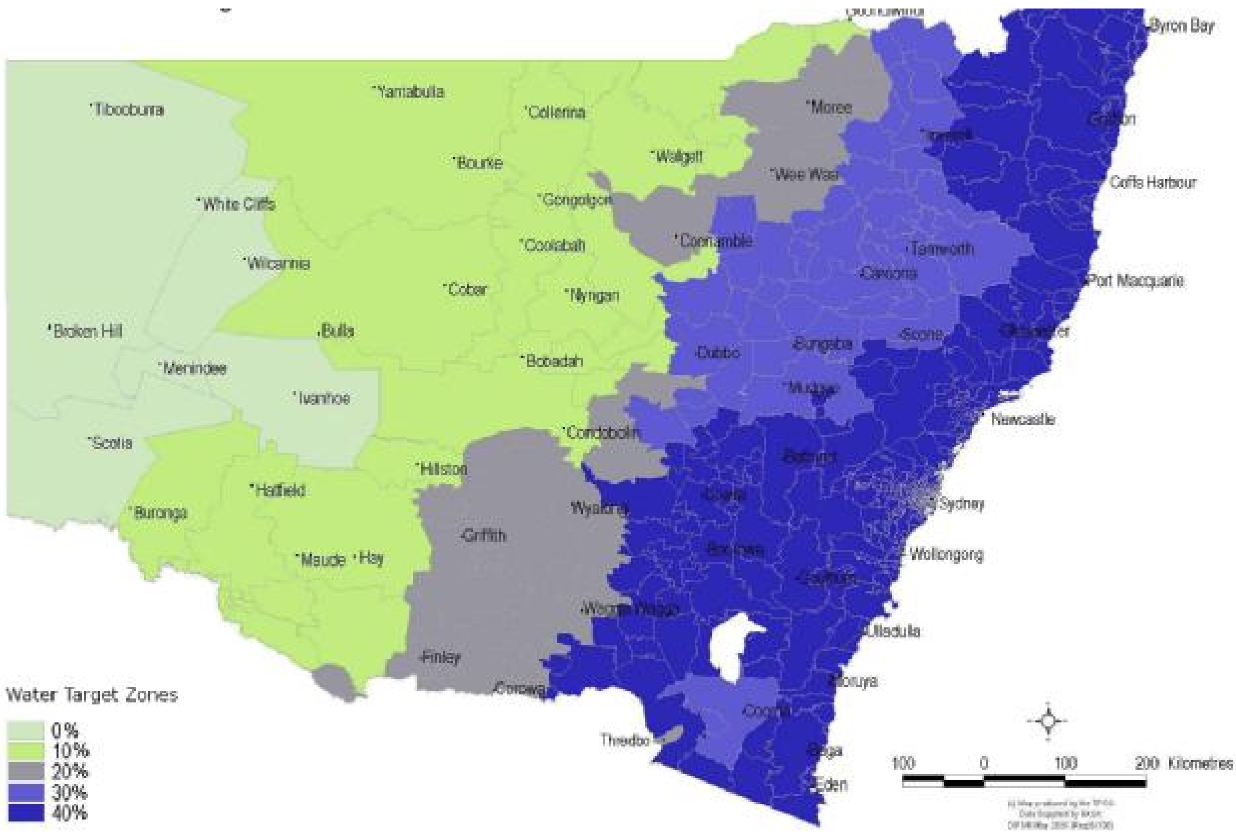
[13] NSW Government Department of Planning BASIX website, available at www.basix.nsw.gov.au.

per person per day (90,340 litres of water per person per year).[14] The BASIX water target is a reduction of between 0 to 40 per cent from the benchmark depending on the location of the dwelling within NSW.[15] As shown in Figure 2.1, the BASIX water target is higher in areas of greater rainfall, such as those closer to the coast. The majority (90 per cent) of new dwellings are required to comply with a 40 per cent reduction.[16]

Common examples of sustainability commitments made to comply with the BASIX water target include the:

- selection of water efficiency labelling scheme (WELS)-star-rated showerheads, taps and dual flush toilets;
- installation and connection of a rainwater tank for water use; and
- use of indigenous or low water use species plants in the garden.

Figure 2.1 BASIX water targets across NSW[17]



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[14] NSW Government Department of Planning (2006), *Benchmarking BASIX.*

[15] NSW Government Department of Planning (2006), *About the BASIX indices.*

[16] Ibid.

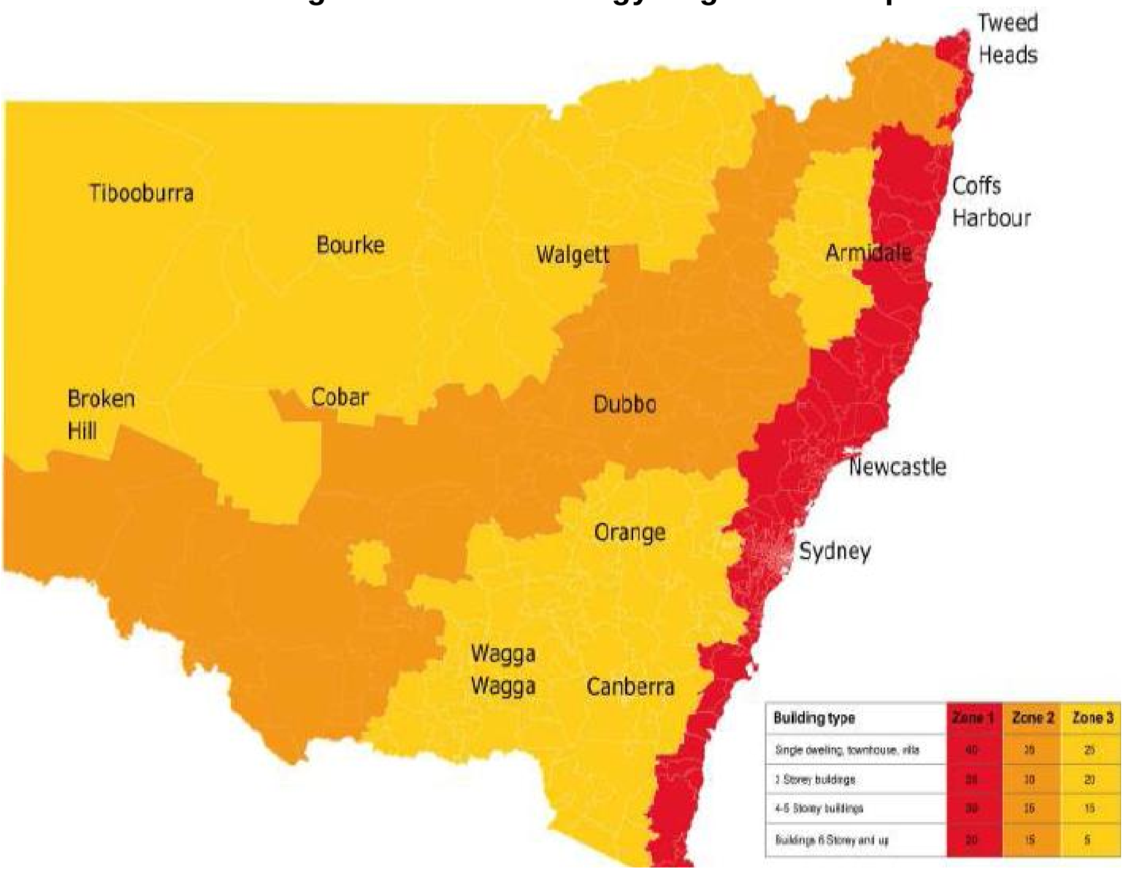
[17] Source: NSW Government Department of Planning website, available at www.basix.nsw.gov.au.

The energy use benchmark is the pre-BASIX NSW average annual greenhouse gas emissions from the residential sector on a per capita basis, equating to 3,292 kg of CO_2-e per person per annum.[18] The energy reduction target is a reduction of between 5 to 40 per cent from the energy benchmark, varying depending on the building type and location. As shown in Figure 2.2, the energy target is typically lower for dwellings located further from the coast, with more extreme climate conditions. Like the water target, the majority (80 per cent) of new dwellings are required to meet a 40 per cent energy target reduction.[19]

Common examples of sustainability commitments made to comply with the BASIX energy target include:

- the installation of energy efficient lights and maximising the availability of natural light;
- the installation of a high-efficiency hot water system in lieu of electric resistance heaters; and
- making use of both indoor and outdoor clothes drying lines.

Figure 2.2 BASIX energy target zone map[20]



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[18] NSW Government Department of Planning (2006), Benchmarking *BASIX.*

[19] NSW Government Department of Planning (2006), About *the BASIX indices.*

[20] Source: NSW Government Department of Planning website, available at www.basix.nsw.gov.au.

Thermal comfort

The thermal comfort measure evaluates how efficiently the dwelling will stay warm in winter, and cool in summer. Unlike the water and energy targets, compliance with the thermal comfort requirements is on a pass or fail basis. It stipulates minimum performance levels for the thermal comfort of the dwelling, expressed as energy (MJ/m^2) required to heat and cool the dwelling.[21] This section of the online program can be completed either by the applicant (this is a free method designed to be completed by experienced designers) or by simulation (this method requires payment to an accredited assessor who will complete the section using accredited thermal comfort software).[22]

The aim of the thermal comfort measure is to:[23]

- ensure thermal comfort for a dwelling's occupants appropriate to the climate and seasonal variation;
- provide the potential to reduce greenhouse gas emissions from artificial cooling and heating through good building design and use of appropriate construction materials; and
- reduce the demand for new, or upgraded, energy infrastructure by assisting with peak demand management for energy required for cooling and heating.

2.1.1.2. BASIX compliance for alterations and additions

From 1 October 2006 alterations and additions to dwellings were obliged to comply with the BASIX requirements, if the cost of the project exceeded a monetary threshold. Initially the threshold was set at $100,000. From 1 July 2007, this threshold was lowered to $50,000.[24] In addition, the installation of large swimming pools (capacity exceeding 40,000 litres) is also required to comply with BASIX.

Compliance with BASIX for alterations and additions differs from compliance with BASIX for the construction of new dwellings. There are no set reduction targets for energy and water under BASIX for alterations and additions. Instead, simple requirements, sensitive to the location's climate, are set based on the proposed alteration or addition. These requirements are flexible and only apply to the section of the house that is being renovated.

2.2. The economic rationale for BASIX

BASIX is designed to correct for the potential failure of the market to deliver socially optimal investment in energy and water efficiency, at the time that a residential dwelling is constructed. The market failure arises because:

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[21] Single Dwelling Outcomes 05-08 BASIX Ongoing Monitoring Program.

[22] NSW Government Department of Planning (2006), *About the BASIX indices.*

[23] NSW Government Department of Planning BASIX website, available at www.basix.nsw.gov.au.

[24] NSW Government Department of Planning (2006) *Alterations and Additions Fact Sheet.*

- often the party responsible for the design and construction of a dwelling differs from the ultimate dwelling resident and so sub-optimal tradeoffs between upfront capital costs and ongoing operating costs are made – the so-called “split incentives” problem;
- there is a lack of information about the opportunities for cost effective investment in water and energy efficiency measures as part of the construction of a dwelling;
- water and energy prices do not (currently) adequately include the cost of environmental (and other) external impacts; and
- of a lack of access to finance to fund cost effective energy or water efficiency investments.

While the introduction of an emissions trading scheme like the CPRS would go some way towards providing a carbon emission price signal through energy prices it will not address suboptimal investment in water and energy efficiency arising from the other market failures. BASIX is designed to address failures in the market for energy and water efficiency investments at the time of construction of a dwelling or alteration or addition to an existing dwelling.

BASIX is a market-based approach that provides flexibility to developers and builders about the actions that are undertaken to comply with the energy and water use reduction targets. It is designed to effectively drive market change in sustainable household design and create incentives for innovation in the design of more energy and water efficient systems. Further, and in contrast to regulatory approaches (eg, banning the installation of electric hot water systems) it does not require governments to second guess what might be the most cost effective approach to achieving desired savings in water and energy use.

3. Methodology and Approach

The economic evaluation undertaken in this study has been conducted in line with the NSW Treasury Guidelines for cost benefit analysis.[25] This chapter sets out the scope of the analysis, the case studies investigated and the key assumptions made amongst other methodological matters.

3.1. Scope of the analysis

The economic evaluation of BASIX has been broken into two principal parts, namely:

- an assessment of the direct costs and benefits to households of compliance with BASIX; and
- an assessment of the state-wide costs and benefits.

The assessment of the direct costs and benefits of households has been undertaken with reference to a number of dwelling case studies, representing the most common BASIX compliance pathways for single and multi dwellings in a number of locations throughout the state.[26]

The direct costs and benefits of BASIX compliance considered as part of this study are those incurred by occupants and developers of BASIX compliant houses. The benefit to occupants of BASIX compliant houses is estimated as the savings on utility bills that BASIX is likely to generate. Estimating these direct benefits has involved:

- identifying the water and energy efficiency measures that are typically undertaken as part of BASIX compliance, for each case study;
- estimating the water and energy savings generated from each of these compliance ‘pathways’ (ie, a BASIX compliance case) relative to the business as usual (BAU) case (ie, in the absence of BASIX); and
- quantifying these savings by applying the applicable water, gas and electricity prices to the geographic region in which each case study is being considered.

The estimated utility bill saving benefits for each case study has then been compared to the cost of compliance (relative to the BAU case), as estimated by BMT Quantity Surveyors (BMT).

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[25] NSW Treasury, (2007), NSW Government Guidelines for Economic Appraisal, Office of Financial Management, pp 07-5, July.

[26] BASIX defines a single dwelling as a development project of no more than one detached house, attached house or unit dwelling. A multi dwelling is an individual dwelling within a residential development project consisting of more than one individual dwelling. Developments assessed by BASIX include projects for single and multiple detached houses, attached houses, units, or any combination of the above. A detached dwelling is a dwelling that is separated from all other dwellings and buildings (excluding a garage or car park) by at least 0.5m. An attached dwelling house is defined as a dwelling that is attached to, or less than 0.5m from, any other dwelling or building (excluding a garage or car park), but which does not have another dwelling or building (excluding a garage or car park) above or below it, such as a semi-detached house, terrace house, row house or townhouse. A unit is defined as a dwelling that has one or more dwellings or buildings (excluding a garage or car park) above or below it, such as a flat, unit or apartment with a unit building containing one or more units.

The assessment of state-wide benefits has been approximated by scaling up the case study results across the entire state, using information on the number of BASIX certificates that have been generated, and expectations about the number of new (and existing) dwellings that will be built over the study period to 2050.

In addition to the direct benefits, we have also estimated the benefits associated with environmental improvements and the avoidance of energy network business costs, as a consequence of reduced and energy use.

Appendix A describes in greater detail the approach that has been used to model the benefits and costs considered in the study.

3.2. Case studies

To estimate the direct costs and benefits of BASIX to households, a number of case studies were developed to represent the most common pathways for compliance with BASIX for single dwellings, multi dwellings and different geographic locations throughout the state.

Data on the actual choices made as part of BASIX compliance were used to develop representative ‘pathways’ of BASIX compliance for each case study. These pathways have been based on the typical choices of water and energy efficiency measures selected by developers as part of BASIX compliance. It is the selections made as part of these pathways that have been used to model the costs and benefits of BASIX compliance for each case study.

Each of the case studies that were developed for consideration is described in greater detail below. The compliance pathways are presented in Appendix D.

3.2.1. Single dwelling case studies

The-starting point for the analysis was a consideration of four case studies of single dwellings located in a number of geographic locations of the state, namely: Sydney; regional New South Wales; the Southern Highlands; and northern New South Wales. The principal characteristics of the single dwelling case studies are outlined in Table 3.1.

Table 3.1 Single dwelling case study characteristics[27]

Case study	Representative Region	Representative Council	Primary case study	Alternative case study
1	Sydney Metropolitan	Blacktown City Council	Average house with electricity and gas access	Affordable house with electricity and gas access
		Baulkham Hills Shire (Rouse Hill)	Large house with electricity and gas access	Large house with electricity access only
2	Regional NSW	Wagga Wagga	Electricity & gas access	Electricity access only
3	Southern Highlands	Wingecarribee Shire Council (Moss Vale)	Electricity & gas access	Electricity access only
4	Northern NSW	Tweed Shire Council	Electricity access only	Electricity & gas access

To consider whether large and affordable houses have greater or less opportunities relative to average sized houses when seeking compliance with BASIX, we have examined alternatives to the primary case study for the Sydney metropolitan area.

To examine the differences in compliance pathways between those premises with access to gas and those without access, for all case studies (apart from the average and affordable house) alternative pathways have been considered that take into account where gas may not be available. These alternatives identify the typical selections in case study locations where new dwellings may need to comply with BASIX without access to a reticulated gas supply (Wagga Wagga, Wingecarribee and Tweed Shire).

Case study 4 is the reverse in that the primary analysis assumes that the new dwelling does not have a gas connection, but that it does in the alternative. This reflects the actual BASIX compliance data where the greatest number of dwellings complying with BASIX in the case study region did not select any gas related compliance.[28]

3.2.2. Multi dwelling case studies

In addition to the single dwelling case studies, we also examined the costs and benefits of BASIX for three multi dwelling case studies all located within Sydney, namely: a row of five attached houses; an eight dwelling low-rise unit block; and a 42 dwelling high-rise unit block. These types of multi dwellings did not commonly feature in the regional distribution of BASIX certificates. The principal characteristics of these case studies are set out in Table 3.2.

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27 These case study characteristics have been developed through data obtained from the Department of Planning.

28 59 per cent of BASIX single dwelling projects in the Northern NSW region (Northern Rivers, North Coast and Mid-North Coast BASIX regions) did not include gas as a fuel source in their BASIX compliance commitments (Source: Department of Planning).

Table 3.2 Multi dwelling case study characteristics

Case study	Type of dwelling	Region	Representative Council	Primary case study	Alternative case study
5	5 attached houses	Sydney Outer Suburbs	Bankstown City Council	Electricity & gas access	Electricity access only
6	Low-rise unit block – 3 stories, 8 dwellings	Sydney Inner Suburbs	Randwick City Council	Electricity & gas access	Electricity access only
7	High-rise unit block – 8 stories, 42 dwellings	Sydney Inner Suburbs	Sydney City Council	Electricity & gas access	Electricity access only

As with the single dwelling case studies, we have also considered alternative pathways for each case study, reflecting the availability of gas as a substitute for electricity use, particularly in relation to hot water heating.

3.3. The 'business as usual' case

To assess the economic benefits and costs of BASIX it is necessary to consider what would have occurred to water and energy use in new developments (and existing developments) in the absence of the introduction of BASIX. This with/without analysis is the basis of all cost benefit analyses and differs from a comparison of the water and energy savings to the BASIX benchmarks. This is because the BASIX benchmarks reflect typical water and energy use at a point in time, namely when BASIX commenced.

It is therefore relevant to consider what water and energy use savings would have been undertaken irrespective of the introduction of BASIX. This question is difficult because it cannot be directly observable, but in general it is likely that a combination of improved technology, other programmes designed to improve energy and water efficiency and increasing awareness amongst households about the importance of improving water and energy efficiency have also led to improvements in housing sustainability performance. While our preference would be to consider other jurisdictions consumption, rather than the past historical uptake evidence in NSW, as a business as usual case our research has suggested that due to the vast variety and type of water and energy efficiency measures existing in different states in Australia this approach is not appropriate.

Therefore, our approach to defining this 'business as usual' (BAU) case has been to investigate the rate of change in household energy and water that would be expected in the absence of all sustainability improvements covered by BASIX, including complementary regulations introduced after BASIX using historical uptake evidence in NSW as a basis. Based on estimates by the Australian Bureau of Agricultural and Resource Economics (ABARE), we have assumed that the average rate of change in future electricity and gas consumption is equal to 0.51% and 0.34% respectively. We have further assumed that future water consumption is constant and equal to an average of previous years, to account for the effect of factors such as droughts and water restrictions. These assumptions are set out in further detail in Appendix A.

3.4. Key modelling assumptions

There are a number of modelling assumptions that we have made as part of this analysis. A summary of the most important assumptions is presented below. Detailed modelling assumptions and data are set out in Appendix A.

3.4.1. Time period for the analysis

The study has involved considering the costs and benefits of BASIX since its inception until 2050. We note that all years referred to are fiscal years eg, 2005 refers to 1 July 2004 to 30 June 2005. A time horizon extending to the year 2050 is considered appropriate as it allows the long-term implications of BASIX over the assumed life-cycle of an average household to be taken into account as part of the analysis.

The dwellings included in the analysis can be broken into two parts, namely:

- dwellings certified by BASIX from its inception in 2004 to 30 June 2009, reflecting life-cycle costs and benefits that have been attributed to BASIX on the basis of actual compliance with the BASIX obligations both historically and ongoing to 2050;[29] and
- new dwellings certified by BASIX, should the program continue from 1 July 2009 until 2050, reflecting the additional life-cycle household benefits and costs of BASIX being applied to new developments in the future.

The analysis calculating the benefits associated with complying for households has been assessed over the period from 2006 ie, since BASIX has been in its current form. In contrast, the benefits for New South Wales associated with BASIX have been calculated since its inception ie, from 2005. This is because when BASIX was first implemented it was only introduced to new single dwellings within Sydney. As a consequence, this can be adjusted for in the state-wide analysis, but not within the individual household analysis.

3.4.2. Discount rate

All of the results in this study have been calculated in net present value terms, reflecting the incurrence of costs mostly at the time of construction of the dwelling, while the benefits are typically spread across the life of the dwelling. In so doing we have applied a real discount rate of 7 per cent in line with the NSW Treasury guidelines.[30] As outlined in Appendix A, our benefits are estimated in nominal terms and so the 7 per cent discount rate has been converted to a nominal value to ensure consistency. We used observed and expected changes in the consumer price index to adjust the real discount rate to a nominal rate.

To investigate the sensitivity of the results to the choice of the discount rate the results have been recalculated using a real discount rate of 4 and 10 per cent (in accordance with the NSW

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[29] This first period can be split into two further periods. The latter being BASIX in its current form, ie water *and* energy reduction targets of up to 40 per cent across NSW and the former being from inception until BASIX reached its current form.

[30] NSW Treasury, (2007), NSW Government Guidelines for Economic Appraisal, Office of Financial Management, pp 07-5, July.

Government Guidelines for Economic Appraisal). The results of this sensitivity analysis are set out in Appendix C.

4. Implications for households

This chapter presents the results of our analysis investigating the direct costs and benefits of BASIX for households with differing characteristics as represented by the seven case studies (and the alternative cases) that are the focus of the study.

4.1. Costs of complying with BASIX

The starting point for our analysis has been considering the typical costs incurred to comply with the BASIX requirements, for each of the case studies examined. The costs have been estimated by BMT based on the compliance pathways most commonly used as identified from the BASIX data and provided to us by the Department.

4.1.1. Costs for single dwellings

To estimate the cost of complying with BASIX for single dwellings, BMT identified a typical dwelling plan for an average, an affordable and a large house in Sydney, and then examined the difference in costs for these houses relative to the business as usual case house in the absence of BASIX ie, typical costs of complying with BASIX were estimated and then compared to the typical cost of constructing a household without BASIX in place.

Table 4.1 sets out the typical house characteristics for a single dwelling in Sydney. The average new BASIX certified single dwelling in Sydney is a 2 storey, 4 bedroom house.[31] This translates to a site area of 600m^2, with the gross floor area of the dwelling itself being 240m^2.

Table 4.1 Summary indicators of an average single dwelling in Sydney

Indicator	Unit
Site area	600 m^2
Gross floor area	240 m^2
Conditioned floor area	216 m^2
Unconditioned floor area	24 m^2
Roof area	229 m^2
Total area of garden or lawn	205 m^2
Number of storeys	2
Number of bedrooms	4

BMT also outline the typical compliance costs for average houses across regional NSW and in areas of the State with distinct climate characteristics. The typical cost of complying with BASIX for a single dwelling ranges from around $5,000 to over $21,000 per dwelling – Table 4.2 and Figure 4.1.

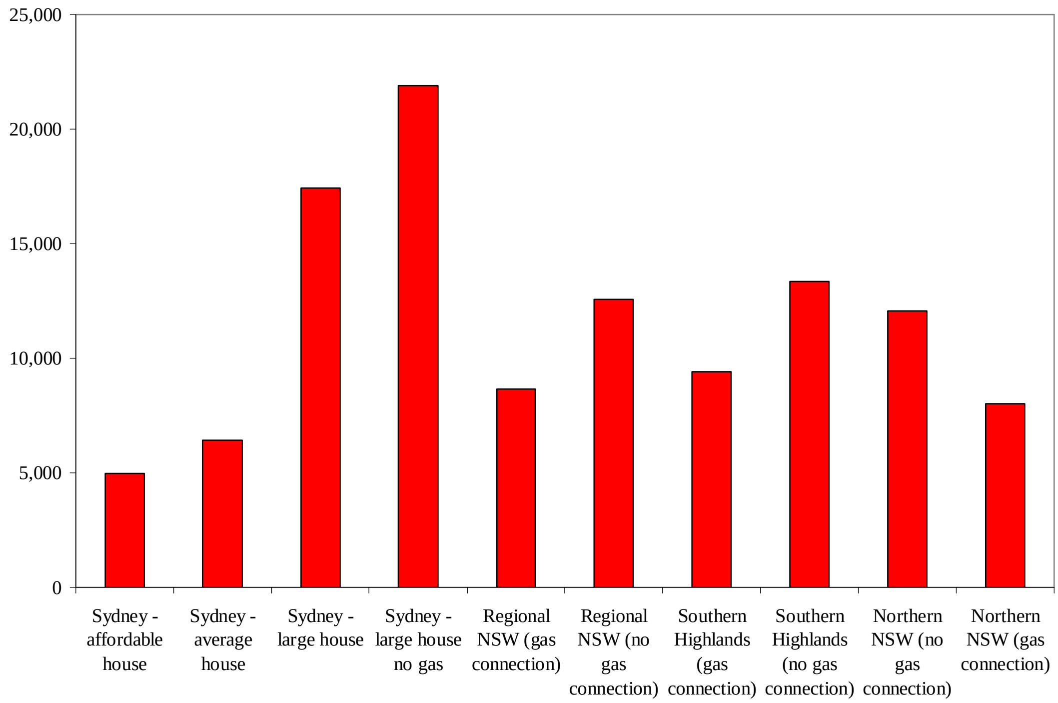
[31] Averages based on data from the Department of Planning.

Table 4.2 Cost of typical compliance with BASIX for single dwellings ($2009)

Case study	Pathway	Total Cost per dwelling ($)
1	- Sydney – average house (gas connection)	6,417
	- Sydney – large house (gas connection)	17,432
	- Sydney – large house (no gas connection)	21,902
	- Sydney – affordable house (gas connection)	4,970
2	- Regional NSW (gas connection)	8,646
	- Regional NSW (no gas connection)	12,563
3	- Southern Highlands (gas connection)	9,403
	- Southern Highlands (no gas connection)	13,345
4	- Northern NSW (no gas connection)	12,064
	- Northern NSW (gas connection)	8,014

Note: These costs include payments made for Renewable Energy Certificates (RECs), where relevant. Further details are provided in Appendix A.

Figure 4.1 Cost of typical compliance with BASIX for single dwellings ($2009)



The estimates demonstrate that the typical cost of complying with BASIX in cases where there is no access to gas is considerable higher. For example, a single dwelling in a regional area would cost 45 per cent (almost 51 per cent in the Southern Highlands) more to comply with BASIX as compared to the same dwelling where gas is accessible. This reflects the generally higher costs of electric appliances where there are no gas alternatives and the relatively higher cost of solar or heat pump hot water systems as compared to gas hot water systems, to achieve the required energy use reductions. This suggests that substituting electricity with gas fuel sources where possible is likely to be the most cost effective approach to meet BASIX energy saving targets.

The typical cost of complying with BASIX for a large house in the Sydney metropolitan area is estimated to be 172 per cent higher than the Sydney average house. This reflects the higher construction costs of the larger house as compared to the average house, needed to comply with BASIX requirements. Other reasons for the higher costs are associated with the larger irrigation area (205m^2 of garden in an average house compared with 443m^2 in a large house) resulting in the need for a larger tank as an alternative irrigation supply to potable water consumption. Also, the larger house size (438m^2 in the large house compared with 240m^2 in the average house) requires greater energy efficiencies to offset the energy required to heat and cool the space ie, to pass the thermal comfort measure. The typical cost of complying with BASIX for an affordable house is smaller than the state-wide average costs of complying with BASIX by approximately 23 per cent, which reflects the lower number of fittings (eg, no heating or cooling system installed), and the fact that the cheapest options for compliance are selected.

4.1.2. Cost for multi dwelling projects

Based on BASIX geographic distribution data, the three multi dwelling case studies are all assumed to be located in the Sydney metropolitan area. As with the single dwellings, BMT have identified a typical multi dwelling design for each of the case studies as the basis for constructing its cost estimates.

Table 4.3 sets out the typical characteristics for each of the multi dwelling project case studies.[32] There are also additional features of BASIX that are available but not costed, as they do not feature in typical compliance pathways eg, co-generation.

[32] Typical multi dwellings have been developed to represent a range of types of multi dwellings present.

Table 4.3 Summary indicators of typical multi dwelling projects

Indicator	Attached houses	Low-rise unit block	High-rise unit block
Site area	1,021 m^2	1,490 m^2	4,587 m^2
Roof area	340 m^2	421 m^2	758 m^2
Number of dwellings	5	8	42
Number of storeys	-	3	8
Residential car spaces	-	8	20
Non-residential car spaces	-	-	10
Gross floor area per dwelling	89m^2 for 2 dwellings 122m^2 for 2 dwellings 155m^2 for 1 dwelling	59m^2 for 2 dwellings 85m^2 for 4 dwellings 123m^2 for 2 dwellings	58m^2 for 12 dwellings 87m^2 for 21 dwellings 122m^2 for 8 dwellings 125m^2 for 1 dwelling
Conditioned floor area per dwelling	82m^2 for 2 dwellings 113m^2 for 2 dwellings 143m^2 for 1 dwelling	55m^2 for 2 dwellings 80m^2 for 4 dwellings 115m^2 for 2 dwellings	57m^2 for 12 dwellings 86m^2 for 21 dwellings 121m^2 for 8 dwellings 123m^2 for 1 dwelling
Unconditioned floor area per dwelling	7m^2 for 2 dwellings 9m^2 for 2 dwellings 12m^2 for 1 dwelling	4m^2 for 2 dwellings 5m^2 for 4 dwellings 8m^2 for 2 dwellings	1 m^2 for 12 dwellings 1 m^2 for 21 dwellings 2 m^2 for 8 dwellings 2 m^2 for 1 dwelling
Area of garden/lawn per dwelling	Individual garden/lawn: 89m^2 No common garden area	Individual garden/lawn: 56m^2 for 2 dwellings Common garden area: 331m^2	Individual garden/lawn: 26m^2 for 2 dwellings Common garden area: 2457m^2
Number of bedrooms per dwelling	2 bedroom for 2 dwellings 3 bedroom for 2 dwellings 4 bedroom for 1 dwelling	1 bedroom for 2 dwellings 2 bedroom for 4 dwellings 3 bedroom for 2 dwellings	1 bedroom for 12 dwellings 2 bedroom for 21 dwellings 3 bedroom for 8 dwellings 4 bedroom for 1 dwelling
Common areas	None	1 Car park 2 Ground floor lobbies 2 Hallways/lobbies	2 Car parks 2 Garbage rooms 2 Ground floor lobbies 4 Hallways/lobbies 2 Lift cars 2 Plant/Service rooms

A typical multi dwelling attached house project is of 5 attached houses, comprising 2 dwellings with 2 bedrooms, 2 dwellings with 3 bedrooms and 1 dwelling with 4 bedrooms. The typical low-rise unit is a 3-storey unit, of 8 dwellings, with 2 dwellings with 1 bedroom, 4 dwellings with 2 bedrooms and 2 dwellings with 3 bedrooms. The typical high-rise unit is an 8-storey building of 42 dwellings, with 12 dwellings with 1 bedroom, 21 dwellings with 2 bedrooms, 8 dwellings with 3 bedrooms and 1 dwelling with 4 bedrooms.

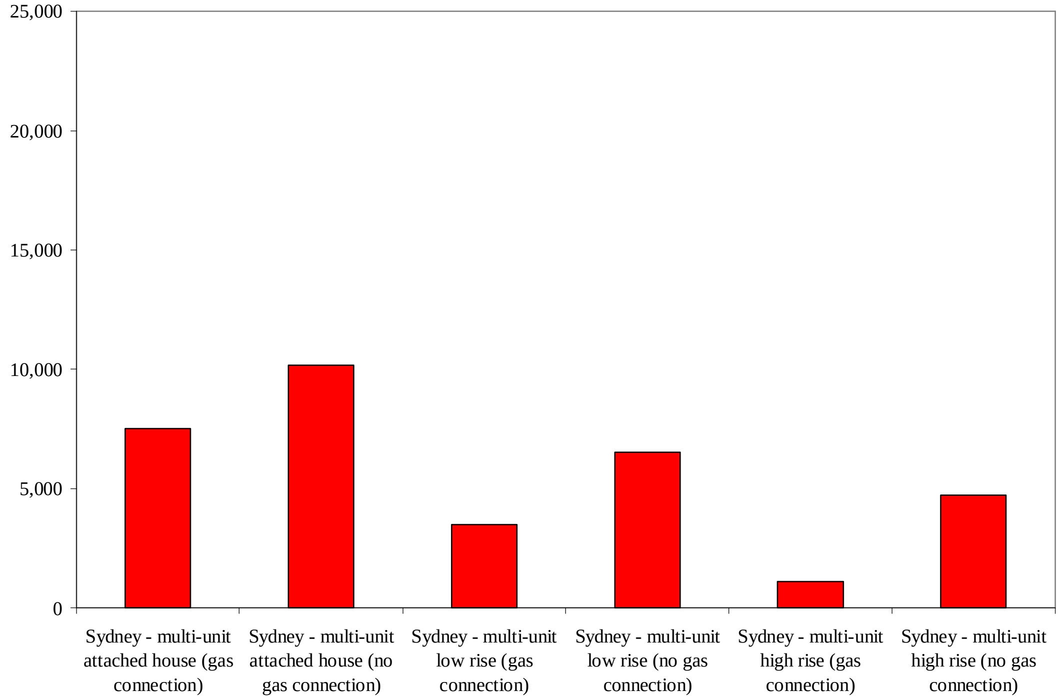
The typical cost of complying with BASIX for multi dwellings is set out in Table 4.4. Note that the typical cost of complying with BASIX is lower per dwelling for multi dwellings compared to single dwellings. This is because there are economies of scale when the cost of complying with BASIX is spread across a number of dwellings. We note that the attached house multi dwelling is more expensive than an average Sydney house (approximately 17 per cent) since a developer would typically install more expensive fittings to a proportion of dwellings. This is so these dwellings could be sold as 'high-end' units. For example, two of the units have electric ovens and stovetops fitted instead of cheaper gas fittings. Consequently, when working out the average cost of compliance per dwelling these higher costs increase the average cost of compliance per dwelling.

Table 4.4 Cost of typical compliance with BASIX relative to the business as usual case for multi dwellings ($2009)

		Cost per dwelling ($)	Cost per multi dwelling complex ($)
Case study 5	- Sydney –attached houses (gas connection)	7,511	37,556
	- Sydney –attached houses (no gas connection)	10,168	50,842
Case study 6	- Sydney –low rise units (gas connection)	3,494	27,954
	- Sydney –low rise units (no gas connection)	6,530	52,238
Case study 7	- Sydney –high rise units (gas connection)	1,114	46,808
	- Sydney –high rise units(no gas connection)	4,741	199,113

Note: These costs include payments made for Renewable Energy Certificates (RECs), where relevant. Further details are contained in Appendix A.

Figure 4.2 Costs of typical compliance with BASIX ($) for multi dwelling projects (per dwelling) ($2009)



As with the single dwelling case studies, the typical cost of complying with BASIX for multiple dwelling projects is higher if there is no access to reticulated gas. For a high-rise unit dwelling compliance costs are almost 326 per cent higher where there is no access to gas. This is due to the much higher cost of a solar system - $178,000[33] – in the "without gas" case compared to a $24,300 gas boiler in the "with gas" case. For a low-rise unit dwelling the costs are 138 per cent higher and for attached houses 58 per cent higher.

4.2. Benefits of complying with BASIX

There are two principal categories of benefits for households that have been quantified as arising from BASIX, namely:

§ reductions in water use, resulting in a commensurate reduction in a household's water bill; and

§ reductions in electricity use, offset in part by increasing gas use, resulting in a commensurate reduction in a household's total energy bills.

Each of these benefits is discussed in greater detail below.

[33] Although $900 would be rebated back in REC payments.

4.2.1. Water consumption benefits

To estimate the benefits associated with reduced potable (mains) water consumption, we have examined in detail the water savings that are likely to have been achieved through compliance with BASIX in NSW from 2006 to 2050. Our approach has been to:

- construct a business as usual water budget by disaggregating average, actual water consumption to each end-use of water for each household ie, constructing a household's water budget in the absence of BASIX;
- estimate the reduction in mains water use for each component of the water budget (eg, shower water use) arising from actions undertaken to comply with BASIX (eg, installation of more efficient showerheads); and
- construct the BASIX compliance case as the business as usual water consumption minus the impact of all of the water systems nominated in each case study ie, the business as usual case minus the estimated reduction in water use results in the BASIX compliant water consumption.

Further details of our approach to estimating water savings are given in Appendix A.

Our results indicate that compliance with BASIX results in a reduction in mains water use from the business as usual case of between 43 per cent and 59 per cent for each of the case studies examined. This translates to a saving of between $1,198 and $2,869 for each dwelling over the period 2006 to 2050. These results are summarised in Table 4.5.

These percentages are larger than the savings associated with BASIX, which were calculated by Sydney Water in a report prepared for the NSW Department of Planning.[34] The Sydney Water BASIX savings are based on actual water consumption data sourced from customers' water bills. Sydney Water has found that as a result of BASIX a 40.5 per cent assumed reduction based on actual percentage potable water savings is achieved relative to the BASIX benchmark.

The differences between our results and the results estimated by Sydney Water stem from our assumption that a household would install 0-star appliances and fixtures in the absence of BASIX. This contrasts with Sydney Water's presumption of a likely installation of a combination of 1- and 2-star appliances in a typical average New South Wales BASIX compliant benchmark dwelling (ie, a dwelling that consumes 247.5 litres of water per person per day).

We believe it is appropriate to use a 0-star appliance assumption for the business as usual case, to reflect the likelihood that a developer would install the lowest cost appliances in the absence of BASIX, without regard for the overall water efficiency of those appliances. Developers would be motivated to install the least-cost fittings

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34 Sydney Water, 2008, "BASIX Monitoring Report Water Savings for 2007-08 Final Report", November 2008, prepared by Sydney Water for the NSW Department of Planning as part of the BASIX Water Monitoring Project Data Sharing Agreement.

in dwellings and so would likely source lower-star rated fittings in order to save on costs. The higher star-rating in the BASIX compliant dwellings most likely reflects growing awareness of water efficiency through public campaigns and water restrictions that is more likely to impact on households as opposed to developers. Given that the compliance pathways are based on typical selections by developers and since BASIX would predominantly be used by developers it is more appropriate that 0-star appliances are used in the business as usual case.

The estimated implied water reductions in Table 4.5 are in some cases higher than the BASIX tool estimated water reduction scores. This mainly reflects the differences that result from the definition of a 0-star business as usual case, as well as the fact that the BASIX tool is based on NSW averages, whereas the case studies are based on geographically specific consumption values.

Table 4.5 Estimated reductions in water bills per dwelling as a consequence of BASIX ($ NPV)

			Implied water reduction from BASIX (%)	Benefits per dwelling ($)
Single dwellings	Case study 1	- Sydney – average house (gas connection)	49 (40)	2,368
		- Sydney – large house (gas connection)	50 (42)	2,869
		- Sydney – large house (no gas connection)	50 (42)	2,869
		- Sydney – affordable house (gas connection)	45 (40)	2,175
	Case study 2	- Regional NSW (gas connection)	56 (25)	2,110
		- Regional NSW (no gas connection)	56 (25)	2,110
	Case study 3	- Southern Highlands (gas connection)	59 (47)	1,743
		- Southern Highlands (no gas connection)	59 (47)	1,743
	Case study 4	- Northern NSW (gas connection)	57 (47)	1,677
		- Northern NSW (no gas connection)	57 (47)	1,677
Multi dwellings	Case study 5	- Sydney –attached houses (gas connection)	53 (41)	2,106
		- Sydney –attached houses (no gas connection)	53 (41)	2,106
	Case study 6	- Sydney – low rise unit (gas connection)	43 (43)	1,198
		- Sydney – low-rise unit (no gas connection)	43 (43)	1,198
	Case study 7	- Sydney – high-rise units (gas connection)	43 (44)	1,231
		- Sydney – high-rise units (no gas connection)	43 (44)	1,231

For case studies one to five (single dwellings, and the multi dwelling attached houses) the principal water use savings and so the major contributors to the water benefits are:

- reductions in toilet, laundry and garden water use through the connection of alternative water supply, achieved by connecting a rainwater tank;[35]
- reductions in water use from installation of more efficient showers; and
- reductions in water use from installation of more efficient taps (and associated reduced leaks).

The reduction in toilet, laundry and garden water use is driven mainly by the installation of a rainwater tank, with this water meeting approximately one third of toilet, laundry and outdoor water demand ie, an alternative water source. Through the use of alternative water mains water is reduced (although water consumption in total is not reduced as alternative water volumes replaces mains water), creating savings. Single dwelling and multi attached house developments typically install individual rainwater tanks to all dwellings for toilet, laundry and irrigation in all dwellings, whilst multi dwelling unit developments typically include central rainwater tanks for use in a small number of dwellings or common garden irrigation only.

The reduction in water use through showers and taps occurs through individual dwellings installing higher water efficient rated showers and taps in line with the water efficiency labelling scheme ratings (WELS).[36] All households complying with BASIX are now required to install 3-star showers, which use approximately 51 per cent less water compared to the 0-star showers that are assumed to be installed in the business as usual case.[37] The majority of households install 3-star taps (now also the minimum standard as set in the BCA), which use 53 per cent less water compared to the 0-star taps installed in the business as usual case.

For the multi dwelling low-rise and high-rise case studies the principal water use savings per dwelling and so the main contributors to the water benefits are:[38]

- reductions in water use from installation of more efficient showers;
- reductions in water use from installation of more efficient taps (and associated reduced leaks); and
- the installation of more efficient washing machines.

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[35] We note that the Marsden Jacob Associates report on the cost-effectiveness of rainwater tanks in urban Australia for the National Water Commission found that a "typical' property owner who installs a rainwater tank will, in most cases, face a net financial loss over time". Our findings suggest that a rainwater tanks contributes greatly to *kilolitre* savings of water under BASIX. Further, that although a rainwater tank by itself may not be cost effective, a rainwater tank in conjunction with other water and energy saving devices can be cost effective as a whole (see Marsden Jacob Associates, The cost-effectiveness of rainwater tanks in urban Australia, March 2007, p. ES.x).

[36] The WELS brands a range of products based on its water efficiency performance.

[37] As discussed earlier, we assume 0-star rated appliances are installed in the absence of BASIX. Note that the BCA now requires the installation of a 3-star WELS rated showerhead.

[38] Other savings in water are achieved through the use of alternative water supply for irrigation, toilets and laundry supply. These reductions are much smaller in magnitude than those achieved through connection of alternative water for single dwellings.

As in the single dwelling and attached house projects (Cases 1 to 5), the reductions in water use from showers and taps in units are a direct consequence of BASIX requiring the installation of higher efficiency WELS-rated fixtures. The remaining savings primarily arise from the installation of more efficient than 1-star pre-BASIX average washing machines. Multi dwelling projects typically do not require an alternative water supply for all dwellings to meet their BASIX water targets – alternative water is most commonly used to partly satisfy common garden irrigation demand and laundry and toilet connection in a few units. This is largely due to reduced per capita demand related to smaller irrigation areas offset against a greater number of dwellings.

For the low-rise unit and high-rise unit dwellings the reductions in water consumption are smaller than those estimated for single dwelling and attached house developments because private outdoor water use is not as significant a contributor to per capita water use in unit dwellings and subsequently is not as significant to potable water savings. This reflects our methodology of considering the water budget of each unit dwelling, as compared to the project as a whole.

4.2.2. Reductions in emissions

New developments can meet BASIX emissions targets through three main actions:

1. lowering energy use eg, improving thermal comfort to reduce the need for artificial heating and cooling,
2. using alternative fuels eg, replacing electric hot water systems with gas or solar system, or
3. increasing energy efficiency eg, committing to higher efficiency star rated appliances.

All three of the above actions contribute to the BASIX energy target being met. The energy benchmark is measured as a reduction in total *emissions* ie, changes in emissions whether these emissions result from use less of one energy source (in 1 and 3 above), or switching to a lower emission energy source (in 2 above). Therefore, to estimate the benefits associated with reduced greenhouse gases, we have examined in detail the greenhouse gas savings that are likely to have been achieved by complying with BASIX requirements. Our intention had been to undertake a ‘bottom up’ examination of energy use by each major household energy use category (eg, hot water), and then consider the implications of BASIX on energy use in each category. However, it has been considerably more difficult obtaining reliable data on end-use energy demand as compared with our examination of end-use water demand.

Our approach therefore involves considering the energy use implications of the largest contributor to end-use energy demand, namely hot water, as a consequence of BASIX. We believe that this provides a good approximation of the **‘lower bound’** impact of BASIX on a household’s energy use because it represents such a large proportion of total energy use as influenced by BASIX. To obtain the **‘upper bound’** we have applied the BASIX engine to estimate the likely change in energy use as a consequence of complying with BASIX according to typical compliance paths provided by the Department. This means that our estimates represent a range of benefits, within which we have confidence the actual benefits are likely to occur – the lower bound indicates the minimum benefits we can expect while the upper bound indicates the maximum benefits we can expect if all systems selected and thermal comfort improvements (according to compliance paths) deliver emission savings as expected.[39]

Our results indicate that greenhouse gases as a consequence of BASIX has reduced from the business as usual benchmark by between 24 and 51 per cent across the case studies – Table 4.6. The differences in greenhouse gas reductions reflect the uncertainty about the actual savings that have been achieved and what appliances have been installed. For example, the single-dwelling Northern NSW case study has high energy reductions due to the installation of a solar hot water system, compared to the gas systems installed in other single dwellings. These energy use reductions result in a reduction in the energy bill of between approximately $5,000 and $12,000 for single dwellings, and $2,000 to $10,000 per dwelling for multi dwellings from 2006 to 2050. This indicates that whilst typical BASIX compliance costs for dwellings without gas connections may be significantly higher, the benefits from alternative fuel sources are significantly higher also.

[39] For the compliance pathways that do not include access to gas infrastructure we have only modelled the 'upper bound' ie, that the assumed BASIX energy score holds.

Table 4.6 Estimated reductions in emissions from BASIX compliance per dwelling, 2006 - 2050

			Reduction in energy	Benefits per dwelling	Reduction in emissions	Benefits per dwelling
			Lower Bound (%)	($ NPV)	Upper Bound (%)	($ NPV)
Single dwellings	Case study 1	- Sydney – average house (gas connection)	28	5,081	41 (40)	7,881
		- Sydney – large house (gas connection)	28	5,081	41 (42)	7,881
		- Sydney – large house (no gas connection)			40	11,792
		- Sydney – affordable house (gas connection)	28	5,081	46	8,972
	Case study 2	- Regional NSW (gas connection)	29	6,093	35	7,547
		- Regional NSW (no gas connection)			35	5,785
	Case study 3	- Southern Highlands (gas connection)	24	6,093	38	9,691
		- Southern Highlands (no gas connection)			37	10,067
	Case study 4	- Northern NSW (gas connection)	32	6,540	51	10,384
		- Northern NSW (no gas connection)			51	7,556
Multi dwellings	Case study 5	- Sydney –attached house (gas connection)	16	3,147	45	9,388
		- Sydney –attached house (no gas connection)			9,554	11,660
	Case study 6	- Sydney –low rise (gas connection)	34	3,625	41	4,362
		- Sydney –low rise (no gas connection)			41	5,383
	Case study 7	- Sydney –high rise (gas connection)	22	2,042	24	2,220
		- Sydney –high rise (no gas connection)			24	3,151

The estimated reductions in emissions are compared against a generally increasing trend in residential energy use per capita as observed across Australia. ABARE estimates that this trend will continue in the near to medium term future.[40] This upward trend primarily reflects increased energy demand as households become wealthier and are able to purchase more appliances, including air conditioners. We are aware that the BASIX benchmark is based on energy consumption and emissions of a typical household pre-2004, but we do not have enough reliable data to consider how energy use performance has tracked against this benchmark level over time.

For each of the case studies where we have assumed access to gas infrastructure, the range of energy savings reflects reductions in emissions through reduced electricity use mainly as a consequence of the installation of more efficient appliances (permitted to help meet BASIX targets in multi dwelling units only) and light bulbs, as well as lowering emissions through meeting thermal comfort targets. However, the largest impact on greenhouse gases arises from switching from an electric hot water system to gas or solar hot water systems. The reduction in emissions (and the resultant lowering in energy bills) as a consequence of switching away from emission intensive electric hot water systems makes up approximately two thirds of the total estimated emissions reductions and so benefits.

For those case studies where the dwelling does not have access to gas infrastructure, the majority of the reductions in emissions (and resultant energy bill benefits) arise from households switching away from electric hot water systems to more expensive solar or heat pump alternatives. For single dwellings without access to gas, households generally are found to switch to solar hot water systems to satisfy the BASIX emission reduction targets. As solar hot water systems contribute even less to greenhouse gas emissions than gas hot water cylinders, a larger proportion of the reduction in greenhouse gases can be attributed to the switch away from electric hot water systems in these case studies. The remaining benefits are achieved through installation of more efficient appliances and lowering electricity use through meeting thermal comfort targets.

For multi dwelling unit developments, gas hot water systems are also generally chosen as a cost effective means of achieving the BASIX reduction targets. This is due to the availability and relatively low cost of large central gas hot water systems in the market and the fact that multi dwelling site areas are not always sufficient to collect enough solar power as an alternative fuel for each dwelling. As with single dwellings, this means that the majority of energy savings are a result of switching away from electric hot water systems. The remaining reductions in energy use for multi dwelling unit developments are likely to arise from developers installing more energy efficient appliances, light bulbs and ventilation systems in dwellings and common areas that meet thermal comfort targets.

The savings from emission reductions are the largest contribution to the benefits for households, with the emission reductions being at least two times in magnitude what the savings from water are (in the lower bound). Further, the majority of the savings in emissions stem from households switching away from electric hot water systems to lower emission intensity fittings.

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[40] ABARE (2007), Australian Energy - National and State Projections to 2030.

As outlined in further detail in Appendix A, the cost of emissions is the marginal cost of electricity and the marginal cost of gas respectively, excluding any potential introduction of a CPRS. We have also conducted some sensitivity of these energy benefits assuming that the CPRS is implemented in 2014. Using the NERA National Electricity Market Model[41] we have obtained estimates of the wholesale prices, and adjusted the retail prices to reflect the rises in wholesale prices. The present value of energy bill benefits from 2006 to 2050 increase by approximately 100 per cent for those on EnergyAustralia tariffs, and around by approximately 80 per cent for those on Country Energy retail tariffs.

4.2.3. Potential savings in development compliance costs

In addition to the water and energy savings benefits that have been identified above, there are also potential benefits relating to the avoided development compliance costs that would have been incurred in the absence of BASIX. These costs are avoided since BASIX replaces the need for builders, developers and local government to comply with the energy efficiency requirements in both volumes of the Building Code of Australia (BCA) relating to energy efficiency, and also separate Development Control Plans for each Local Government Area that controlled construction elements that impacted on dwelling energy and water use.

We have been unable to sufficiently quantify these benefits, due to the lack of sufficient data relating to both of these potential benefits. We expect that the benefits in relation to development compliance costs would be a relatively small proportion of the total benefits. Some preliminary estimates indicate that the benefits may be in the range of $1,000 for single dwellings ie, less than 5 per cent of other benefits.[42]

4.2.4. Summary of the benefits

In summary energy bill savings represent the largest contributor to the estimated total benefits, representing between 60 per cent and 85 per cent of total benefits across the case studies. The estimated energy savings are typically two times the magnitude of water bill savings – see Figure 4.3 for single dwellings and Figure 4.4 for multi dwellings. The solid shaded energy benefits reflect the ‘lower bound’ energy bill reduction benefits ie, the switch from an electric hot water system to a gas hot water system whereas the hatched shaded energy benefits reflect the ‘upper bound’ energy bill reduction benefits ie, assuming that the BASIX score holds.

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41 For a full description of this model see Appendix B.

42 This is based on the assumption that 4.5 days will be saved for builders/developers and 1.2 days for local government., using earnings estimates from ABS data (Cat No. 6302.0). These estimates have not been included in the benefit calculations for this report.

Figure 4.3 Benefits for single dwellings ($NPV)

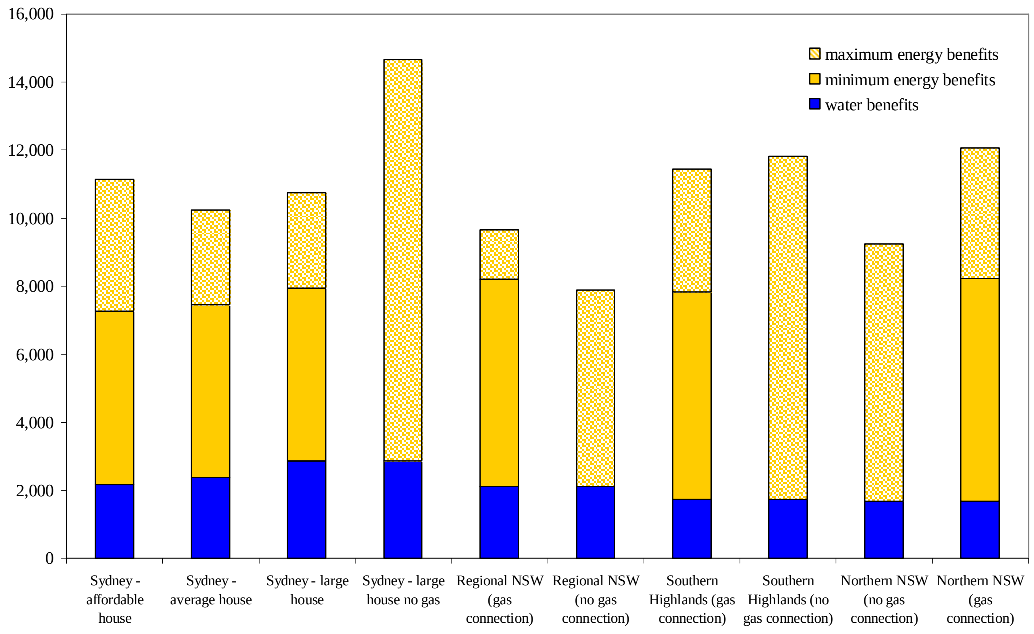
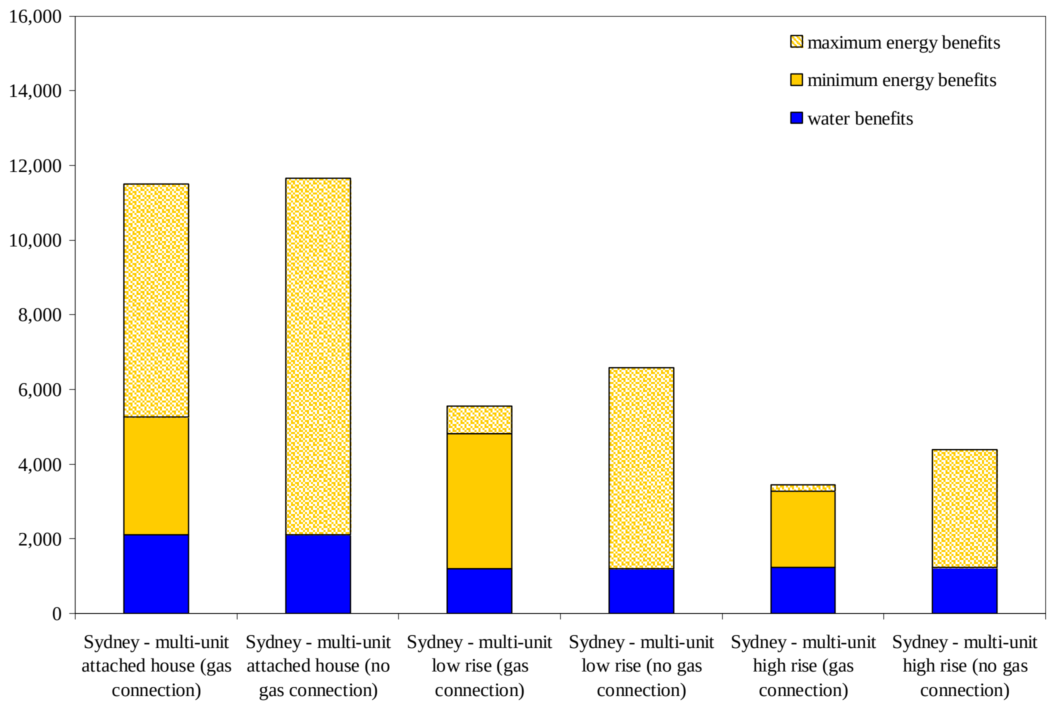


Figure 4.4 Benefits for multi dwellings per dwelling ($NPV)



4.3. Net benefits of BASIX to households

Comparing the estimates of the cost of complying with BASIX against the resultant benefits for each of the case studies indicates that (Table 4.7):

- the direct benefits to the household outweigh the costs of complying with BASIX for:
  - average single dwelling with access to gas in Sydney;
  - affordable single dwelling with access to gas in Sydney;
  - single dwelling with access to gas in Northern NSW;
  - low-rise units with access to gas in Sydney; and
  - high-rise units with access to gas in Sydney.
- in almost all of the case studies (except the large home) access to gas results in higher net benefits than where the case study has no access to gas.

Table 4.7: Net benefits of BASIX, 2006 to 2050 per dwelling ($ NPV)

			Lower Bound	Upper Bound
Single dwellings	Case study 1	- Sydney – average house (gas connection)	1,032	3,831
		- Sydney – large house (gas connection)	-9,482	-6,682
		- Sydney – large house (no gas connection)		-7,241
		- Sydney – affordable house (gas connection)	2,286	6,178
	Case study 2	- Regional NSW (gas connection)	-443	1,010
		- Regional NSW (no gas connection)		-4,668
	Case study 3	- Southern Highlands (gas connection)	-1,566	2,032
		- Southern Highlands (no gas connection)		-1,534
	Case study 4	- Northern NSW (gas connection)	203	4,048
		- Northern NSW (no gas connection)		-2,831
Multi dwellings	Case study 5	- Sydney –attached houses (gas connection)	-2,259	3,983
		- Sydney –attached houses (no gas connection)		1,491
	Case study 6	- Sydney –low rise (gas connection)	1,330	2,066
		- Sydney –low rise (no gas connection)		49
	Case study 7	- Sydney –high rise (gas connection)	2,158	2,336
		- Sydney –high rise (no gas connection)		-359

The differences in net benefits in case studies 1 to 4 reflect varying avoided costs from energy and water consumption reductions due to differences in water and energy pricing for each location. They also reflect the larger and more expensive appliances and fittings needed to comply with BASIX. For example, in the

Southern Highlands a 5,000L rainwater tank is the most common selection to meet BASIX water targets, compared to a 3,000L rainwater tank in the average Sydney home.

The highest benefit-cost ratios arise for the multi dwelling high-rise in Sydney (benefit cost ratio of 2.94) and the average and affordable houses in Sydney (benefit cost ratio of 1.60 and 2.24 respectively). The high-rise multi dwellings in Sydney have a high benefit-cost ratio as they have relatively low costs of complying with BASIX. For example, the same hot water system type (gas boiler) commonly used in BASIX compliant cases is the same system most commonly used in high-rises preceding BASIX's introduction, reducing the difference in BASIX compliance and business as usual development costs.[43] Further, the costs are spread across a large number of dwellings. The average house in Sydney has relatively high benefits from water use reductions that contribute to the high overall benefit-cost ratio. The affordable house in Sydney has relatively low costs of compliance with BASIX due to the cheapest options to comply, rather than most common selections, being chosen, which contributes to the high overall benefit-cost ratio.

The lowest benefit-cost ratios arise for a large house in Sydney (benefit cost ratio of 0.46) and a single dwelling located in northern NSW with no gas connection (benefit cost ratio of 0.77). The large house in Sydney must install more expensive fittings in order for the dwelling to comply with BASIX. For example, the large house case study was included to reflect the trend in increasing floor area of new homes that consume more electricity to light and comfortably cool and heat than the average Sydney house case study. In turn these large houses require a larger number of efficient fittings and appliances to be installed in order to satisfy the emissions reduction target, as well as a larger area of thermal comfort modifications (i.e. insulation) to be installed. A relatively expensive photovoltaic system was also required to reduce the emissions produced from coal-fired electricity. Further, it required a larger water tank to be installed compared to the average house in Sydney (4,000L compared to 3,000L respectively) due to a larger garden watering area. The relatively high cost of complying with BASIX in Northern NSW (including the Northern Rivers, North Coast and Mid-North Coast BASIX regions) reflects limited access to gas infrastructure. In order to comply with BASIX, households most often select a solar hot water system that has a five time greater cost compared to installing an electric hot water system under the business as usual case (approximately $4,682 including the value of renewable energy certificates (RECs) compared with $1,328).

We acknowledge that our lower bound energy benefits are a conservative estimate on emission reductions, and only estimate one of the actions that individuals can take to comply with BASIX. Further energy efficiency measures would be made by individuals that would improve the net benefits for households from negative to positive in some cases. For example, costs remain the same for the lower and upper

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[43] As per research conducted by the Department of Planning preceding the introduction of the BASIX Multi Dwelling Tool. Note that in the compliance case study for high-rise units without gas, it was assumed that individual electric hot water systems were more common before the introduction of BASIX.

bound cases, so for the single dwelling in regional NSW the lower bound of the net benefits are only just negative, and if the household received any additional benefits from the other energy efficiency measures above installing a gas hot water system then positive net benefits would result.

Table 4.8: Benefit-cost ratios and Internal Rate of Return

			Benefit/Cost ratio – lower bound	Benefit/Cost ratio – upper bound	IRR – lower bound (%)	IRR – upper bound (%)
Single dwellings	Case study 1	- Sydney – average house (gas connection)	1.16	1.60	12	15
		- Sydney – large house (gas connection)	0.46	0.62	5	7
		- Sydney – large house (no gas connection)		0.67		7
		- Sydney – affordable house (no gas connection)	1.46	2.24	14	21
	Case study 2	- Regional NSW (gas connection)	0.95	1.12	10	11
		- Regional NSW (no gas connection)		0.63		7
	Case study 3	- Southern Highlands (gas connection)	0.83	1.22	9	12
		- Southern Highlands (no gas connection)		0.89		9
	Case study 4	- Northern NSW (gas connection)	1.03	1.51	11	14
		- Northern NSW (no gas connection)		0.77		8
Multi dwellings	Case study 5	- Sydney –attached house (gas connection)	0.70	1.53	8	15
		- Sydney –attached house (no gas connection)		1.15		12
	Case study 6	- Sydney –low rise (gas connection)	1.38	1.59	14	16
		- Sydney –low rise (no gas connection)		1.01		11
	Case study 7	- Sydney –high rise (gas connection)	2.94	3.10	27	29
		- Sydney –high rise (no gas connection)		0.92		10

The results highlight that the principal actions that are contributing to the observed energy and water savings are the installation of gas hot water systems (or an alternative in circumstances where access to gas is not available) and the installation of a rain water tank and connection to alternative water sources as a substitute for potable water for toilets, laundries and irrigation in particular. The remaining actions, including the achievement of thermal comfort levels through improved insulation provide the basis for the remaining observed energy and water use savings.[44]

[44] We have not attempted to separately quantify any benefits from satisfying the thermal comfort requirements in BASIX. This does not cause problems in our analysis as the thermal comfort measures feed into the emission reduction targets required by BASIX therefore any benefits that may occur as a result of meeting the thermal comfort threshold are included in the 'upper bound' of the net benefits.

5. Implications for New South Wales

This chapter presents the results of our analysis investigating the costs and benefits of BASIX for New South Wales as a whole. The costs and benefits to New South Wales include the private costs and benefits that have been estimated for each of the case studies, plus the inclusion of public benefits resulting from the potential to avoid electricity network costs and reduce greenhouse gas emissions.

5.1. Aggregate costs of complying with BASIX

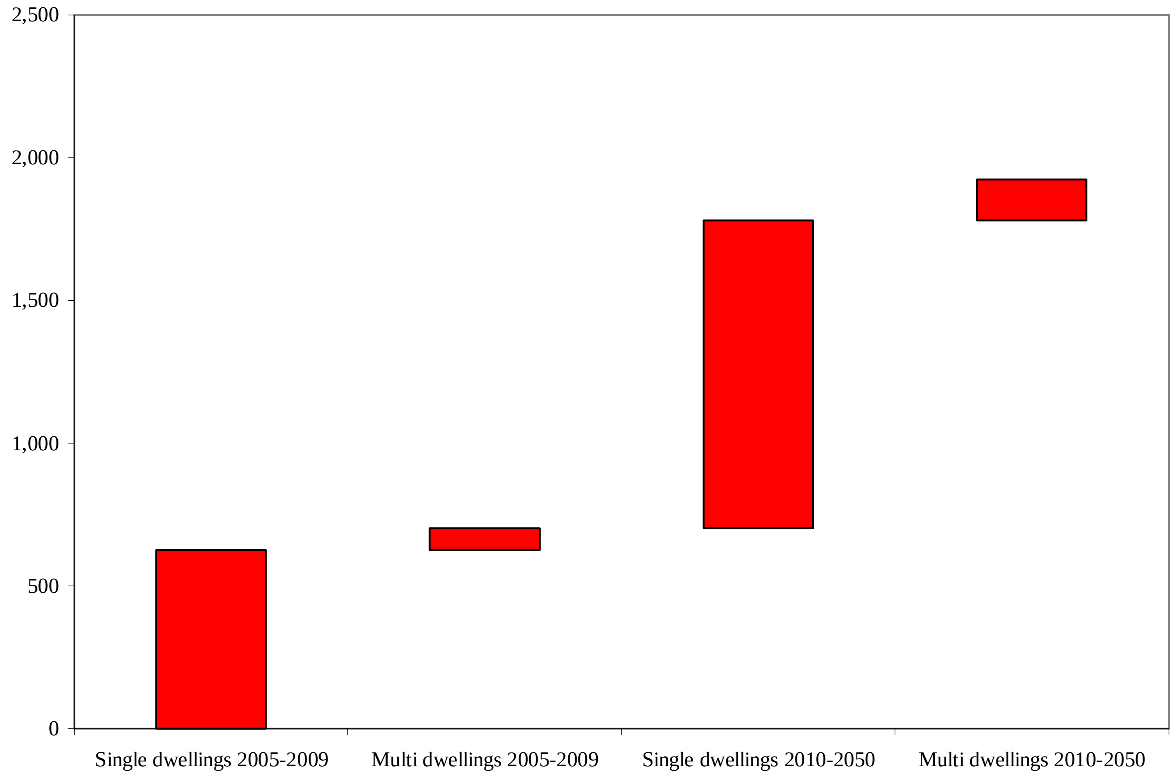
5.1.1. Total cost of complying with BASIX

To estimate the total cost of BASIX compliance across New South Wales, we have scaled up the case study estimates of costs by the total number of approved developments in NSW issued since BASIX's inception, and taking into account expectations of the number of new developments until 2050.[45]

The total cost of complying with BASIX is estimated as $1,907 million for all new and projected dwellings across the State. This total cost reflects the costs to developers or households. These costs are dominated by the large compliance costs (and significant proportion for dwellings in this area) associated with the single dwelling in Northern NSW without access to gas, and the large proportion of single dwellings in Sydney. Figure 5.1 illustrates the higher costs associated with single dwellings, compared with multi dwellings in NSW, as well as the costs which have been incurred up to 2009, and those costs that are still to be incurred.

45 A more detailed explanation of the scaling approach taken is set out in Appendix A.

Figure 5.1 Total cost of complying with BASIX in New South Wales 2005 to 2050 (NPV $ millions)



5.1.2. Ongoing running costs of BASIX

There are also ongoing running costs incurred by the Department of Planning. These comprise the initial development and inception costs of BASIX (including consultants) and the ongoing administration costs of the BASIX program from inception until 2050. The total cost of operating the BASIX program until 2050 is estimated at $15 million in net present value terms. This is a very small cost when compared with the total cost of complying with BASIX for New South Wales (less than 1 per cent). Further assumptions relating to the ongoing running costs of BASIX are detailed in Appendix A.

5.1.3. Summary

In summary the total costs associated with BASIX is estimated at $1,922 million in net present value terms, with the majority of these costs being incurred by households through the actions undertaken to comply with BASIX. Only 1 per cent of the cost of BASIX is incurred for the establishment, administration and development of BASIX by the government.

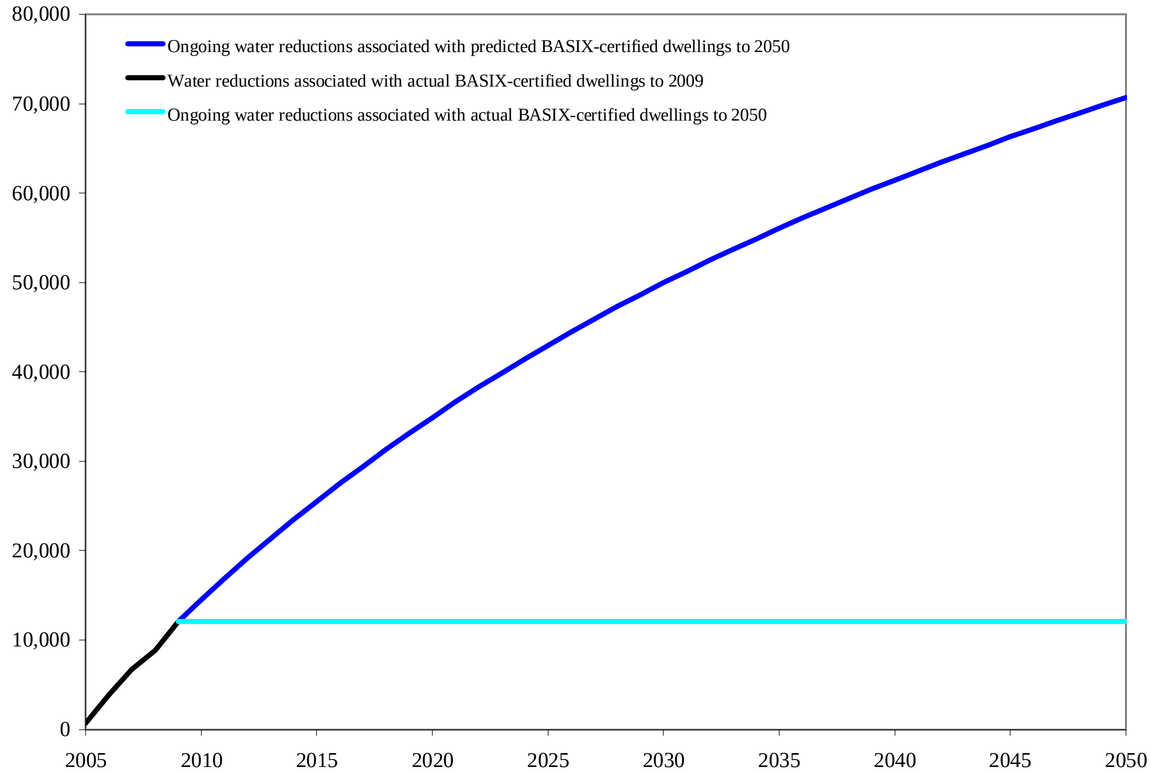
5.2. Aggregate private household benefits from BASIX

As explained earlier in this report, the principal private household benefits arising from the introduction of BASIX relate to the water and energy savings. This section sets out the aggregate New South Wales private household benefits resulting from BASIX.

5.2.1. Total water and energy bill savings

The largest aggregate benefits arising from the introduction of BASIX are associated with the estimated water and energy bill savings. Water bill savings make up as much as 22 per cent of the total estimated benefits arising from BASIX in New South Wales. These savings are equal to a cumulative net present value of $495 million. Figure 5.2 shows the reductions in water consumption that are estimated to occur in New South Wales as a result of BASIX to 2050.

Figure 5.2 Water consumption reductions in NSW as a result of BASIX (ML/year)

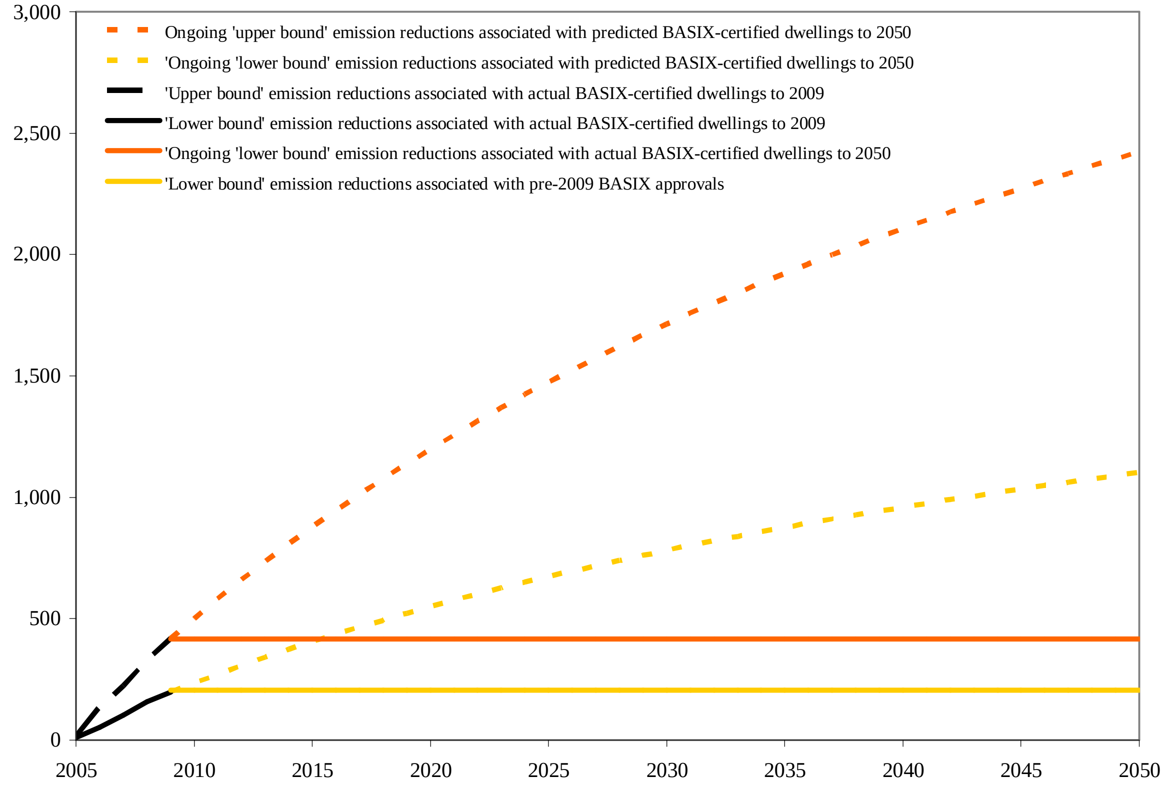


The majority of these savings are associated with single dwellings in Sydney or regional New South Wales (ie, case studies 1 and 2). This is partly because of the relatively high water benefits for these types of dwellings and because they make up a high proportion of the total number of developments approved in New South Wales (approximately 50 per cent).

Energy bill savings make up between approximately 69 per cent of total benefits in New South Wales. This translates to a range of energy bill saving benefits of between $1,518 million and $2,081 million in net present value terms. Figure 5.3 shows the increase in reductions in emissions (ie, the sum of the reduction in electricity emissions and increase in gas emissions) that occur as a result of BASIX. The dashed lines represent the range of energy benefits which can occur as a result of the BASIX program. These savings increase over the period as the number of dwellings complying with BASIX increases each year.

Like the water savings, the majority of these savings are from single dwellings in Sydney or regional New South Wales (ie, case studies 1 and 2). This is because these dwelling types have both high energy efficiency benefits at a household level, and also represent a high proportion of the total number of BASIX certificates issued in New South Wales (over 50 per cent).

Figure 5.3 Emission reductions in NSW as a result of BASIX (kilotonnes CO_2/year)



5.2.2. Summary

In summary the total private household benefits resulting from the introduction of BASIX range from $2,013 million to $2,576 million. The breakdown of benefits since inception and across the time period to 2050 is set out in Table 5.1 below.

Table 5.1 Total private household benefits for New South Wales, 2005 to 2050 (NPV $m)

	Benefits from dwellings complying between 2005 and 2009	Benefits from dwellings complying between 2009 and 2050	Total
Water bills ($m)	184	311	495
Energy bills ($m) (lower bound – upper bound)	–559 - 767	960 - 1314	1,518 – 2,081

We acknowledge that as with the household benefits there may be avoided development compliance cost benefits at an aggregated level. Given that these benefits are likely to be small, although benefits would be increased we would not anticipate the increases to be large. However, we also note that these savings would likely increase over time as local governments or developers became more familiar with processing the BASIX scheme.

5.3. Environmental benefits

A principal benefit of BASIX for New South Wales is the reduction in greenhouse gas emissions that occurs as a consequence of a reduction in electricity consumption for new dwellings. The greenhouse gas emission reductions are the net result of lower electricity consumption, and higher gas consumption (as applicable) due to the switching between electricity and gas consumption that BASIX drives.

Importantly, the size of the greenhouse gas emission reduction benefit will vary according to the time of day profile of the reduction in electricity consumption, reflecting the different amount of greenhouse gas emissions produced to generate a kilowatt hour of electricity during each half hour time period.

For example, one kilowatt of electricity used during the middle of the night where the marginal generator is a coal plant will create higher greenhouse gas emissions as compared to one kilowatt of electricity used during the middle of the day, where the marginal generator is likely to be a peaking gas generator. This means that reducing electricity use at night will result in a larger reduction in greenhouse gas emissions than reducing electricity use during the day.

While in aggregate this outcome seems counter intuitive (ie, lowering electricity demand during peak periods does not reduce greenhouse gas as much as during off-peak periods) understanding the time of day profile of energy efficiency will make some difference to estimates of greenhouse gas emission reductions.

Our approach to estimating the greenhouse gas reduction benefits has been to:

§ develop a time of day profile for the energy efficiency benefits for each compliance pathway based on the energy efficiency assumptions made for the compliance profile;

§ using the estimates of the total change in electricity demand, develop a NSW time of day load demand profile assuming that BASIX was not present;

§ estimate the likely change in electricity wholesale market dispatch associated with the change in demand resulting from the introduction of BASIX, using NERA's model of the Australian National Electricity Market;

§ estimate the carbon emission reduction associated with the change in generation attributable to BASIX;

§ estimate the increase in carbon emissions associated with increased domestic consumption of gas; and

§ subtract the electricity emission reductions from increased gas emissions to calculate the total emission reductions.

The reduction in carbon emissions between 2005 and 2009 has been estimated to have been approximately 360,000 tonnes. Looking ahead, we estimate that the total future carbon emission reductions out to 2050 will amount to over 14,000,000 tonnes (lower bound emissions associated with all approved dwellings until 2050). Further, the total emission reductions for anticipated BASIX approvals associated with the upper bound are estimated to be 33,000,000 tonnes.

The total greenhouse gas reduction benefits arising from BASIX are therefore estimated to range between $106 million and $300 million in net present value terms. These estimates are based on an assumed time profile for electricity demand reduction and are higher than the expected reduction in emissions if a flat time of day profile was assumed.[46]

Table 5.2 Greenhouse gas reduction benefits for New South Wales (NPV $m)

	Benefits from dwellings complying between 2005 and 2009	Benefits from dwellings complying between 2009 and 2050	Total
Greenhouse gas reduction benefits ($ m)	56 - 123	50 - 177	106 – 300

5.4. Avoided network investment benefits

In addition to the private and environmental benefits associated with BASIX, reductions in energy and water use has the potential to delay electricity and water network augmentation that might otherwise have been required to satisfy electricity and water demand, and so achieve network savings.

It is difficult to estimate the potential for network augmentation to be avoided because decisions to augment the network are based on local demand conditions compared to the extent of spare capacity in the associated local network. For example, a reduction in electricity use in an area where there are no network constraints or during off-peak periods of the day would result in no associated network benefits. This highlights that not all reductions in water and energy are likely to result in network benefits. For this reason we have discounted the potential network benefits by a margin reflecting the proportion of electricity savings that does in fact avoid the need for network augmentation.

For the purposes of this study we have focused on estimating the avoided network investment benefits for electricity only. In our opinion, the lumpy nature of water supply investments (ie, investment in desalination) and the relatively flat water demand profile means that the opportunity for water savings to result in substantial avoided water augmentation costs to be negligible. In contrast, the opportunity to avoid electricity network augmentation by reducing peak demand has the potential to create significant benefits.[47]

[46] The methodology used to estimate the greenhouse gas benefits is described in detail in Appendix B.

[47] Appendix A describes in greater detail the approach that has been used to estimate the avoided network investment benefits.

The estimated avoided electricity network investment benefits ranged between $97 million and $183 million, which represents approximately 5 per cent of the total benefits of BASIX in New South Wales – Table 5.3.

Table 5.3 Avoided electricity network investment benefits for New South Wales (NPV $m)

	Benefits from dwellings complying between 2005 and 2009	Benefits from dwellings complying between 2009 and 2050	Total
Avoided network augmentation ($m)	44 - 81	–53 - 102	97 - 183

5.5. Avoided development control plan costs

Another further benefit of BASIX is the avoided development control plan costs. BASIX substitutes for environmental provisions and development control plans developed by local governments and so councils are no longer required to periodically update these development control plans. Due to lack of publicly available information and large differences between the 152 councils within NSW, we have not attempted to estimate the avoided development control plan costs. However, we envisage that while total benefits may be increased, the increases will only be small compared to the other benefits that have been estimated.

5.6. Net benefits to New South Wales of BASIX

Since its inception BASIX has delivered between $135 million to $448 million in net benefits, predominantly from the direct benefits of reduced water and energy use. The associated net benefits with the predicted future dwellings will contribute a further $159 million to $689 million until 2050 in net present value terms – Table 5.4.

Table 5.4 Net Benefits for New South Wales ($ million)

	Benefits from dwellings complying between 2005 and 2009	Benefits from dwellings complying between 2009 and 2050	Total
Direct benefits			
- Water bill savings	184	311	495
- Energy bill savings	559 - 767	960 – 1,314	1,518 – 2,081
Avoided network augmentation	44 - 81	53 - 102	97 - 183
Environmental benefits	56 - 123	50 - 177	106 - 300
Total benefits	**843 – 1,155**	**1 374 – 1,904**	**2,216 – 3,059**
Direct costs			
- Compliance costs	-701	-1 207	-1,907
- Administration costs	-6	-8	-15
Total costs	**-707**	**-1,215**	**-1,922**
Net benefits	**135 - 448**	**159 - 689**	**294 – 1,137**
Cost-benefit ratio	**1.2 – 1.6**	**1.1 – 1.6**	**1.2 – 1.6**

Note: Some of the numbers do not add due to rounding.

These results highlight that the majority of the benefits for New South Wales arise from the aggregate net reduction in energy bills. The contribution of reduced water bills to the total benefits is lower at (22 per cent) compared to the lower bound energy bills contribution to total benefits (69 per cent). The impact of avoided network augmentation is even smaller again – less than 5 per cent of the total benefits. Finally, the environmental benefits from greenhouse gas reduction are estimated to be 5 per cent of the total dollar value benefits.

Appendix A. Detailed methodology for estimating the benefits and costs of BASIX

This appendix details the methodology and key assumptions used to estimate the benefits of the BASIX program. The appendix is divided into three sections, namely: a description of the methodology used to estimate the benefits of BASIX compliance for each of the case studies; a description of the methodology used to estimate the state-wide benefits of BASIX; and a description of the methodology used to estimate the costs of BASIX.

A.1. Estimating the benefits for each of the case studies

The first part of our analysis involved estimating the direct costs and benefits of BASIX compliance for each of the seven case studies (and the associated alternatives).

The time horizon for all of the household case study assessments is from 2006 to 2050, in line with the commencement of BASIX in its current form ie, with a greenhouse gas emission reduction target of 40 per cent.

The remainder of this section describes in detail the approach that has been used to estimate the benefits in terms of reduced water and energy bills for households.

A.1.1. Estimating benefits associated with household water utility bills

To estimate the change in water utility bills resulting from BASIX compliance for each of the seven case studies, a bottom up end-use water demand approach has been used. This involves:

§ obtaining average total water consumption for the case study dwelling type, drawing upon both publicly available information and data provided by Sydney Water (actual water consumption from 2006 – 2009, and estimated for 2010 onwards as the average water consumption over the previous four years);

§ allocating the above average total water consumption to the principal end-uses, based on publicly available end-use demand studies ie, creating a business as usual case based on the average total water consumption disaggregated to principal end-uses;

§ examining the likely change in water demand from the business as usual case as a consequence of BASIX compliance for each of the end-uses (eg, anticipated reductions in outdoor water use as a consequence of installing a rain water tank);

§ summing the total changes in water demand for each end-use to estimate the total change in water demand as a consequence of complying with BASIX ie, creating a BASIX compliance water consumption based on the business as usual water consumption minus changes associated with water fittings specified; and

§ multiplying the change in water demand by the usage charge for water in the relevant geographic location, based on published water charges.

This approach assumes that a reduction in water use produces benefits at the value of the marginal water usage charge. This means that the water usage charge is assumed to be equal to the long run marginal costs of water provision, and so is the appropriate value of the benefits. To the extent that water usage charges are less than long run marginal cost, then the benefit of reducing water use may be undervalued.

The total water consumption for each case study has been derived from average annual water consumption figures provided by Sydney Water (case studies 1, 5, 6 and 7) and from public information on local council websites (case studies 2, 3 and 4).[48]

The costs and benefits of BASIX compliance have been estimated against a counterfactual, or 'business as usual' case, in the absence of BASIX. The total water consumption for the business as usual case has been assumed as the actual average water consumption for dwellings, as outlined above for the relevant time period.[49] This is the average water consumption across the entire local government areas specified in the compliance pathway ie, including both BASIX-compliant and non-BASIX compliant homes.

Although the business as usual case water consumption assumption may include *some* effects of BASIX, it is likely that this amount is small in aggregate since the majority of dwellings existing in NSW would have been built *prior* to the introduction of BASIX. Average water consumption therefore reflects consumption in the absence of BASIX since it is measured predominantly based on dwellings that do not comply with BASIX. Further, this approach contributes to ensuring that other water efficiency schemes (eg, efficient showerhead rebates) are not included in the benefits, since the business as usual case is based on *actual* consumption including reductions in water consumption occurring as a result of other water efficiency programs. Moreover, since the water budget used to disaggregate total water consumption is sourced from 2006 (ie, pre-BASIX) this further ensures that the business as usual case does not include changes in water consumption associated with BASIX itself.

The assumed distribution of total water use by residential water end-use is set out in Table A.1.[50]

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[48] National Water Commission, *National Performance Report 2005-06; National Performance Report 2006-07; National Performance Report 2007-08; and National Performance Report 2008-09.* Sydney Water has provided us internal data specifically for the purposes of this cost-benefit analysis.

[49] We have assumed that each case study's future water consumption, ie future years where forecasts were not available, is constant and equal to an average of previous years.

[50] This water budget was derived from: Water for Life, *2006 Metropolitan Water Plan*, available at: http://www.waterforlife.nsw.gov.au/about/plan. These assumptions were used as a cross-check for BASIX and are broadly similar to the breakdowns in the BASIX engine.

Table A.1: Assumed distribution of total residential water use by end-use for single dwellings

End-use	%
Shower	25
Toilet	14
Dishwasher	1
Washing Machine	17
$Outdoor_1$	23
$Outdoor_2$	4
Taps	16
Total	100

Note: '$Outdoor_1$' includes water used for lawn and garden watering; '$Outdoor_2$' includes water for pools, hosing down and car washing; and 'Taps' includes water used in kitchen, laundry and bathroom taps, and leaks.

This distribution of total water use by end-use is applied to each of the single dwelling case studies. For multi dwellings we assume that the ***amount*** of water used for outdoor purposes is the same as that for outdoor purposes in the Sydney single dwelling (case study 1). Consequently this translates to a smaller end-use percentage for multi dwellings ie, the same amount divided by a larger number. The excess end-use percentages of outdoor water for the multi dwellings are therefore allocated across the other end uses according to their share of total indoor end-use consumption (excluding common area water use). This translates to multi dwellings using a smaller proportion of total water use in outdoor consumption (5 per cent for low rise units compared to 27 per cent for single dwellings). A worked example of this methodology is presented below.

Common area water use (ie, water associated with areas that are jointly used by all residents eg, common landscape lawn and garden, and pools) is excluded for multi dwellings since there is little publicly available information regarding common area water use in multi dwelling buildings. Consequently, we do not have sufficient information to derive BASIX implied reductions for common area use. Further, there are few common water use areas nominated in the case studies.

Example 1: Calculating Outdoor Water Use for Case Study 6 – Low-Rise Unit Building

§ For the Sydney single dwelling (case study 1) 52 and 9 kL of water is consumed in the end-uses of *outdoor – lawn & garden watering* and *outdoor – pools, hosing down, car washing* respectively.

§ The total water consumption for the low-rise unit building in 2006 is 1056 kL.

§ The percent associated with the end-use of *outdoor – private lawn & garden watering* (ie, excluding common garden) for the low-rise unit building is 4.9 per cent (52 / 1056 * 100).

- The percent associated with the end-use of *outdoor – hosing down, car washing* for the low-rise unit building is 0.9 per cent (9 / 1056 * 100).
- Therefore, the estimated percentage of water end-use for the low-rise unit building is 4.9 and 0.9 per cent for *outdoor – lawn & garden watering* and *outdoor – pools, hosing down, car washing* respectively.
- Given this percentage, 21 per cent still remains to be allocated. This is allocated on a pro rata basis to the following end-uses: shower, toilet, dishwasher, washing machine and taps translating into 32, 18, 1, 22 and 21 per cent respectively.
- These percentages are assumed to apply each and every year to obtain estimates of the quantity (kL) water associated with each end-use for the Low-Rise Unit Building.

The associated end-use distribution assumption for multi dwellings is set out in Table A.2.

Table A.2: Assumed distribution of total residential water use by end-use for multi dwellings

End-use	Attached houses (%)	Low-rise units (%)	High-rise units (%)
Shower	32	32	34
Toilet	18	18	19
Dishwasher	1	1	1
Washing Machine	22	22	23
$Outdoor_1$	6	5	1
$Outdoor_2$	1	1	0
Taps	20	21	22
Total	100	100	100

Note: '$Outdoor_1$' is lawn and garden watering; '$Outdoor_2$' is pools, hosing down and car washing; and 'Taps' is kitchen, laundry & bathroom taps, leaks. Common area water is not included.

Applying the respective total water budgets to assumed end-use distribution for each case study yields the estimated water demand for each end-use and case study. For example, the 2006 assumed end-use water consumption for each case study is set out in Table A.3:

Table A.3: Implied mains water consumption per dwelling (kL/annum)

End-use	Single dwelling - Sydney	Single dwelling – regional NSW	Single dwelling – Southern Highlands	Single dwelling – Northern NSW	Multi dwelling attached houses	Multi dwelling low-rise units	Multi dwelling high-rise units
Shower	57	91	48	52	58	43	46
Toilet	32	51	27	29	33	24	26

Dishwasher	2	4	2	2	2	2	2
Washing Machine	39	62	33	36	40	29	31
Outdoor1	52	83	44	48	10	7	1
Outdoor2	9	14	8	8	2	1	0
Taps	36	58	31	33	37	24	30
Total	**228**	**363**	**192**	**209**	**183**	**132**	**136**

Note: 'Outdoor$_1$' is lawn and garden watering; 'Outdoor$_2$' is pools, hosing down and car washing; and 'Taps' is kitchen, laundry & bathroom taps, leaks. Numbers may not add due to rounding.

To estimate the impact that BASIX compliance has on a case study's water consumption we have estimated how compliance affects each of the end-uses. The assumed savings on each of the end-uses in the water budgets are set out in Table A.4. The weighted average savings presented are reductions in water from the business as usual case ie, a pre-BASIX dwelling. For example, for a single dwelling in Sydney mains water consumption is assumed to be 49 per cent less with BASIX compliance than without BASIX compliance.

Table A.4 Assumed water savings from BASIX compliance (%)

End-use	Single dwelling - Sydney	Single dwelling – regional NSW	Single dwelling – Southern Highlands	Single dwelling – Northern NSW	Multi dwelling - attached houses	Multi dwelling - low-rise units	Multi dwelling - high-rise units
Shower	51	51	51	51	51	51	51
Toilet	61	66	72	62	48	45	44
Dishwasher	0	0	0	0	0	18	20
Washing Machine	68	80	78	75	54	26	22
Outdoor1	29	44	52	52	85	41	100
Outdoor2	29	44	52	52	85	0	0
Taps	52	52	52	52	52	52	52
Weighted average savings	**49**	**56**	**59**	**57**	**53**	**43**	**43**

Note: 'Outdoor$_1$' is lawn and garden watering; 'Outdoor$_2$' is pools, hosing down and car washing; and 'Taps' is kitchen, laundry & bathroom taps, leaks. This excludes common area water use.

Below, our assumptions relating to each of the above assumed water savings are detailed. Note that we do not assume reductions in water due to the installation of recycled water as it is not part of a typical compliance pathway.

We believe it is appropriate to use minimum-star rating appliance assumptions for the business as usual case, to reflect the likelihood that a developer would install the lowest cost appliances in the absence of BASIX without regard for the overall water efficiency of those appliances. Developers would be motivated to install the least-cost fittings in dwellings and so would likely source lower-star rated fittings in order to save on costs. The higher star-rating in the BASIX compliant dwellings most likely reflects growing awareness of water efficiency through public campaigns and water restrictions that is more likely to impact on households as opposed to developers. Given that the compliance pathways are based on typical selections by developers and since the BASIX online tool is predominantly used by developers it is more appropriate that minimum-star appliances are used in the business as usual case. The exact minimum-star rating assumptions in the business as usual case are detailed below, along with other assumptions made.

Showers

The BASIX primary compliance pathway for all case studies involved 3-star WELS rated showerheads in each bathroom. We have assumed that the business as usual case would install 0-star rated showerheads. This is because the introduction of BASIX preceded the adoption of minimums for shower and tap WELS star ratings in the BCA. Further, we believe it is appropriate to use a 0-star appliance assumption for the business as usual case, to reflect the likelihood that a developer would install the lowest cost appliances (in the absence of BASIX,) without regard for the overall water or energy efficiency of those appliances. The higher-star-rating in the BASIX-compliant dwelling most likely reflects growing awareness of water and energy efficiency through public campaigns and water restrictions.

The BASIX savings are therefore calculated as the water saved from using an average Water Efficiency Labelling and Standards (WELS) 3-star rated showerhead relative to an average WELS 0-star rated showerhead.

Toilets

The BASIX primary compliance pathway for all case studies involved 3-star WELS rated toilets in each bathroom or toilet. We have assumed that the business as usual case would install 1-star rated toilets since this is the minimum star-rated toilet available under the WELS system. The BASIX savings are therefore calculated as the average amount of water saved from using 3-star WELS rated 'lavatory equipment' relative to 1-star WELS rated 'lavatory equipment.'

We have also assumed that there are savings associated with having alternative water supply to the toilet. To estimate these water savings we have used the BASIX online tool, and estimated the compliance pathway with and without connection of the toilet to an alterative water supply. The difference in the BASIX water score translates into the estimated savings associated with connecting a toilet to alternative water supply. For example, with connection of alternative water the BASIX water score is *x*, without connection of alternative water the BASIX water score is *y*. Therefore, the estimated savings with connecting the toilet to the alternative water supply is *x-y* per cent.

Dishwashers

Case studies 1 to 5 do not specify a dishwasher as part of the BASIX primary compliance pathway since appliance water ratings are only made available to assist unit dwellings in meeting their water targets.

Dishwashers with WELS ratings of 4 stars were selected as typical in Case Studies 6 and 7 with dishwashers installed in 5 units in Case Study 6 and 29 units in Case Study 7 to reflect the proportionate distribution of dishwashers across Multi Dwelling units in the BASIX Tool. We have assumed that the business as usual case would install a 1-star WELS rated dishwasher since this is the minimum star-rated appliance available under the WELS systems. The BASIX savings are therefore calculated as the average water saved from using a 4-star WELS rated dishwasher relative to a 1-star WELS rated dishwasher for those dwellings that install a dishwasher.

Washing Machines

A washing machine is not included as part of the BASIX primary compliance pathways for case studies 1 to 5 because appliance water ratings are only made available to assist unit dwellings in meeting their water targets. However, we have assumed that there are savings in having an alternative water supply connected to the laundry. To estimate these water savings we have used the online BASIX tool and estimated the compliance pathway with and without connecting the washing machine to the alternative water supply. The difference in the water score translates into the estimated savings associated with connecting a washing machine to alternative water supply.

Case studies 6 and 7 include 4-star washing machines in the BASIX primary compliance pathway. We have assumed that the business as usual case would install a 1-star WELS rated washing machine. Based on selection data sourced from BASIX certificates, 5 dwellings in case study 6 install a washing machine, whereas 17 dwellings in case study 7 install a washing machine. To estimate the BASIX savings, we have calculated the average water saved from using a 4-star WELS rated washing machine relative to a 1-star WELS rated washing machine for those dwellings that install a washing machine. We also estimated savings associated with connecting the laundry to an alternative water supply using the same approach as for case studies 1 to 5 ie, using the online BASIX tool.

Outdoor water use

We have assumed that a rainwater tank would not be installed in the business as usual cases as per data supplied by the Department on average dwellings preceding the introduction of BASIX. However, all case studies install a rainwater tank to comply with BASIX. We have used the online BASIX tool to estimate the savings in outdoor use that would be achieved by installing a rainwater tank in all case studies. For example, we ran the BASIX tool with and without installing a rainwater tank for outdoor water use. The difference in the water score is the estimated percentage savings for outdoor water use ie, irrigation associated with installing a rainwater tank.

Taps

The BASIX primary compliance pathway for all case studies involved 3-star rated taps in kitchens and bathrooms. We have assumed that the business as usual case would install 0-star rated taps since this is the lowest WELS rated tap avaliable. This is because we assume that BASIX preceded the adoption of the minimums for shower and tap-star ratings as set out in the BCA. Further, that developers would install the cheapest fitting available, with this likely being the lowest water efficiency fitting as well. Further, we believe it is appropriate to use a 0-star appliance assumption for the business as usual case, to reflect the likelihood that a developer would install the lowest cost appliances (in the absence of BASIX) without regard for the overall water or energy efficiency of those appliances. The higher-star-rating in the benchmark dwelling most likely reflects growing awareness of water and energy efficiency through public campaigns and water restrictions.

The BASIX savings are therefore calculated as the average water saved from using 3-star WELS rated taps in bathrooms and kitchens relative to 0-star rated taps.

A.1.1.1. Water bill savings

To estimate the water bill savings, we have used water usage charges for the relevant local council or Sydney Water for the geographic locations associated with each case study. Future water usage charges have been estimated by applying the expected rate of growth in the consumer price index over the time period of the analysis. The assumed inflation rates are set out in Table A.5.

Table A.5 Assumed future rates of inflation

2009	2010	2011	2012-2050
1.5%	2.8%	2.0%	2.5%

The estimated water use savings for each case study are multiplied by the water usage charge to estimate the annual water bill savings associated with BASIX compliance.

A.1.2. Estimating benefits associated with reduced household emissions

To estimate the change in energy utility bills resulting from compliance with BASIX we had intended to apply a similar methodology to that used to estimate the change in water utility bills ie, examine the change in energy demand using end-use data on a household's energy consumption. However, unlike for water use, we have been unable to obtain detailed and credible estimates of end-use demand for electricity and gas that could be used in our analysis.

As a consequence, we have applied a different approach to estimating the change in household energy bills to that used to estimate the change in water bills. Our approach involves:

§ estimating average gas and electricity consumption for each case study dwelling under the business as usual scenario;

§ estimating the implications of changes in energy use for greenhouse gas emissions under the business as usual scenario;

§ estimating the change in energy use for two scenarios to generate a range of likely changes in energy use; and

§ multiplying the change in energy use by electricity and gas prices to estimate the total change in household energy bills.

The remainder of this section describes the assumptions made in developing these estimates in greater detail.

A.1.2.1. Gas consumption under the 'business as usual' case

Average gas consumption for the Sydney case studies (ie, case studies 1, 5, 6 and 7) has been estimated based on the average volume of gas supplied by Jemena to small customers.[51] The average gas consumption for the remaining case studies has been assumed to be equal to the average volume of gas supplied by Country Energy to small customers.[52]

To account for differences in average gas consumption between houses, units and regions the average volumes of gas supplied have been scaled according to estimates derived from the IPART 2006 household survey of 'Residential Energy and Water Use in Sydney, the Blue Mountains and Illawarra' and the IPART 2008 household survey of 'Residential Energy and Water Use in the Hunter, Gosford and Wyong'.[53] For all future years where average gas consumption was not available we have assumed that gas consumption increases at the average rate forecasted by ABARE for the period 2010 to 2025 – Table A.6.[54]

Table A.6 Assumed future increases in gas and electricity demand, 2010-2025

Annual change in natural gas	0.34%
Annual change in electricity	0.51%

Figure A.1 sets out the assumed 'business as usual' gas consumption *per dwelling* over the study time period to 2050. The large decrease in gas consumption that is observed in Country Energy is a result of climatic variations. 2006 was a very cold winter which resulted in high gas consumption, whereas 2007 had a mild winter which led to the observed large drop in consumption.[55]

51 JGN, Access Arrangement Information, 25 August 2009 and McLennan Magasanik Associates Pty Ltd, Draft report to Independent Pricing and Regulatory Tribunal of NSW Review of demand forecasts for the AGL Gas Network (AGLGN), 5 April 2004.

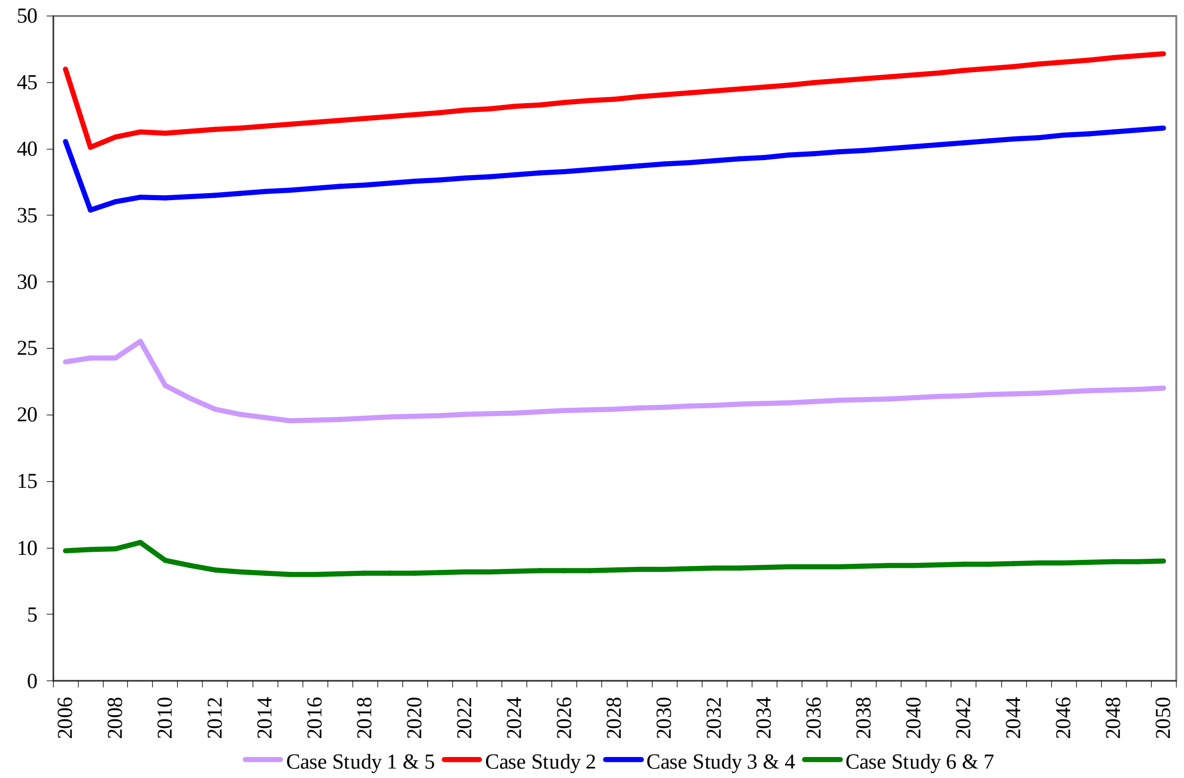
52 Country Energy Gas Networks, Access Arrangement for the Wagga Wagga Natural Gas Distribution Network, 1 July 2010.

53 With the exception of case studies 3 and 4, as the IPART surveys didn't cover these areas. The gas consumptions for these areas have been assumed to be equal to the average supplied by Country Energy to small customers.

54 ABARE, (2007), Australian Energy - National and State Projections to 2030.

55 Country Energy, 2010-2015 *Gas Access Arrangement Information for Wagga Wagga*, p.6.

Figure A.1: Assumed gas consumption per dwelling under the 'business as usual' case (GJ)



Gas prices for each case study have been based on the relevant default gas retailer in the geographic location of each case study. For the Sydney case studies (ie, cases studies 1, 5, 6 and 7) gas prices have been assumed to be equal to the AGL 'retail energy residential gas prices'.[56] Gas prices for the remaining case studies have been based on Country Energy's 'regulated retail reticulated gas fees for small retail customers'.[57] The price of gas has been assumed to increase in line with the expected change in the consumer price index, as described in Table A.5.

A.1.2.2. Electricity Consumption under the BAU

Average household electricity consumption for the Sydney case studies (cases studies 1, 5, 6 and 7) has been assumed to equal that of the 'Sydney metro region' from the 2006 IPART household survey of 'Residential Energy and Water Use in Sydney, the Blue Mountains and Illawarra'. Average household electricity consumption for the other case studies has been assumed equal to regions in the IPART 2006 household survey of 'Residential Energy and Water Use in Sydney, the Blue Mountains and Illawarra' and the IPART 2008 household

56 AGL Retail Energy (AGLRE) Residential Gas Prices, Prices as of 1 April 2008; and AGL, AGL Natural Gas Plans - NSW, Prices as of 1 July 2009.

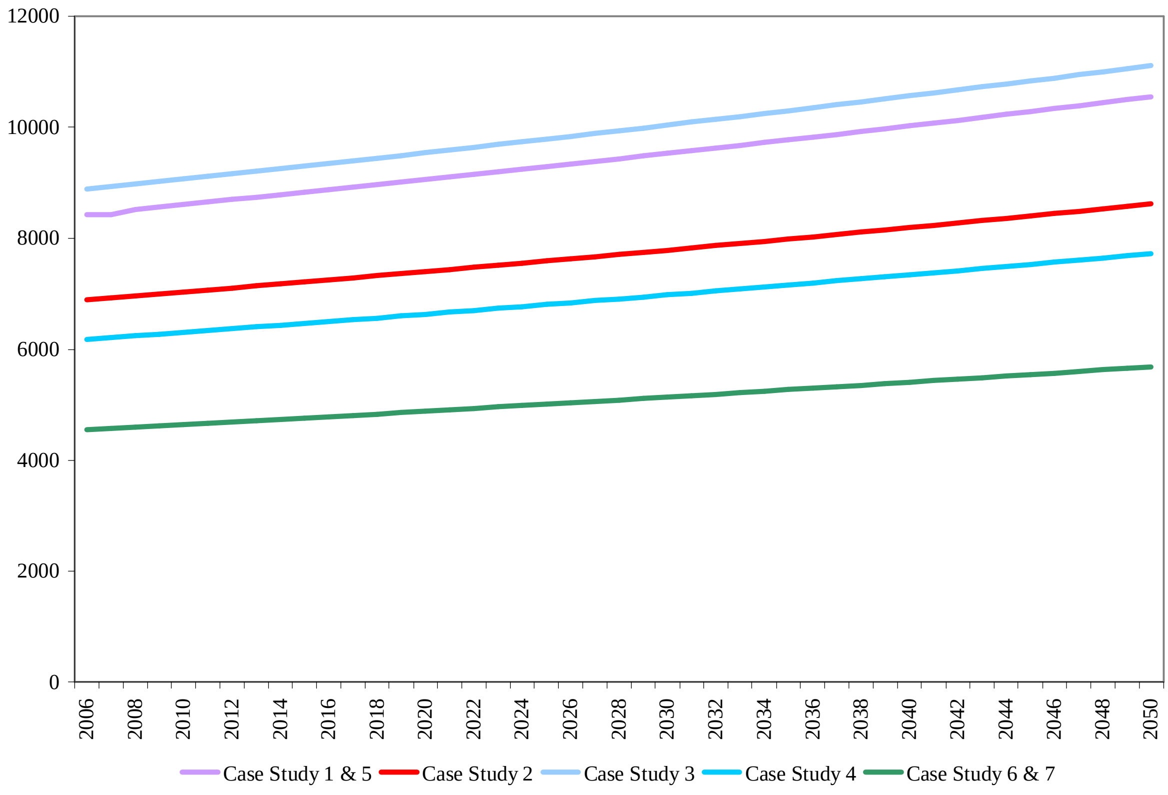
57 Country Energy, Regulated Retail Reticulated Gas Fees for Small Retail Customers, Prices as of 1 July 2008; Country Energy, Regulated Retail Reticulated Gas Fees for Small Retail Customers, Prices as of 1 July 2009; Country Energy, Regulated Retail Reticulated Gas Fees for Small Retail Customers, Prices as of 1 July 2010.

survey of 'Residential Energy and Water Use in the Hunter, Gosford and Wyong'.[58] The regional NSW and the Northern Rivers case studies are considered geographically most similar to the Gosford and Wyong data respectively.

To compensate for differences in electricity consumption of houses, units and regions the estimates of average electricity consumed have been scaled according to estimates derived from the IPART 2006 household survey of 'Residential Energy and Water Use in Sydney, the Blue Mountains and Illawarra' and the IPART 2008 household survey of 'Residential Energy and Water Use in the Hunter, Gosford and Wyong'. As with assumed gas consumption, for forecast years where the average electricity consumption was not available we have assumed that it increases at the average rate forecasted by ABARE for the period 2010-2025.[59]

Figure A.2 sets out the assumed 'business as usual' electricity consumption *per dwelling* over the study time period to 2050.

Figure A.2: Assumed electricity consumption per dwelling under the 'business as usual' case (kWh)



For the alternative BASIX compliance pathways where there is no access to reticulated gas, we have assumed that the case study's electricity consumption is higher than where there is

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58 Electricity consumption in case study 2 was assumed to be equal to Gosford's electricity consumption. Electricity consumption in case study 3 was assumed to be equal to the Blue Mountains and electricity consumption in case study 4 was assumed to be equal to that of Wyong.

59 ABARE, (2007), Australian Energy - National and State Projections to 2030.

access. We expect that the additional electricity use will be regional specific and influenced by factors such as income and temperatures. We have assumed that the electricity consumption of these alternative case studies is reduced in the same proportion estimated by IPART - Table A.7.

Table A.7 Impact of gas connection on electricity consumption

Case study	Reduction in electricity consumption if a household has access to gas (%)
Single dwelling - Sydney	24
Single dwelling – Regional NSW	3
Single dwelling – Southern Highlands	24
Single dwelling – Northern NSW	3
Multi dwelling - Attached houses	24
Multi dwelling - Low-rise units	24
Multi dwelling - High-rise units	24

For the Sydney region case studies (including case study 2 in regional NSW), historic electricity prices are estimated to be the weighted average[60] of the time of use (TOU) tariff for EnergyAustralia – based on EnergyAustralia regulated retail tariffs. For the other case studies, historic electric prices are assumed to be the weighted average of the TOU tariff for Country Energy – based on Country Energy regulated retail tariffs. This reflects our opinion that all new dwellings will have smart meters installed and so will be on TOU tariffs ie, the BAU case is for dwellings to be charged a TOU tariff for electricity consumption.

For the forecast electric prices for years 2010 to 2013, the price of electricity has been assumed to rise in accordance with those increases approved by IPART in its recent retail price determination for electricity for the components of network charges, wholesale energy costs, retail costs and margins. We assume that this percentage increase applies to both the fixed and variable components of the retail price ie, if total prices increase by 11 per cent then the fixed price increases by 11 per cent and the variable price increases by 11 per cent. Table A.8 shows the price increases and cost drivers for EnergyAustralia, Country Energy and Integral Energy until 2012/13.

60 This is the weighted average of the various prices multiplied by the number of hours in the year that these prices apply to. For example, Country Energy has 14.5, 60.4 and 26.2 per cent of the number of the hours in a year in peak, off-peak and shoulder periods respectively, with 2010 regulated prices of 23.8240c, 11.9290c and 23.8240c respectively. This translates into a weighted average price of 16.90 cents.

From 2014 to 2050, we assume that retail prices remain constant in real terms ie, they increase in accordance with the expected change in the CPI as set out in Table A.5. None of our prices include estimates of what prices would be if the CPRS is introduced. This is considered appropriate given the large uncertainty in the timing of a CPRS being introduced in Australia at this time.

Table A.8 Price increases and cost drivers to 2012-13 (nominal, %)

Cost driver	Energy Australia	Country Energy	Integral Energy
Network charge increases (as determined by the AER)	31	35	16
Increase in wholesale energy costs (if the CPRS is not introduced)	1	3	1
Increases in retail costs and margin	3	3	2
Total	**36**	**42**	**20**

Source: IPART, (2010), Review of regulated retail tariffs and charges for electricity 2010 – 2013, Final report, March.

Table A.9 outlines the assumed price increases for the period 2011 to 2013, both in aggregate and on an annualised basis.

Table A.9 Price increases and cost drivers to 2012-13 (nominal, %)

	Energy Australia	Country Energy
Annual rate	10.79	12.40
Total	36	42

Note: As opposed to making assumptions about each case study's split in annual electricity bill between fixed and variable components, we have assumed that these increases apply to the variable component.

A.1.2.3. Case study emissions under the BAU

To obtain a total annual greenhouse gas emissions estimate for each case study, the estimated consumption of electricity and gas was transformed into emissions based on the most recent emissions intensity factors estimated by the Australian Greenhouse Office.[61] These emissions intensity factors have been applied to all past and future years, ie assuming that there are no future changes to the generation profile in NSW, and so the emissions intensity factor for electricity in NSW. Table A.9 sets out the emissions intensity factors assumed for a NSW household's consumption of electricity and natural gas.

[61] AGO, (2009), National Greenhouse Accounts (NGA) Factors, June.

Table A.9 Assumed emissions intensity factors

Energy	Intensity factor
Natural gas	67.6 kg CO_2-e/GJ
Electricity	1.07 kg CO_2- e/kWh

Note: the natural gas intensity factor is the emissions intensity factor for gas by full fuel cycle (ie, the summation of Scope 1 and 3 measures).

A.1.2.4. Impact on energy bills from BASIX compliance

In light of the uncertainty surrounding the energy use changes arising from compliance with BASIX, we have considered two scenarios for estimating the impact on a household's energy bills following BASIX compliance, namely:

- where the BASIX energy 'score' predicting emission savings in each case study is assumed to be accurate – representing an **'upper bound'** of the likely energy consumption reduction attributable to BASIX; and
- where the only impact of BASIX energy compliance is that the hot water system is switched from electricity to gas (or solar as appropriate) – representing a **'lower bound'** of the likely energy use change attributable to BASIX.

We are of the opinion that this approach provides some certainty about the most likely range of energy use reductions that can be appropriately attributed to compliance with BASIX. The lower bound estimate represents the minimum benefits for BASIX compliance, and represents as much as 92 per cent of the total likely reduction in emissions that can be attributable to BASIX.

For all case studies which have gas connections we have estimated a lower bound. We have assumed that BASIX only affects a case study's electricity and gas consumption through switching from an electric to gas hot water system ie, the *minimum* reductions in greenhouse gas reductions that may occur. Therefore, the impact on electricity/gas bills is the implied reduced/increased energy consumption through the assumed CO_2 emissions of each system, for each case study, with these being sourced from the Australian Greenhouse Office as described below.

To estimate the change in greenhouse gases associated with switching from electricity to gas hot water, we have applied estimates of the emissions attributable to both electrical and gas hot water systems as provided by the Australian Greenhouse Office (AGO).[62] Specifically, the AGO estimate that an electric hot water system will emit approximately 4,000kg of CO_2 per household per year, as opposed to 1,000kg of CO_2 for a gas hot water system. These figures have been assumed for single dwelling case studies and scaled down for each dwelling in the multi dwelling case studies. For each multi dwelling case study, the proportion of total electricity and gas consumption in the business as usual case relative to the

62 Australian Greenhouse Office, (2005), *Greenhouse Gas Abatement Program: Round 3*.

Sydney single dwelling business as usual case study has been used to adjust the assumed emissions in these case studies from electrical and gas hot water systems.

For the upper bound the BASIX energy score for all case studies is applied to the business as usual electricity and gas consumptions. The BASIX scores vary across the case studies according to the selections made as part of the typical compliance pathways – Table A.10. These are the ***maximum*** reductions in greenhouse gases which may occur, as we recognise the behavioural variation and imprecise performance of some systems. These case studies are based on 'typical' compliance pathways sourced from data from the Department of Planning.

Table A.10 Case study BASIX energy scores

Case study	Energy score (%)
Single dwelling – Sydney (gas connection)	41
Single dwelling – Sydney affordable (gas connection)	46
Single dwelling – Sydney large (gas connection)	41
Single dwelling – Sydney large (no gas connection)	40
Single dwelling – regional NSW (gas connection)	35
Single dwelling – regional NSW (no gas connection)	35
Single dwelling – Southern Highlands (gas connection)	38
Single dwelling – Southern Highlands (no gas connection)	37
Single dwelling – Northern NSW (gas connection)	51
Single dwelling – Northern NSW (no gas connection)	51
Multi dwelling attached houses (gas connection)	45
Multi dwelling attached houses (no gas connection)	44
Multi dwelling low-rise (gas connection)	41
Multi dwelling low-ruse (no gas connection)	41
Multi dwelling high-rise (gas connection)	24
Multi dwelling high-rise (no gas connection)	24

Note: These BASIX scores have been provided by the Department for each case study through the BASIX online tool.

The upper bound assumes that the same amount of CO_2 emissions are saved from switching from an electrical resistance or storage hot water system to one fuelled by gas, solar or low emission electric heat pump for each case study. Further, it is assumed that the additional emissions saved to meet the BASIX energy target are achieved through reduced electricity consumption as a consequence of investing in other measures to lower electricity consumption and comply with the BASIX requirements. Therefore, the upper bound includes benefits associated with thermal comfort as it uses the estimated BASIX scores to estimate benefits. Moreover, the upper bound also includes energy benefits associated with the installation of energy efficient fittings in common areas since these are incorporated within the BASIX score. We note that one limitation with the upper bound method is that we can not attribute what actions result in the highest level of benefits under BASIX.

For both the upper and lower bounds, the emissions savings (and so impact on energy bills) are calculated for 2006 and kept constant in absolute terms over the time horizon. This allows household consumption of energy to change over time, based on factors outside of the control of BASIX.[63]

A.2. Estimating the state-wide benefits of BASIX in New South Wales

The second part of our analysis involved a wider assessment of the costs and benefits of BASIX compliance across New South Wales, focusing on the greenhouse gas emission and water efficiency reductions since its inception.

This section profiles our methodology and assumptions behind estimating the private benefits across New South Wales and estimating the value of avoided electricity network augmentation costs. Appendix B outlines our approach to estimating the greenhouse gas reduction benefits in New South Wales.

A.2.1. Estimating the water and energy use reductions

The below section details how the state-wide energy and water use benefits are estimated.

A.2.1.1. Scaling up of private energy and water use reduction benefits across New South Wales

The first step in estimating the benefits that BASIX has had on New South Wales is to build an aggregate profile of water and efficiency savings attributable to BASIX from its introduction in 2006 to 2010 and to 2050. This step involves scaling up the case study assessments to form a state-wide estimate of the direct energy and water reduction benefits that can be attributable to BASIX.

Our approach involves assuming that all of the single dwelling certificates for the years 2006/07 and 2007/08 could be approximated by one of the four single dwelling case studies. Table A.11 sets out the application of BASIX compliance certificates to each of the single dwelling case studies.

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63 This primarily reflects increased energy demand as households become wealthier as well as new energy intensive technologies such as plasma televisions being developed.

Table A.11: Single dwelling case studies by BASIX region

BASIX Reporting Region	2006/07 Certificates	2007/08 Certificates	Assumed case study
Central Coast	781	750	1
Hunter	1034	1164	1
Illawarra	648	804	1
Mid North Coast	1409	1751	4
Murray/ Murrumbidgee	1304	1501	2
North Coast	1099	1298	4
Northern Tablelands	805	1021	4
Northern Rivers	960	1353	4
Northern Sydney	974	1791	1
Outer Sydney	412	523	1
South Coast	1306	1553	2
Southern Highlands	933	1167	3
Southern Sydney	2802	3502	1
Western	1001	1321	3
Western Sydney	1396	2165	1
TOTAL	**16864**	**21664**	

Source: NSW Department of Planning.

For each of the multi dwelling case studies we have assumed that they are representative of respective project types (attached houses, low-rise units and high-rise units) across New South Wales. This assumption is based on the relative homogeneity of BASIX compliance pathways for these multi dwelling types across New South Wales, and the strong concentration of these developments in the Sydney Metropolitan area.[64] Combining this assumption with the single dwelling assumption provides the following assumed state-wide profile. We have excluded ‘other’ certificates where the certificates do not adequately match one of the case studies. ’Other’ certificates are essentially all regional multi dwelling projects and multi dwelling projects in Sydney not classified as either attached houses, low-rise units or high-rise units.

64 Most regional BASIX Multi Dwelling projects were for developments of several detached houses which were considered adequately represented in case studies 2 to 4.

Table A.12: Estimated state-wide profile of compliance with BASIX (%)

Dwelling type	BASIX case study	Proportion of 06/07 Dwellings	Proportion of 07/08 Dwellings	Average
Single dwelling	Single dwelling - Sydney	36	48	**45**
	Single dwelling – Regional NSW	12	14	**14**
	Single dwelling – Southern Highlands	9	11	**11**
	Single dwelling – Northern NSW	19	24	**23**
Multi dwelling	Attached house	8	8	**1.8**
	Low-rise	4	4	**0.6**
	High-rise	11	11	**0.3**
Total		100	100	**32**

Note: The average figures are used for all years from 2008/09 – 2049/50. Numbers may not add due to rounding. The percentages are based on the assumption that for attached houses there are 5 dwellings in each project; for low-rise there are 8 dwellings in each project; and for high-rise there are 42 dwellings in each project. This excludes a percentage of 'other' certificates that are excluded from the state-wide estimates of net benefits of BASIX – approximately 4 per cent of BASIX certificates.

To include the implications of BASIX when a project does not have a gas connection, we have made assumptions about what proportion of projects fall under the primary and alternative BASIX case study compliance pathways. For each region we have assumed that the split between the primary and alternative case studies is as follows.

Table A.13: Proportion of case studies that are not connected to mains gas

Case study	Proportion assumed not connected to mains gas
Single dwelling – Sydney – large house	27%
Single dwelling – regional NSW	25%
Single dwelling – Southern Highlands	37%
Single dwelling – Northern NSW	59%
Multi dwelling –attached house	27%
Multi dwelling –low-rise	27%
Multi dwelling –high-rise	27%

Source: From Department of Planning BASIX certificates that selected no gas fuelled appliances or systems.

We have also assumed that approximately 50 per cent of all single dwellings in Sydney are within the 'average' house design, 25 per cent within the 'affordable' house design, and 25 per cent with the 'large' house design.

Finally, to estimate the impact of BASIX for New South Wales we have developed a time profile of the number of dwellings complying with BASIX in each year over the period to 2050. For the period 2005 to 2009, we have used the actual number of BASIX certificates that have been generated. For the period 2009 to 2050, we have assumed that the number of BASIX certificates for single dwellings and multi dwellings follows general trends in building approvals for these types of projects. The annual change in the number of BASIX certificates generated for single dwellings has been assumed to reduce by 3.7 per cent each year, while for multi dwellings units it increases by 0.9 per cent each year. These estimates are based on the average change in the number of new building approvals for houses and flats, units or apartments over the past 15 years.[65]

A.2.2. Estimating the benefits from avoided electricity network augmentation

We have estimated the benefits associated with the avoided network electricity augmentation by:

- estimating the total MWh of electricity that is saved in each year of the study time period;
- assuming that the aggregate MWh are saved evenly in each hour of the year;
- assuming a power factor of 0.8 to convert the MWh to a measure of network capacity measured in kVa; and
- multiplying the associated change in kVa by an industry standard annualised cost of network augmentation, namely $140/kVa/year.

A.3. Estimating the costs of BASIX

A.3.1. Estimating the administrative costs of BASIX

We have also estimated the establishment, administrative and development costs of BASIX based on internal information from the Department of Planning. The total cost of administering BASIX between 2005 and 2007/08 is based on actual amounts spent by the Department. For the period from 2008, estimates were formulated based on discussions with the Department.

These costs include establishment costs (incurred in 2004), administration costs (from inception until 2050), and also development costs of the online BASIX tool, including associated research and consultant assistance from between 2005 and 2010. This translates to

[65] Source: ABS 2009: Cat. No. 8731.0, Table 22.

approximately $15 million in net present value terms of administrative costs. From 2015 onwards we have assumed that just under $1 million ($2015) is incurred each year.

A.3.2. Estimates of the cost of BASIX compliance

The cost of complying with BASIX obligations for each of the case studies have been estimated by BMT Quantity Surveyors, taking into account information on the typical BASIX compliance pathways for each of the case study dwelling types. To develop the cost assumptions BMT selected typical dwelling plans, and for the single residential dwelling also considered a larger house. Based on this dwelling plan and information on the compliance pathways, BMT estimated the appliance and building construction costs of complying with BASIX as compared to what might have been expected to be installed in the absence of BASIX.

These costs take into account costs associated with the thermal comfort requirements of BASIX. This is needed as the savings which we estimate for the upper bound of energy benefits are extrapolated from scores based on thermal comfort performance.

A.3.2.1. Adjusting the costs for Renewable Energy Certificate payments

The costs provided by BMT for solar hot water and photovoltaic cells are the total costs without taking into account the potential benefits associated with the generation of renewable energy certificates (RECs) that can be sold following the installation of these appliances. In practice, the rights to the associated RECs are transferred to the company providing the equipment, and the actual price paid by the consumer is the total price less the value of the associated RECs.

The actual cost of installing these solar appliances in order to comply with BASIX is therefore the BMT estimated costs less the value of the associated RECs. For the purpose of this study we have valued the RECs as the average of the spot price from June 2001 until mid-2009, namely $30 per REC.[66] The compliance pathway specifies the numbers of RECs associated with each of the compliance actions, so we have simply multiplied the average REC spot price (ie, $30) by the number of RECs and then subtracted this from the total incremental cost estimated for the case study by BMT.

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[66] Clean Energy Council, *Carbon & Renewable Energy Markets Report 2009,* 2009.

Appendix B. Estimating greenhouse gas emission reduction benefits

BASIX was designed to reduce greenhouse gas emissions by 40 per cent from a benchmark of 3,292 kg of CO_2-e per person each year. The benchmark was based on an estimate of average emissions per person from household energy use in 2004.

To estimate the greenhouse gas emission reduction benefits, we have used NERA's model of the Australian National Electricity Market to forecast the change in greenhouse gas emissions as a consequence of changes in both the total amount of electricity use, and the time of day load profile of electricity use.

B.1. Description of the NERA National Electricity Market Model (NEMM)

The NERA National Electricity Market Model (NEMM) is a stochastic model that has been developed to analyse the implications of market uncertainties on future market prices and the value of generation investments. The NEMM allows investigation of the implications of changing demand and supply conditions, carbon prices, fuel prices and the timing of electricity load on the prices, revenues, generation value, and carbon emissions within the market.

The following modelling steps were taken to estimate greenhouse gas emissions from actual and expected electricity demand:

Step 1: Develop the model parameters

This step involves developing assumptions for the principal drivers for wholesale market prices, namely: fuel prices, load growth, the cost of new generation, carbon emission permit prices, reserve trading standards, and the overall demand and supply equilibrium. Fuel price assumptions and the cost of new generation, and carbon emission permit prices are sourced from ACIL Tasman.[67] Load growth forecasts for each region are obtained from the Australian Energy Market Operator.[68]

Step 2: Develop a generation supply build plan

Having defined the parameters, the model then develops a new generation build plan that will be required to meet the anticipated growth in total and maximum electricity demand. This build plan takes into account the government's Renewable Energy Target obligations and the reserve margins as set out in the market rules.

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[67] ACIL Tasman, (2009), *Fuel resource, new entry and generation costs in the NEM*, A report for the Inter-Regional Planning Committee, February, and as updated for the National Transmission Network Development Plan.

[68] AEMO, (2009), *Electricity Statement of Opportunities for the National Electricity Market.* Melbourne. 2010 information was also obtained from the AEMO website.

Step 3: Estimate market supply curves

The next step is to use information on the marginal cost of generation for each generating unit in the National Electricity Market (NEM) to estimate supply curves for each NEM region. The marginal cost of generation is estimated using information on the thermal efficiency of each generating unit, and forecasts of fuel costs over the analysis period. In addition, the marginal costs are modified by expectations about the cost of carbon emission permits, given the emissions intensity of each generating unit.

Step 4: Estimate half hourly market prices

Having developed electricity generation supply curves for each NEM region, the next step involves estimating the half hourly market prices taking into account the historic hourly load shape and forecasts of the growth in load over the analysis period. By comparing the load to the supply curve, the half hourly price is estimated. This approach assumes that all generators bid at their marginal cost, and so no strategic bidding behaviour is assumed. We are of the opinion that this is a reasonable approximation of the medium to long-term behaviour of the market, which is therefore appropriate for estimating changes in greenhouse gases over the medium to long term.

The estimate of market prices takes into account transmission constraints between the NEM regions.

Step 5: Estimate greenhouse gas emissions

The final step involves using information on the carbon emission factors for each generating unit in the NEM in combination with the estimated generation dispatch to calculate the total emissions for each half hourly period of the day over the entire analysis period. This is summed for each year to estimate the total generation emissions for each region.

B.2. Methodology used to estimate carbon benefits from BASIX

To estimate the benefits arising from a reduction of greenhouse gas emissions, we have used actual and forecast change in electricity demand over the study period to estimate the generation mix that would be dispatched in order to satisfy the demand. Specifically we have:

§ estimated the change in end-use consumer electricity demand in the absence of BASIX ie, the difference between the business as usual case electricity demand and the implied BASIX-reduction in electricity demand (BASIX compliant case), drawing upon the analysis undertaken for each of the case studies and the aggregated change in electricity demand in NSW;

§ factored in the additional generation required to transmit electricity from a generator to the end-user (ie, we have account for transmission network and distribution network losses);

§ modified the time of day demand profile to account for expectations about the likely change in the pattern of demand as a consequence of BASIX (for example reducing more electricity during off-peak periods that are typically supplied by higher carbon emitting black coal generation). This modified profile results in most of the electricity savings occurring on off-peak periods in line with the assumptions surrounding the proportion of total benefits attributable to hot water load;[69]

- considered alternative assumptions about carbon prices into the future, drawing upon estimates developed as part of the Commonwealth Treasury White Paper in response to the Garnaut Review;
- estimated the change in greenhouse gas emissions from electricity generation as a consequence of BASIX;
- added back the change in emissions associated with increased demand for gas as a consequence of switching between electric and gas appliances as a consequence of BASIX; and
- estimated the value of the greenhouse gas emission scheme reductions by multiplying the total reduction in emissions for each year by the carbon price assumption.

B.3. NEMM assumptions

The key assumptions that have been made in the NEMM for this project include:

- carbon emission permit prices; and
- change in the aggregate load and time of day load profile as a consequence of BASIX.

The carbon permit price assumptions used in the analysis are set out in Table C.1. For the period 2005 to 2013 we have based the price on the average spot price of carbon abatement permits in New South Wales through the NSW greenhouse gas abatement scheme, and forecasts of this price.[70] Prices between 2014 and 2026 reflect the forecasts made by Treasury,[71] modified by the Commonwealth government's announcement that it intends to introduce the Carbon Pollution Reduction Scheme after 2013. For the period between 2027 and 2050 we have assumed year on year growth in the carbon price in line with the estimated increases in the Consumer Price Index.

Table C.1 sets out the change in total NEM load assumed to be a consequence of BASIX. These assumptions have been developed having regard to the information collected as part of the case study analysis.

[69] We have also considered the sensitivity of the results to a flat time of day profile, and have found that the choice of profile is very small (the total emissions change by less than 0.005 per cent). This is likely to be a consequence of the relatively small amount of load conserved due to BASIX as a proportion of the total electricity load.

[70] See figure 7.1, page 76, IPART, (2009), Compliance and Operation of the NSW Greenhouse Gas Reduction Scheme during 2008, Report to Minister, July; and Intelligent Energy Systems, *Review of Wholesale Energy Price for Period 2010-2013*, 7 May 2010, p.12.

[71] Australian Government The Treasury (2008), *Australia's Low Pollution Future: The Economics of Climate Change Mitigation Summary*.

Table B.1 Greenhouse gas emission modelling assumptions

Year	Increase in electricity load without BASIX		Carbon price[72]
	Lower bound (GWh)	Upper bound (GWh)	($/tonne)
2005	14.5	19.5	10.37
2006	68.6	147.1	13.08
2007	125.3	239.5	8.26
2008	192.9	354.8	5.75
2009	242.1	448.5	3.89
2010	288.5	537.4	4.83
2011	333.3	623.4	5.44
2012	376.7	706.7	5.59
2013	418.7	787.3	5.73
2014	459.4	865.3	42.18
2015	498.8	940.9	44.96
2016	537.0	1,014.1	47.92
2017	574.0	1,085.0	51.08
2018	609.8	1,153.7	54.46
2019	644.6	1,220.4	58.05
2020	678.3	1,285.0	61.89
2021	711.0	1,347.7	65.97
2022	742.7	1,408.6	70.33
2023	773.5	1,467.7	74.96
2024	803.4	1,525.0	79.91
2025	832.5	1,580.7	85.19
2026	860.7	1,634.9	90.81
2027	888.2	1,687.5	96.81
2028	914.8	1,738.6	103.19

72 Nominal dollars

2029	940.8	1,788.4	110.00
2030	966.1	1,836.9	117.26
2031	990.6	1,884.0	120.19
2032	1,014.6	1,930.0	123.19
2033	1,037.9	1,974.7	126.27
2034	1,060.7	2,018.3	129.43
2035	1,082.9	2,060.9	132.67
2036	1,104.5	2,102.4	135.98
2037	1,125.6	2,142.9	139.38
2038	1,146.3	2,182.5	142.87
2039	1,166.4	2,221.1	146.44
2040	1,186.1	2,258.9	150.10
2041	1,205.4	2,295.9	153.85
2042	1,224.3	2,332.1	157.70
2043	1,242.7	2,367.5	161.64
2044	1,260.8	2,402.2	165.68
2045	1,278.6	2,436.2	169.82
2046	1,295.9	2,469.5	174.07
2047	1,313.0	2,502.2	178.42
2048	1,329.7	2,534.3	182.88
2049	1,346.2	2,565.9	187.45
2050	1,362.4	2,596.8	192.14

Table B.2 Estimated change in CO_2 emissions due to BASIX

Year	Change in emissions from electricity and gas	
	Lower bound (tonnes)	Upper bound (tonnes)
2005	-6,583	-10,744
2006	-37,097	-104,020
2007	-69,359	-164,338
2008	-108,263	- 242,342
2009	-142,114	- 307,547
2010	-172,803	- 367,154
2011	-201,286	- 422,694
2012	-230,003	-478,507
2013	-252,517	-523,277
2014	-267,438	- 554,688
2015	-290,746	- 600,648
2016	-321,423	- 659,239
2017	-341,776	-699,728
2018	-349,210	-717,738
2019	-374,659	-766,768
2020	-370,842	-765,173
2021	-372,555	-773,050
2022	-357,073	-751,272
2023	-377,657	-791,426
2024	-376,628	-794,323
2025	-360,777	-771,702
2026	-348,856	-755,761
2027	-364,532	-793,211
2028	-367,077	-802,269
2029	-369,425	-810,864
2030	-371,599	-819,040

2031	-373,617	-826,833
2032	-375,496	-834,277
2033	-377,251	-841,402
2034	-378,895	-848,233
2035	-380,437	-854,793
2036	-381,889	-861,103
2037	-383,257	-867,180
2038	-384,549	-873,040
2039	-385,772	-878,699
2040	-386,930	-884,168
2041	-388,030	-889,460
2042	-389,074	-894,585
2043	-390,067	-899,553
2044	-391,012	-904,372
2045	-391,911	-909,050
2046	-392,767	-913,593
2047	-393,582	-918,009
2048	-394,358	-922,303
2049	-395,096	-926,480
2050	-395,798	-930,545

Appendix C. Sensitivity testing of the assumed discount rate

The estimation of the costs and benefits associated with BASIX as part of this analysis has been discounted at a real rate of 7 per cent.[73] This is in line with the NSW Treasury guidelines for economic appraisal. This appendix outlines the results of our sensitivity testing around this assumed discount rate to see if the outcome is sensitive to such variations. In addition to the 7 per cent discount rate assumed, we have conducted sensitivity tests using real discount rates of 4 per cent and 10 per cent, in line with the NSW Treasury guidelines for economic appraisal. The results of this sensitivity analysis for Module 1 are given below:

[73] As outlined in Appendix A, our benefits are estimated in nominal terms and so the 7 per cent discount rate has been put into nominal terms to ensure consistency. We have used observed and expected CPI inflation rates to adjust the real discount rate into a nominal rate.

Table C.1 Net benefits assuming a real discount rate of 4 per cent ($)

			Net benefits for 2005 to 2050 per dwelling – lower bound (NPV)	Net benefits for 2005 to 2050 per dwelling – upper bound (NPV)
Single dwellings	Case study 1	- Sydney – average house (gas connection)	5,295	9,660
		- Sydney – large house (gas connection)	-4,939	-574
		- Sydney – large house (no gas connection)		955
		- Sydney – affordable house (gas connection)	6,442	12,510
	Case study 2	- regional NSW (gas connection)	4,391	6,691
		- regional NSW (no gas connection)		-165
	Case study 3	- Southern Highlands (gas connection)	3,043	8,739
		- Southern Highlands (no gas connection)		5,240
	Case study 4	- Northern NSW (gas connection)	5,299	11,384
		- Northern NSW (no gas connection)		2,493
Multi dwellings	Case study 5	- Sydney – attached house (gas connection)	718	10,450
		- Sydney – attached house (no gas connection)		8,010
	Case study 6	- Sydney – low rise (gas connection)	4,052	5,207
		- Sydney – low rise (no gas connection)		3,726
	Case study 7	- Sydney – high rise (gas connection)	4,029	4,312
		- Sydney – high rise (no gas connection)		2,090

Table C.2 Net benefits assuming a real discount rate of 10 per cent ($)

			Net benefits for 2005 to 2050 per dwelling – lower bound (NPV)	Net benefits for 2005 to 2050 per dwelling – upper bound (NPV)
Single dwellings	Case study 1	- Sydney – average house (gas connection)	-1,182	803
		- Sydney – large house (gas connection)	-11,841	-9,857
		- Sydney – large house (no gas connection)		-11,510
		- Sydney – affordable house (gas connection)	129	2,887
	Case study 2	- regional NSW (gas connection)	-2,947	-1,933
		- regional NSW (no gas connection)		-7,011
	Case study 3	- Southern Highlands (gas connection)	-3,954	-1,444
		- Southern Highlands (no gas connection)		-5,055
	Case study 4	- Northern NSW (gas connection)	-2,396	286
		- Northern NSW (no gas connection)		-5,596
Multi dwellings	Case study 5	- Sydney – attached house (gas connection)	-3,807	618
		- Sydney – attached house (no gas connection)		-1,905
	Case study 6	- Sydney – low rise (gas connection)	-87	432
		- Sydney – low rise (no gas connection)		-1,867
	Case study 7	- Sydney – high rise (gas connection)	1,187	1,311
		- Sydney – high rise (no gas connection)		-1,636

Appendix D. Compliance Pathways

D.1. Case Study 1 – Single dwellings - Sydney

PROJECT TYPE	Average	Affordable	Large House	Large House [No Gas]
Number of bedrooms	4	5	5	5
LGA	Blacktown City Council	Blacktown City Council	Baulkham Hills Shire Council	Baulkham Hills Shire Council
Postcode	2148	2148	2153	2153
Suburb	Blacktown	Blacktown	Baulkham Hills	Baulkham Hills
No. of Stories (single or multiple)	2	2	2	2
SITE DETAILS				
Site Area	600m2	450m2	1000m2	1000m2
Roof Area	229m2	173m2	382m2	382m2
Gross Floor Area	240m2	162m2	438m2	438m2
Conditioned Floor Area	216m2	146m2	394m2	394m2
Unconditioned Floor Area	24m2	16m2	44m2	44m2
Swimming Pool (Yes/No)	No	No	No	No
Outdoor Spa (Yes/No)	No	No	No	No
THERMAL COMFORT				
In-Slab Heating	No	No	No	No
Concrete slab on floor?	Yes	Yes	Yes	Yes
Wall materials	Brick veneer	Brick veneer	Brick veneer	Brick veneer
Wall insulation	R-value 1.5	R-value 1.5	R-value 2.0	R-value 2.0
Roof type	Flat ceiling, pitched roof	Flat ceiling, pitched roof	Flat ceiling, pitched roof	Flat ceiling, pitched roof
Roof ventilation	Unventilated	Unventilated	Unventilated	Unventilated
Ceiling insulation	R-value 2.5 (up)	R-value 2.5 (up)	R-value 3 (up)	R-value 3 (up)
Roof insulation	25mm foil faced polystyrene boards and RFL Sarking (R-value 1.7 up)	25mm foil faced polystyrene boards and RFL Sarking (R-value 1.7 up)	25mm foil faced polystyrene boards and RFL Sarking (R-value 1.7 up)	25mm foil faced polystyrene boards and RFL Sarking (R-value 1.7 up)
No. of windows	13	9	24	24
Window area	3.07m2 x 13 = 40m2	3.2m2 x 9 = 28.8m2	3.13m2 x 24 = 75.2m2	3.13m2 x 24 = 75.2m2
Window frame	Standard aluminum	Standard aluminum	Standard aluminum	Standard aluminum
Glazing	Single clear, 5mm	Single clear, 5mm	Single clear, 5mm	Single clear, 5mm
Window shading	600mm eaves	600mm eaves	600mm eaves	600mm eaves
Skylights	Costed in Energy: Natural lighting section	None	Costed in Energy: Natural lighting section	Costed in Energy: Natural lighting section
Suspended floors	No	No	No	No

WATER - TARGET 40	SCORE: 40	40	42	42
Landscape				
Total Area of Garden or Lawn	205m2	154m2	443m2	443m2
Area of indigenous or Low Water Use Species	41m2	20m2	112m2	112m2
Fixtures				
Showerhead Rating	3 star	3 star	3 star	3 star
Toilet Rating	3 star	3 star	3 star	3 star
Kitchen Taps Rating	3 star	3 star	3 star	3 star
Bathroom Basin Taps Rating	3 star	3 star	3 star	3 star
On-Demand Hot Water reticulation System (Yes/No)	No	No	No	No
Alternative Water				
System Type	3,000L rainwater tank	3,000L rainwater tank	4,000L rainwater tank	4,000L rainwater tank
Area diverted to tank	200m2 (roof only)	150m2 (roof only)	288m2 (roof only)	288m2 (roof only)
Alternative Water Supply Connections				
Garden & Lawn	Yes	Yes	Yes	Yes
All toilets	Yes	Yes	Yes	Yes
Laundry	Yes	Yes	Yes	Yes
All Hot Water	No	No	No	No
Drinking and Other Household Water	No	No	No	No
Pool	No	No	No	No
Spa	No	No	No	No

ENERGY - TARGET 40	SCORE: 41	46	41	40
Hot Water System				
Type	Gas instantaneous (5 star efficiency rated)	Gas storage (3 stars)	Gas instantaneous (5 star efficiency rated)	Solar - electric boosted (31-35 RECS)
Heating and Cooling				
Cooling/Heating System Type - Bedroom areas	Reverse cycle 1-phase conditioning (3.5 stars preceding 2010 rating change)	No cooling/heating	Reverse cycle 1-phase conditioning (3.5 stars preceding 2010 rating change)	Reverse cycle 1-phase conditioning (3.5 stars preceding 2010 rating change)
Cooling/Heating System Type - Living areas	Reverse cycle 1-phase conditioning (3.5 stars preceding 2010 rating change)	No cooling/heating	Reverse cycle 1-phase conditioning (3.5 stars preceding 2010 rating change)	Reverse cycle 1-phase conditioning (3.5 stars preceding 2010 rating change)
Ventilation				
Bathroom/Kitchen/Laundry Exhaust (all)	Individual fan ducted to façade or roof which is controlled manually by an on/off switch	Individual fan ducted to façade or roof which is controlled manually by an on/off switch	Individual fan ducted to façade or roof which is controlled manually by an on/off switch	Individual fan ducted to façade or roof which is controlled manually by an on/off switch

Natural Lighting

Bathrooms/toilets lit by skylight	600mm x 600mm (x1)	0	600mm x 600mm (x1)	600mm x 600mm (x1)
Artificial Lighting				
All rooms lit with energy efficient lighting	Yes	Yes	Yes	Yes
Dedicated Fittings	None	None	None	None
Pool and Spa				
Pool Heating System	No pool/spa	No pool/spa	No pool/spa	No pool/spa
Alternative Energy				
PV System Yes/No (Peak kW)	No	No	1 peak KW	1 peak KW
Other				
Cooking - Type of stove/oven installed	Gas cook top, electric oven	Freestanding electric cook top, electric oven (cheapest model)	Gas cook top, electric oven	Electric cook top, electric oven

D.2. Case Study 2 – Single dwelling – regional NSW

PROJECT TYPE	[With gas]	[No gas]
Number of bedrooms	4	4
LGA	Wagga Wagga	Wagga Wagga
Postcode	2650	2650
Suburb	Wagga Wagga	Wagga Wagga
No. of Stories (single or multiple)	2	2
SITE DETAILS		
Site Area	867m2	867m2
Roof Area	269m2	269m2
Gross Floor Area (Conditioned + Unconditioned)	193m2	193m2
Conditioned Floor Area	173.7m2	173.7m2
Unconditioned Floor Area	19.3m2	19.3m2
Swimming Pool (Yes/No)	No	No
Outdoor Spa (Yes/No)	No	No
THERMAL COMFORT		
In-slab heating	No	No
Concrete Slab on floor	Yes	Yes
Wall materials	Brick veneer	Brick veneer
Wall insulation	R-value 2.0	R-value 2.0
Roof type	Flat ceiling, pitched roof	Flat ceiling, pitched roof
Roof ventilation	Unventilated	Unventilated
Ceiling insulation	R-value 3 (up)	R-value 3 (up)
Roof insulation	Foil/sarking	Foil/sarking
No. of windows	10	10
Window area	3.2m2 x 10 = 32m2	3.2m2 x 10 = 32m2
Window frame	Standard aluminum	Standard aluminum
Glazing	Single clear, 5mm	Single clear, 5mm
Window shading	600mm eaves	600mm eaves
Skylights	Costed in Energy: Natural lighting section	Costed in Energy: Natural lighting section
Suspended floor concession	No	No
WATER | TARGET 20	**SCORE | 25**	**25**
Landscape		
Total Area of Garden or Lawn	319m2	319m2
Area of indigenous or Low Water Use Species	160m2	160m2
Fixtures		
Showerhead Rating	3 star	3 star
Toilet Rating	3 star	3 star
Kitchen Taps Rating	3 star	3 star
Bathroom Basin Taps Rating	3 star	3 star
On-Demand Hot Water reticulation System (Yes/No)	No	No
Alternative Water		

System Type	4,000L rainwater tank	4,000L rainwater tank
Collection Area	180.2m2 (roof)	180.2m2 (roof)
Alternative Water Supply Connections		
Garden & Lawn	Yes	Yes
All toilets	Yes	Yes
Laundry	Yes	Yes
All Hot Water	No	No
Drinking and Other Household Water	No	No
Pool	No	No
Spa	No	No
ENERGY | TARGET 25	**SCORE | 35**	**35**
Hot Water System		
Type	Gas instantaneous (5 star efficiency rated)	Solar (electric boosted) - 31-35 RECS
Heating and Cooling		
Cooling System Type - Bedroom areas	Evaporative Cooling	Evaporative Cooling
Cooling System Type - Living areas	Evaporative Cooling	Evaporative Cooling
Heating System Type - Bedroom areas	Gas-fixed flued heater (3 stars)	1-phase air-con (1.5 2009 stars) (3 stars pre-2009 labeling change)
heating System Type - Living areas	Gas-fixed flued heater (3 stars)	1-phase air-con (1.5 2009 stars) (3 stars pre-2009 labeling change)
Ventilation		
Bathroom/Kitchen/Laundry Exhaust (all)	Individual fan ducted to façade or roof which is controlled manually by an on/off switch	Individual fan ducted to façade or roof which is controlled manually by an on/off switch
Natural Lighting		
Bathrooms/toilets lit by skylight	600mm x 600mm (x1)	600mm x 600mm (x1)
Artificial Lighting		
All rooms lit with energy efficient lighting	Yes	Yes
Dedicated Fittings	None	None
Alternative Energy		
PV System Yes/No (Peak kW)	No	No
Other		
Cooking - Type of stove/oven installed	Gas cook top, electric oven	Electric cook top, electric oven

D.3. Case Study 3 – Single dwelling – Southern Highlands

PROJECT TYPE	[With gas]	[No gas]
Number of bedrooms	4	4
LGA	Wingecarribee Shire Council	Wingecarribee Shire Council
Suburb	Moss Vale	Moss Vale
Postcode	2577	2577
No. of Stories (single or multiple)	2	2
SITE DETAILS		
Site Area	867m2	867m2
Roof Area	269m2	269m2
Gross Floor Area (Conditioned + Unconditioned)	193m2	193m2
Conditioned Floor Area	173.7m2	173.7m2
Unconditioned Floor Area	19.3m2	19.3m2
Swimming Pool (Yes/No)	No	No
Outdoor Spa (Yes/No)	No	No
THERMAL COMFORT		
In-slab Heating	No	No
Concrete slab on floor	Yes	Yes
Wall materials	Brick veneer	Brick veneer
Wall insulation	R-value 2.0	R-value 2.0
Roof type	Flat ceiling, pitched roof	Flat ceiling, pitched roof
Roof ventilation	Unventilated	Unventilated
Ceiling insulation	R-value 3 (up)	R-value 3 (up)
Roof insulation	Foil/sarking	Foil/sarking
No. of windows	10	10
Window area	3.2m2 x 10 = 32m2	3.2m2 x 10 = 32m2
Window frame	Standard aluminum	Standard aluminum
Glazing	Single clear, 5mm	Single clear, 5mm
Window shading	600mm eaves	600mm eaves
Skylights	Costed in Energy: Natural lighting section	Costed in Energy: Natural lighting section
Suspended floor concession	No	No
WATER | TARGET 40	**47**	**47**
Landscape		
Total Area of Garden or Lawn	319m2	319m2
Area of indigenous or Low Water Use Species	113m2	113m2
Fixtures		
Showerhead Rating	3 star	3 star
Toilet Rating	3 star	3 star
Kitchen Taps Rating	3 star	3 star
Bathroom Basin Taps Rating	3 star	3 star
On-Demand Hot Water reticulation System (Yes/No)	No	No
Alternative Water		

System Type	5,000L rainwater tank	5,000L rainwater tank
Collection area	219m2 (roof only)	219m2 (roof only)
Alternative Water Supply Connections		
Garden & Lawn	Yes	Yes
All toilets	Yes	Yes
Laundry	Yes	Yes
All Hot Water	No	No
Drinking and Other Household Water	No	No
Pool	No	No
Spa	No	No
Pool & Spa		
Pool Volume	No pool/spa	No pool/spa
ENERGY | TARGET 25	**38**	**37**
Hot Water System		
Type	Gas instantaneous (5 star efficiency rated)	Solar (electric boosted) (26-30 RECS)*
Heating and Cooling		
Cooling System Type - Living areas	Ceiling fans only	Ceiling fans only
Heating System Type - Living areas	Gas fixed flued heater (3 star EER)	Wood heater
Cooling System Type - Bedroom areas	No cooling	No cooling
Heating System Type - Bedroom areas	No heating	No heating
Ventilation		
Bathroom/Kitchen/Laundry Exhaust	Individual fan ducted to façade or roof which is controlled manually by an on/off switch	Individual fan ducted to façade or roof which is controlled manually by an on/off switch
Natural Lighting		
Bathrooms/toilets lit by skylight	600mm x 600mm (x1)	600mm x 600mm (x1)
Artificial Lighting		
All rooms lit with energy efficient lighting	Yes	Yes
Dedicated Fittings	None	None
Alternative Energy		
PV System Yes/No (Peak kW)	No	No
Other		
Cooking - Type of stove/oven installed	Gas cook top, electric oven	Electric cook top, electric oven

D.4. Case Study 4 – Single dwelling – Northern NSW

PROJECT TYPE	[With gas]	[No gas]
Number of bedrooms	4	4
LGA	Tweed Shire Council	Tweed Shire Council
Suburb	Tweed Heads	Tweed Heads
Postcode	2485	2485
No. of Stories (single or multiple)	2	2
SITE DETAILS		
Site Area	867m2	867m2
Roof Area	269m2	269m2
Gross dwelling floor area	193m2	193m2
Conditioned Floor Area	173.7m2	173.7m2
Unconditioned Floor Area	19.3m2	19.3m2
Swimming Pool (Yes/No)	No	No
Outdoor Spa (Yes/No)	No	No
THERMAL COMFORT		
In-slab heating	No	No
Concrete slab on floor	Yes	Yes
Wall materials	Brick veneer	Brick veneer
Wall insulation	R-value 1.5	R-value 1.5
Roof type	Flat ceiling, pitched roof	Flat ceiling, pitched roof
Roof ventilation	Unventilated	Unventilated
Ceiling insulation	R-value 2.5 (down)	R-value 2.5 (down)
Roof insulation	Foil/sarking	Foil/sarking
No. of windows	10	10
Window area	3.2m2 x 10 = 32m2	3.2m2 x 10 = 32m2
Window frame	Standard aluminum	Standard aluminum
Glazing	Single clear, 5mm	Single clear, 5mm
Window shading	600mm eaves	600mm eaves
Skylights	Costed in Energy: Natural lighting section	Costed in Energy: Natural lighting section
Suspended floor concession	No	No
WATER | TARGET 40	**47**	**47**
Landscape		
Total Area of Garden or Lawn	319m2	319m2
Area of indigenous or Low Water Use Species	76m2	76m2
Fixtures		
Showerhead Rating	3 star	3 star
Toilet Rating	3 star	3 star
Kitchen Taps Rating	3 star	3 star
Bathroom Basin Taps Rating	3 star	3 star
On-Demand Hot Water reticulation System (Yes/No)	No	No
Alternative Water		
System Type	5000L rainwater tank	5000L rainwater tank
Collection area	136m2 (roof only)	136m2 (roof only)

Alternative Water Supply Connections		
Garden & Lawn	Yes	Yes
All toilets	Yes	Yes
Laundry	Yes	Yes
All Hot Water	No	No
Drinking and Other Household Water	No	No
Pool	No	No
Spa	No	No
ENERGY | TARGET 40	**51**	**51**
Hot Water System		
Type	Gas - instantaneous (5 stars)	Solar - electric boosted (26-30 RECS)
Heating and Cooling		
Cooling System Type - Living/Bedroom areas	Ceiling fans	Ceiling fans
Heating System Type - Living/Bedroom areas	No heating	No heating
Ventilation		
Bathroom/Kitchen/Laundry Exhaust	Individual fan ducted to façade or roof which is controlled manually by an on/off switch	Individual fan ducted to façade or roof which is controlled manually by an on/off switch
Natural Lighting		
Bathrooms/toilets lit by skylight	600mm x 600mm (x1)	600mm x 600mm (x1)
Artificial Lighting		
All rooms lit with energy efficient lighting	Yes	Yes
Dedicated Fittings	None	None
Alternative Energy		
PV System Yes/No (Peak kW)	No	No
Other		
Cooking - Type of stove/oven installed	Gas cook top, electric oven	Electric cook top, electric oven

D.5. Case Study 5 – Multi dwelling Attached Houses

PROJECT TYPE	[With gas]	[No gas]
ATTACHED DWELLING		
No. Of Building Types	5 Attached House dwellings	
LGA	Bankstown City Council	
Suburb / Postcode	Bankstown / 2200	
PROJECT DETAILS		
Site Area	1021m2	
Roof Area	340m2 (68m2/dwelling)	
Common Areas		
Common Area Type (excluding common garden)	None	
Dwelling Details (each dwelling)		
No. of bedrooms	2 x 2 bedroom 2 x 3 bedroom 1 x 4 bedroom TOTAL = 14 bedrooms	
Gross floor area	2 bedrooms = 89m2 ea 3 bedrooms = 122m2 ea 4 bedroom = 155m2 TOTAL = 577m2	
Conditioned floor area	2 bedrooms = 82.2m2 ea. 3 bedrooms = 112.7m2 ea. 4 bedrooms = 143.1m2	
Unconditioned floor area	2 bedrooms = 6.8m2 ea. 3 bedrooms = 9.3m2 ea. 4 bedrooms = 11.9m2	
WATER | TARGET 40	**SCORE | 41**	
Central Systems and Common Areas (if any)		
Common Gardens	None	
Central Alternative Water Supply	No central alternative water system	
Alternative Water Use (for each supply)	No central alternative water system	
Common Swimming Pools, Spas	No pools or spas	
Common showerhead rating	No common facility	
Common taps rating	No common facility	
Common clothes washer rating	No common facility	
Common toilet rating	No common facility	
Fire Sprinkler Systems	Not identified	
Cooling Tower	No cooling tower (100%)	
Dwellings		
Private Landscape		
Total Area of Garden or Lawn	4 b/r = 134 m2 3 b/r = 88 ea. (x2) 2 b/r = 67m2 ea. (x2) TOTAL = 444m2	

Area of indigenous or Low Water Use Species	2 gardens with some indig/low-water use planting (4 b/r, 3 b/r with encl. sub-floor) 4 b/r (#1) = 67m2 3 b/r (#2) = 44m2 TOTAL = 111m2	
Fixtures		
Showerhead Rating	3 star for all showers in 5 dwellings	
Toilet Rating	3 star for all toilets in 5 dwellings	
Kitchen Taps Rating	3 star for all kitchen taps in 5 dwellings	
Bathroom Taps Rating	3 star for all bathroom taps in 5 dwellings	
Alternative Water		
System Type	Individual tanks x 5 dwellings	
Tank volume	2500L x 5 tanks	
Roof Area diverted to tank	4 b/r = 64m2 3 b/r = 48m2 ea. (x2) 2 b/r = 32m2 ea. (x2) TOTAL = 224 m2	
Overflow directed to: (central tank or other ind. Tank)	None	
Connected to:	Garden = 5 dwellings Toilet = 4 dwellings (4 b/r, 2 x 3 b.r, 1 x 2 b/r #4) Laundry = 3 dwellings (4 b/r, 2 x 3 b/r) No other connections	
THERMAL COMFORT		
In-Slab Heating? (Yes/No)	No	
Wall materials	Cavity masonry walls, >220kg/m2 surface density	
Wall insulation	RFL Sarking (R-value 0.9)	
Roof type	Flat ceiling, pitched roof	
Roof ventilation	Unventilated	
Ceiling insulation	R-value 1.25	
Roof insulation	25mm foil faced polystyrene boards and RFL Sarking (R-value 1.7 up)	
No. of windows/glazed areas	No reliable data	
Window area	No reliable data	
Window frame	Standard aluminium	
Glazing	35m2 e-glass U-value 5.70, SHGC 0.47	
Window shading	600mm eaves	
Skylights	Costed in Energy: Natural lighting section	
ENERGY | TARGET 40	**SCORE | 45**	**44**
Central Systems	None	

Common Areas	None	
Dwellings (for each dwelling)		
Hot Water Systems		
Hot Water System Type	Gas instantaneous x 5 dwellings	3 dwellings = solar electric boosted (#1-3) 2 dwellings = electric heat pump (#4-5)
Efficiency Rating	5 stars x 5	3 x solar = 26-30 RECS 2 x elec heat pumps = 26-30 RECS
Ventilation		
Laundry Exhaust system type	5 x individual fan ducted to façade or roof	
Laundry Operational Control	5 = manual on/off	
Kitchen Exhaust system type	5 = individual fans, ducted to façade or roof	
Kitchen Operational Control	5 = Manual on/off	
Bathroom exhaust system type	5 = ind. fan, ducted to facade or roof	
Bathroom Operational Control	5 = manual on/off	
Cooling/Heating Systems		
Cooling/heating System Type Living	3 dwellings = reverse cycle 1-phase air-conditioning systems (#1-3) (3.5 stars preceding 2010 rating upgrade) 2 dwellings = No heating or cooling (2 b/r #4-5)	
Cooling/heating System Type Bedroom	2 dwellings = reverse cycle 1-phase air-conditioning systems (#1-3) (3.5 stars preceding 2010 rating upgrade) 3 dwellings = No heating or cooling (2 b/r #4-5)	
Artificial Lighting		
All rooms lit with energy efficient lighting	Yes	
Dedicated Fittings	None	
Natural Lighting		
# of sep. bathrooms/toilets lit by skylight	600mm x 600mm (x 5 - 1 per dwelling)	
Appliances		
Cooktop/oven type	3 dwellings = gas cooktop & electric oven (#1-3) 2 dwellings = elec. Cooktop & elec oven (#4-5)	5 dwellings = Elec cooktop & elec oven

Note: Where there are no compliance actions listed in the [No Gas] case, these compliance actions are the same as in the [With Gas] case.

D.6. Case Study 6 – Multi dwelling low-rise

PROJECT TYPE	[With gas]	[No gas]
LOW-RISE UNIT		
Building Types	1 unit building	
LGA	Randwick City Council	
Suburb / Postcode	Randwick / 2031	
Building Heights	3 stories	
Dwelling numbers	8	
PROJECT DETAILS		
Site Area	1490.4m2	
Roof Area	421m2 [38m2/dwg]	
Common Areas		
Common Area Type	1 Car park 2 Ground floor lobbies 2 Hallway/lobbies 0 lifts	
Common Floor Area	Car Park: 80m2 Ground floor lobby: 10m2 (ea.) Hallway/lobby: 10m2 (ea.) TOTAL: 120m2	
Central Systems or Facilities		
Central System or Facility Type(s)	Central Water Tank	
Dwelling Details (each dwelling)		
No. of bedrooms/dwelling	2 x 1 b/r 4 x 2 b/r 2 x 3 b/r	
Gross Floor Area	1 b/r = 59m2 ea. X2 = 118m2 2 b/r = 85m2 ea X 4 = 340m2 3 b/r = 123m2 ea X 2 = 246m2 TOTAL = 704m2	
Conditioned floor area	1 b/r = 55.3m2 ea 2 b/r = 79.7m2 ea. 3 b/r = 115.3m2 ea.	
Unconditioned floor area	1 b/r = 3.7m2 2 b/r = 5.3m2 3 b/r = 7.7m2	
WATER TARGET 40	**43**	
1 Central Systems and Common Areas (if any)		
Common landscape area (lawn + garden)	554m2	
Common Lawn Area	223m2	
Common Garden Area	331m2	
Indigenous/low-water use Species Area	172.1m2	

1a) Alternative Water Supply		
Supply Type	Central Water Tank	
Central tank volume	10000L	
Collection Area	277.9m2	
Overflow diverted	No	
(1b) Common Area Alternative Water Use (for each supply)		
Irrigation of common landscape	220m2	
No. of car wash bays	0	
Central cooling system cooling tower (yes/no)	No cooling tower	
1c) Swimming Pools and Spas		
Volume of pool	No common pool (94%)	
Volume of spa	No common spa (99%)	
1d) Common Area Fixtures		
Taps	No common facility	
Toilet	No common facility	
Showerhead	No common facility	
Clothes Washer	No common laundry	
1e) Fire Sprinkler Systems		
Test water diverted to closed system (yes/no)	Not specified	
1f) Cooling Tower	No cooling tower	
<u>2 Dwellings</u>		
2a) Private Landscape		
Total Area of Garden or Lawn	56.2m2 x 2 dwellings (#1-2) = 112.4m2 total	
Area of indigenous or Low Water Use Species	1 garden = 35.4m2 (#1)	
2b) Fixtures		
Showerhead Rating (3 stars only?)	3 stars for all fixture type in 8 dwellings	
Toilet Rating	3 stars for all fixture type in 8 dwellings	
Taps Rating (kitchen and bathroom)	3 stars for all fixture type in 8 dwellings	
Clothes Washer	5 dwellings = 3 stars (#1-5) 3 dwellings = none (#6-8)	
Dish Washer	5 dwellings = 3 stars (#1-5) 3 dwellings = none(#6-8)	
2c) Alternative Water		
Individual System Type	None	

Dwelling alternative water supply connections	Toilet = 4 dwellings (#1-4) Laundry = 2 dwellings (#1-2) Pvt. Garden = 2 dwellings (#1-2)	
THERMAL COMFORT		
In-slab heating?	No	
Wall materials	Solid reinforced concrete walls, >220kg/m2 surface density	
Wall insulation	None	
Roof type	Skillion roof less than 5 degrees pitch, 10mm plaster below rafters, metal external cladding	
Roof ventilation	Unventilated	
Ceiling insulation	None	
Roof insulation	R-value 2.5 (up) 25mm foil faced polystyrene boards and RFL Sarking (R-value 1.7 up)	
No. of windows/glazed areas	insufficient data	
Window area	insufficient data	
Window frame	Standard aluminum	
Glazing	57.6m2 of e-glass U-value 5.70, SHGC 0.47	
Window shading	1 dwelling with 8m2 of fixed louvre screening (#1)	
Skylights	None	
ENERGY | TARGET 35	**41**	**41**
1 Central Systems	_	
1a) Central Hot Water		
Central System Type	None	
1b) Central Cooling System		
System type	None	
1c) Central Heating System		
System type	None	
1d) Alternative Energy Supply		
System type	None	
1e) Lift systems	None	
1f) Pools & Spas		
Pool heating source	No central pool	
Spa heating source	No central spa	
1g) Saunas		

Heating Source	No central sauna	
1h) Other		
BMS System?	None	
Active power factor correction?	None	
Common area clothes drying line?	None	
1i) Fixtures		
Common area clothes washer rating	No common clothes washer facility	
Common area clothes dryer rating	No common dryer	
2 Common Areas	_	
2a) Ventilation (for each common area)		
Ventilation system type	Car park: Ventilation (exhaust only) Gr. Floor lobby: No Mech. Ventilation Hallways: No mech. Ventilation	
Efficiency Measures	Car park: Carbon monoxide monitor plus VSD fan	
2b) Lighting (for each common area & lift)		
Primary lighting system type: Car Park	Fluorescent	
Primary lighting system type: Ground Floor Lobby Type	Compact fluorescent x 2	
Primary lighting system type: Hallway/Lobby	Compact Fluorescent x2	
Efficiency measure: Car Park	Motion Sensors + timers	
Efficiency measure: Ground Floor Lobby Type	2 x Manual on/timer off	
Efficiency measure: Hallway/Lobby	2 x Manual on/timer off	
BMS (yes/no)? For each common area	No for all	
3 Dwellings (for each dwelling)		
3a) Hot Water Systems		
Hot Water System Type	Gas instantaneous x 8 dwellings	5 dwellings = solar (electric boosted) (#1-5) 3 dwellings = electric heat pump (#6-8)
Efficiency Rating	8 dwellings = 5 stars (#1-8)	5 x solar HWS = 31-35 RECS (#1-5) 3 x Heat pump = 26-30 RECS (#6-8)
3b) Ventilation		

Laundry Exhaust system type	individual fan ducted to façade or roof	
Laundry Ventilation operational control	manual on/off	
Kitchen Exhaust system type	individual fan ducted to façade or roof	
Kitchen ventilation operational control	manual on/off	
Bathroom exhaust system type	individual fan ducted to façade or roof	
Bathroom ventilation operational control	manual on/off	
3c) Cooling Systems		
Living Cooling System Type	4 x 1-phase (#1-4) 4 x No cooling (#5-8)	
Efficiency Rating	4 x 1-phase = 2 2009 stars (5 star pre-2009 standards change) (#1-6)	
Bedroom Cooling System Type	4 x 1-phase (#1-4) 4 x No cooling (#5-8)	
Efficiency Rating	4 x 1-phase = 2 2009 stars (5 star pre-2009 standards change) (#1-5)	
3d) Heating Systems		
Living Heating System Type	4 x 1-phase (#1-4) 4 x No heating (#5-8)	
Efficiency Rating	4 x 1-phase = 2.5 2009 star (5 stars pre-2009 standards change) (#1-6)	
Bedroom Heating System Type	4 x 1-phase (#1-4) 4 x No heating (#5-8)	
Efficiency Rating	4 x 1-phase = 2.5 2009 star (5 stars pre-2009 standards change) (#1-5)	
3e) Artificial Lighting		
All rooms lit with energy efficient lighting	Yes	
Dedicated Fittings	None	
3f) Natural Lighting		
# of sep. bathrooms/toilets lit by skylights	None	
3g) Pool and Spa		
Pool Heating System	No individual pool (99%)	
Spa heating System Type	No individual spa (99%)	
3h) Appliances		
Cooktop/oven type	6 = Gas cooktop and electric oven (#1-6) 2 = electric cooktop & elec oven (#7-8)	8 x electric cooktop & elec oven (all dwellings

Refrigerator rating	4 dwellings = 4 2010 star fridges (5 BASIX stars) (#1-4) 4 dwellings = None (#5-8)	
Dishwasher rating	5 dwellings = 4 stars (#1-5) 3 dwellings = None (#6-8)	
Clothes Washer Rating	5 dwellings = 4 stars (#1-5) 3 dwellings = none (#6-8)	
Clothes Dryer Rating	5 dwelling = 4 stars (#1-5) 3 dwellings = not specified (#6-8)	

Note: Where there are no compliance actions listed in the [No Gas] case, these compliance actions are the same as in the [With Gas] case.

D.7. Case Study 7 – Multi dwelling high-rise

PROJECT TYPE	[With gas]	[No gas]
HIGH-RISE UNIT	Average Choice	
No. of Building Types	1 unit building	
LGA	Sydney City Council	
Suburb	Sydney City	
Postcode	2000	
Building Height	8 stories	
Dwellings	42	
PROJECT DETAILS		
Site Area	4587.4m2	
Roof Area	758m2	
Non-Residential Floor Area	694m2	
Common Areas		
Common Area Type	2 Car Parks 2 garbage rooms 2 Ground floor lobbies 4 Hallway/lobbies 2 Lift cars 2 Plant or Service Rooms	
Floor Area	Car Parks = 80m2 ea. (x2) Garbage rooms = 10m2 ea. (x2) Ground floor = 10m2 (x2) Hallway/lobby = 10m2 (x4) Lift car = n/a Plant or service room = 5m2 (x2) TOTAL = 250m2	
Central Systems or Facilities		
Central System or Facility Type(s)	2 Lifts (average of HR projects with lifts) Central Hot Water System Central water tank	
Dwelling Details (each dwelling)		
No. of bedrooms	1 x 4+ b/r 8 x 3 b/r 21 x 2 b/r 12 x 1 b/r	
Gross Floor Area	1 b/r = 58m2 (x12) = 696m2 2 b/r = 87m2 (x21) = 1827m2 3 b/r = 122m2 (x8) = 976m2 4 b/r = 125m2 (x1) = 125m2 TOTAL AREA = 3624m2	
Conditioned floor area	1 b/r = 57.3 2 b/r = 85.9 3 b/r = 120.5m2 4 b/r = 123.4m2	

Unconditioned floor area	1 b/r = 0.7m2 2 b.r = 1.1m2 3 b/r = 1.5m2 4 b/r = 1.6m2	
WATER | TARGET 40	**44**	**44**
1 Central Systems and Common Areas (if any)		
Common landscape area (garden + lawn)	662m2	
Common Lawn Area	205m2	
Common Garden Area (excluding lawn)	457m2	
Indigenous Species Area	0m2	
1a) Alternative Water Supply		
Central Supply Type	Central water tank	
Tank volume	19,000L	
Collection Area	500.3m2	
Overflow diverted	No	
1b) Alternative Water Use (for each supply)		
Irrigation of common landscape	328m2	
No. of car wash bays	0	
Central cooling system cooling tower (yes/no)	No cooling tower	
1c) Swimming Pools and Spas		
Volume of pool	No central pool (82%)	
Volume of spa	No central spa (96%)	
1d) Common Area Fixtures		
Taps	3 stars x 5 fixtures	
Toilets	No common facility	
Showerhead	No common facility	
Clothes Washer	No common laundry	
1e) Fire Sprinkler Systems		
Test water diverted to closed system (yes/no)	Not specified	
1f) Cooling Tower	No cooling tower (96%)	
2 Dwellings		
2a) Private Landscape		
Total Area of Garden or Lawn	2 dwellings with pvt. Gardens (3 b/r #2-3) = 25.7m2 ea. TOTAL = 51.4m2	
Area of indigenous or Low Water Use Species	1 garden (3b/r #2) = 19.8m2	
2b) Fixtures		
Showerhead Rating (3 stars only?)	3 star x fixtures in 42 dwellings	
Toilet Rating	3 star x fixtures in 42 dwellings	

Taps Rating (kitchen and bathroom combined)	3 star x fixtures in 42 dwellings	
Clothes Washer	22 dwellings = 3 stars 20 dwellings = no appliance	
Dish Washer	24 dwellings = 3 star appliances 18 dwellings = no appliance	
2c) Alternative Water		
System Type	15 dwellings = toilet connection (#1-15) 5 dwellings = laundry connection (#1-5)	
2d) Pool & Spa		
Pool Volume	No individual pool (99%)	
Spa Volume	No individual spa (99%)	
THERMAL COMFORT		
Wall materials	Solid reinforced concrete walls, >220kg/m2 surface density	
Wall insulation	None	
Roof type	Skillion roof less than 5 degrees pitch, 10mm plaster below rafters, metal external cladding	
Roof ventilation	Unventilated	
Ceiling insulation	None	
Roof insulation	R-value 2.5 (up) 25mm foil faced polystyrene boards and RFL Sarking (R-value 1.7 up)	
No. of windows/glazed areas	insufficient data	
Window area	insufficient data	
Window frame	Standard aluminium	
Glazing	302.4m2 of e-glass U-value 5.70, SHGC 0.47	
Window shading	3 dwellings (#1-3) = Sliding aluminium fixed louvre screen to external (8m2 ea.) = 24m2 total	
Skylights	None	
In-Slab Heating? (Yes/No)	No (100%)	
ENERGY | TARGET 20	**24**	**24**
1 Central Systems	_	
1a) Central Hot Water		
Central system Type	Gas-fired boiler	Central solar (electric boosted)
Solar Collector Area	n/a	105m2
1b) Central Cooling System		
System type	None (97%)	
1c) Central Heating System		

System type	None (97%)	
1d) Alternative Energy Supply		
System type	None (97%)	
1e) Lift systems		
System types (all lifts)	gearless traction with V V V F motor (x2)	
Levels serviced (all lifts)	9 (x2)	
1f) Pools & Spas		
Pool Heating System	No central pool (82%)	
Spa Heating System	No central spa (96%)	
1g) Saunas		
Sauna Heating system	No central Sauna (99%)	
1h) Other		
BMS System?	No (80%)	
Active power factor correction?	No (85%)	
Common area clothes drying line?	No (99% of all Class 2 Unit Projects)	
1i) Fixtures		
Common area clothes washer rating	No common laundry (97%)	
Common area clothes dryer rating	No common dryer (97%)	
<u>2 Common Areas</u>	_	
2a) Ventilation (for each common area)		
System Type: Car parks	Car park: ventilation (supply + exhaust) (x2)	
System Type: Garbage Room	ventilation exhaust only (x2)	
System Type: Ground Floor Lobby	No mechanical ventilation (x2)	
System Type: Hallway/Lobby	No mechanical ventilation (x4)	
System Type: Plant or Service Room	ventilation exhaust only (x2)	
Efficiency Measure: Car Park	Carbon Monoxide monitor + VSD fan (x2)	
Efficiency Measure: Garbage Room	n/a	
Efficiency Measure: Ground Floor Lobby	n/a	
Efficiency Measure: Hallway/Lobby	n/a	
Efficiency Measure: Plant or Service Room	Interlocked to light (x2)	
2b) Lighting (for each common area & lift)		
Primary lighting system type: Car Park	Fluorescent x2	
Primary lighting system type: Garbage Room	Fluorescent x2	
Primary lighting system type: Ground Floor Lobby Type	Compact fluorescent x2	
Primary lighting system type: Hallway/Lobby	Compact Fluorescent x4	
Primary lighting system type: Lift Car	Compact Fluorescent x2	
Primary lighting system type: Plant or Service Room	Compact Fluorescent x2	

Efficiency measure: Car Park	Motion sensors and timers (x2)	
Efficiency measure: Garbage Room	Manual on/off x2	
Efficiency measure: Ground Floor Lobby Type	Motion sensors and timers (x2)	
Efficiency measure: Hallway/Lobby	Motion sensors and timers (x4)	
Efficiency measure: Lift Car	connected to lift call button x2	
Efficiency measure: Plant or Service Room	Manual on/ manual off x2	
BMS (yes/no)? For each common area	No to all	
3 Dwellings (for each dwelling)	_	
3a) Hot Water Systems		
Hot Water System Type	Central gas boiler x 42	Central solar (elec) x 42
3b) Ventilation		
Laundry Exhaust system type	All = individual fan ducted to façade or roof	
Laundry Ventilation operational control	All = manual switch on/off	
Kitchen Exhaust system type	All = individual fan ducted to façade or roof	
Kitchen ventilation operational control	All = manual switch on/off	
Bathroom exhaust system type	All = individual fan ducted to façade or roof	
Bathroom ventilation operational control	All = manual switch on/off	
3c) Cooling Systems		
Living Cooling System Type	28 dwellings = 1-phase air-conditioning (#1-28) 14 dwellings = no cooling (#29-42)	
Efficiency Rating	28 x 1-phase = 1 2010 star (3.5 stars pre-2009 standards change) (#1-34)	
Bedroom Cooling System Type	25 dwellings = 1-phase air-conditioning 17 dwellings = No cooling	
Efficiency Rating	25 x 1-phase = 1 2010 star (3.5 stars pre-2009 standards change) (#1-30)	
3d) Heating Systems		
Living Heating System Type	28 dwellings = 1-phase air-conditioning 14 dwellings = no heating	
Efficiency Rating	28 x 1-phase = 1.5 2010 star (3.5 stars pre-2009 standards change) (#1-34)	
Bedroom Heating System Type	25 dwellings = 1-phase air-conditioning 17 dwellings = No heating	

Efficiency Rating	25 x 1-phase = 1.5 2010 star (3.5 stars pre-2009 standards change) (#1-30)	
3e) Artificial Lighting		
All rooms lit with energy efficient lighting	Yes	
Dedicated Fittings	None	
3f) Natural Lighting		
# of sep. bathrooms/toilets lit by skylight	None	
3g) Pool and Spa		
Pool Heating System	No individual pool (99%)	
Spa heating System Type	No individual spa (99%)	
3h) Appliances		
Cooktop/oven type	37 dwellings = gas cooktop & electric oven (#1-37) 5 dwellings = electric cooktop & electric oven (#38-42)	42 dwellings = electric cooktop/electric oven
Refrigerator rating	13 x 4 2009 stars (6 BASIX stars) (#1-13) 29 x no appliance. (#14-42)	
Dishwasher rating	29 x 4 stars (#1-29) 13 x no appliance (#30-42)	
Clothes Washer Rating	17 x 4 stars (#1-17) 25 x no appliance (#18-42)	
Clothes Dryer Rating	25 x 4 stars (#1-25) 17 x no appliance (#26-42)	

Note: Where there are no compliance actions listed in the [No Gas] case, these compliance actions are the same as in the [With Gas] case.

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