Green Building Council of Australia

The Value of Green Star - A Decade of Environmental Benefits

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greenstar Developed by the Green Building Council of Australia

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Executive summary

Since the launch of the Green Star rating system in 2003, hundreds of buildings around Australia have been independently certified for their sustainable design and construction using Green Star rating tools.

A large amount of evidence that illustrates the transformative effect of Green Star on sustainability at the individual building level has been collected to date. However before now, no comprehensive quantitative research has been conducted into the overall impact that Green Star has had on Australia's built environment.

In late 2012, the Green Building Council of Australia (GBCA) conducted a quantitative research study using data from certified projects to quantify the overall impact of Green Star on greenhouse gas emissions, operational energy usage, operational water consumption and construction and demolition waste.

The study utilised data from 428 Green Star certified projects' submissions and compared this data to standard minimum practice benchmarks. The majority of data included in Green Star submissions are estimations of operational performance. There is evidence that confirms such estimates are representative of actual performance. Despite this, it is important to note that many of this study's findings are derived from estimated performance.

KEY FINDINGS

- On average, Green Star certified buildings produce **62% fewer greenhouse gas emissions** than average Australian buildings.
- On average, Green Star certified buildings produce **45% fewer greenhouse gas emissions** than if they had been built to meet minimum industry requirements.
- On average, Green Star certified buildings use **66% less electricity** than average Australian buildings.
- On average, Green Star certified buildings use **50% less electricity** than if they had been built to meet minimum industry requirements.
- On average, Green Star buildings **use 51% less potable water** than average buildings.
- The cumulative savings in green house gas emissions from Green Star certified buildings equates to **172,000 cars removed from our roads,** when compared to average Australian building – that is 625,000 tonnes CO_2 per annum.
- Green Star certified buildings save enough potable water to fill more than **1,300 Olympic swimming pools every year** – that is, over 3,300,000 kL per annum.

- On average, Green Star As Built certified buildings **recycled 96% of their construction and demolition waste**.
- Since Green Star's introduction to the market in 2003, more than **5.5 million square metres of building area have been Green Star certified**.
- Green Star certified buildings **save the equivalent of 76,000 average households' electricity use annually**.
- **37,600 truckloads of construction and demolition waste** has been diverted from landfill due to good waste management practices when constructing Green Star certified buildings.
- **The higher the Green Star certified rating of a building (4, 5 or 6 star) the greater the environmental savings across all key areas** – greenhouse gas emissions, energy use, water consumption, and construction and demolition waste.

The average Green Star office building

Green Star - Office Design and As Built projects account for the majority (58 per cent) of projects included in this study and 70 per cent of rated floor area for the dataset. Green Star office projects are a particularly good dataset for the comparison of area normalised (per metre square) figures with established benchmarks.

The average Green Star – Office building is 15,900 m^2, is located in a CBD and achieves the following environmental outcomes:

	All projects (Average 4.72 Stars)	4 Star	5 Star	6 Star
Size (m^2 NLA)	15,900	11,200	16,900	26,500
Greenhouse gas emissions ($kgCO_2/m^2$/annum)	59	73	58	44
Electricity use (kWh/m^2/annum)	48	64	49	24

Natural gas use (MJ/m2/annum)	116	63	62	293
Water consumption (L/m^2/annum)	500	540	510	430
Construction and demolition waste generated (kg/m^2)	519	367	675	395
Construction and demolition waste to landfill (kg/m^2)	22	23	23	20

1. Introduction

The Green Building Council of Australia (GBCA) was established in 2002 to develop a sustainable property industry in Australia and drive the adoption of green building practices through market-based solutions.

The GBCA's key objectives are to drive the transition of Australia's property industry towards sustainability by promoting green building programs, technologies, design practices and operations as well as the integration of green building initiatives into the mainstream design, construction and operation of buildings and communities.

In order to achieve these objectives, the GBCA launched the Green Star rating system in 2003. Green Star rating tools help the property industry to reduce the environmental impact of buildings, fitouts and communities, improve occupant health and productivity and achieve cost savings, while showcasing innovation in sustainable building practices.

Green Star rating tools are currently available for a variety of building types, including offices, public buildings, retail centres, schools and universities, hospitals, apartment buildings and industrial facilities.

Green Star certification is based on an independent assessment of sustainability outcomes against key impact criteria. Demonstration of compliance with these criteria requires project teams to submit detailed design and construction data for review by an independent assessment panel.

For the purposes of this study, submission data from 428 buildings and fitouts that have achieved Green Star certification since 2003 has been analysed. The analysis compared the results of a Green Star certified project against standard practice benchmarks across four key areas:

- greenhouse gas emissions;
- operational energy usage;
- operational water consumption; and
- demolition and construction waste.

The cumulative savings calculated in these areas represent a decade of environmental benefits provided by Green Star.

1.2 AIMS & OBJECTIVES

The aim of this research study is to quantify the impact of the Green Star rating system on Australia's built environment. The objectives are:

- to compare the environmental impact of Green Star certified buildings and fitouts against standard practice benchmarks for buildings and fitouts;

- to identify the environmental benefit generated by each level of Green Star certification, from 4 Star Green Star through to 5 and 6 Star Green Star;
- to demonstrate the cumulative environmental benefits generated by buildings that have been designed and constructed to Green Star certified standard; and
- to represent the value and ongoing impact of Green Star in accessible language and easy-to-understand graphics.

2. Methodology

The environmental benefits of Green Star certified projects (428 buildings and fitouts) are compared with defined standard practice benchmarks. Environmental benefits are calculated using the below formula:

Environmental benefits	**=**	**Environmental impact if meeting standard practice**	**-**	**Environmental impact if meeting Green Star requirements**

For the purposes of this study, the following methodology was adopted:

1. Collection of data from Green Star submissions and calculation of cumulative environmental impacts
2. Calculation of the expected environmental impacts of same projects if designed/ constructed in accordance with 'standard practice'
3. Assessment of Green Star results in comparison to standard practice case and calculation of variance.

The above comparison was undertaken across four main impact categories:

- greenhouse gas emissions;
- operational energy usage;
- operational water consumption; and
- construction and demolition waste

Details of the comparative assessment methodology for each category are included below.

2.1 ABOUT GREEN STAR DATA

The data used for this study was obtained from the Green Star submission documentation provided by applicants as part of the Green Star certification process.

Green Star submissions are compiled by building or fitout project teams. These teams typically consist of design consultants, architects, project managers, and construction company representatives. Submission data is presented to the GBCA in a number of formats, including completed Green Star calculators, short reports and summary tables.

Project information is submitted in accordance with the Green Star credit compliance requirements that are clearly outlined in each Green Star rating tool's technical manual. Standardised calculators that can be used to demonstrate compliance for many Green Star credits can be found within the Green Star scorecards available on the GBCA website.

This research used data from both 'Design' and 'As Built' certified project submissions across all Green Star rating tools. Green Star - Design ratings are based on design documentation for buildings which must be at 'tender' stage or beyond. Green Star - Design ratings can be achieved for projects at any time from the completion of tender documentation until 24 months after a project's practical completion.

Green Star - As Built ratings are based on an assessment of the sustainability of a finished building, after practical completion. Documentation for Green Star - As Built submissions is provided in the form of commissioning reports, receipts, drawings and confirmations from relevant parties. Green Star - As Built ratings must be achieved within 24 months of a building's practical completion.

A subset of the Green Star - As Built rating tool category is the Green Star - Office Interiors rating tool, which provides office fitouts with an avenue to achieve Green Star - As Built certification.

The same building can receive multiple Green Star ratings, including Green Star - Design, Green Star - As Built and Green Star – Office Interiors. Where a building has achieved both Green Star - Design and a Green Star - As Built certification, the data used within this study has been drawn from the Green Star - As Built submission only. This methodology has been adopted to ensure data accuracy and to eliminate 'double-counting'.

The data for greenhouse gas emissions, operational energy usage and water consumption provided in Green Star submissions is based on calculated predictions. These predictions are determined using rigorous estimation protocols, such as dynamic simulation of energy use.

A recent study[1] of 70 Green Star certified office buildings now in operation found that the predicted mean NABERS Energy rating for these buildings was 4.9 stars, with mean actual performance at a 4.5 Stars NABERS Energy level.

An equal number of buildings (17 per cent each) had a NABERS rating more than 1 Star better or 1 Star worse than predicted. The findings of this study demonstrate that operational performance is similar to predicted performance, albeit slightly lower. The findings of this study support the assumption that Green Star buildings' estimated performance is generally representative of operational performance.

1 Bell, H., Milagre, R., Sanchez, C., 2012," Predicted vs actual greenhouse gas performance in Green Star certified office buildings", AIRAH Achieving the Green Dream Conference, Sydney 2012

2.2 ABOUT DEFINING STANDARD PRACTICE

The environmental impact across defined categories (water, energy etc) of Green Star certified projects is compared to the impact that the same projects would have had if they been designed/built in accordance with standard building practices. For the purpose of the study 'standard practice' control cases* have been defined for:

- operational greenhouse gas emissions;
- operational energy usage;
- water consumption; and
- demolition and construction waste.

*A detailed schedule of assumptions and calculations of 'standard practice' for each category are outlined in **Section 3: Green Star: Environmental benefits.**

In the case of greenhouse gas emissions and operational energy use, standard practice has been identified for standard practice new construction and average existing building stock. In some cases it is possible to compare the impacts of a Green Star certified building to those it could be reasonably expected to have should it have been built in accordance with standard practices. In other instances it is of more benefit to compare the average performance of existing building stock to the estimated performance of Green Star buildings and fitouts.

Due to the lack of regulation in the area of water efficiency in buildings, the standard practice for water consumption is considered to be the same for new and existing buildings. In the case of construction and demolition waste, standard practice is taken to be representative of 2010 levels. The comparison between new and existing is not deemed relevant in this area.

2.3 DATA SAMPLE

The data used for this analysis was obtained from the submission documentation for all Green Star projects certified from 2003 through to October 2012. Out of all certified buildings within the dataset, 73 have achieved Design and As-Built certification. For these 73 buildings, the Design rating submission data has been excluded from this paper.

The data utilised for the study originates from Green Star submissions under the various Green Star rating tools, as follows:

Rating tool	Number of certified buildings[2]	Total certified floor area (m^2)
Office	249	3,957,000
Office Interiors	95	690,000
Education	47	314,000
Healthcare	2	7,000
Industrial	7	242,000
Multi Unit Residential	12	175,000
Retail Centre	14	351,000
Public Buildings	2	10,000
Total	428	5,746,000

The table below displays the state or territory where the buildings and fitouts are located, and the total certified floor area that these buildings and fitouts represent.

State	Number of certified buildings	Total certified floor area (m^2)
ACT	32	506,000
NSW	98	1,584,000
NT	4	16,000
QLD	85	1,060,000

[2] These figures represent all certified projects included in this quantitative study. Figures listed do not include design submissions for buildings that have both design and as-built ratings. Figures represented here are presented exclusive of the Design submission data for the 73 projects that are certified as both Green Star Design and As-Built. This avoids double counting of Design and As-Built submission data relating to the same buildings.

Two certified projects have been excluded from this study. One project is certified through the Green Star Convention Centre PILOT tool and the other is a certified Green Star Custom project. These projects have been excluded because they do not readily compare to other projects included in this study. It is our intention that the GBCA will report on the performance of certified Green Star – Custom Design and As-Built projects in future iterations of this report.

SA	38	341,000
TAS	5	30,000
VIC	131	1,825,000
WA	35	385,000
Total	428	5,746,000

The table below displays the distribution of 4, 5 and 6 Star Green Star certified ratings across the dataset, and the total certified floor area that these buildings and fitouts represent.

Green Star Rating	Number of certified buildings	Total certified floor area (m^2)
4 Stars	173	2,000,000
5 Stars	201	2,625,000
6 Stars	54	1,121,000
Total	428	5,746,000

2.4 LIMITATIONS

While all Green Star rating tools for buildings and fitouts include criteria across nine different impact categories, this study focuses on the four areas most suitable for numeric quantification and comparison to standard practice benchmarks. These are:

- greenhouse gas emissions;
- operational energy usage;
- operational water consumption; and
- demolition and construction waste.

The availability of widely accepted minimum standard practice data in each of these areas has facilitated the determination of standard practice cases and the subsequent generation of meaningful comparisons.

3. Green Star: environmental benefits

3.1 GREENHOUSE GAS EMISSIONS

A conditional requirement for Green Star certification is the provision of a modelled estimate of the operational greenhouse gas emissions associated with the building or fitout. The requirements for estimating greenhouse gas emissions are slightly different for each Green Star rating tool, however in all cases, a comparison has been made against a benchmark, with points awarded for reductions to emissions below that benchmark. Advice and requirements for the calculation of greenhouse gas emissions estimations are available from the GBCA website. For the purposes of this study, an analysis for greenhouse gas emissions has been performed for both:

- New construction, assumed to meet the Green Star Energy Conditional Requirement (Standard Practice new construction);
- Average greenhouse gas emissions of all existing stock in Australia (Average Performance of existing stock).

3.1.1 DATA COLLECTION

An estimate of greenhouse gas (GHG) emission performance is provided in the vast majority of Green Star submissions. In such cases, the data utilised for this study has been retrieved directly from the submission for each project. The result for each project is given in $kgCO_2e/m^2$ annum.

Greenhouse gas emissions data was not readily available for 40 Green Star – Office v1 and v2, and Green Star – Office Interiors submissions[3]. These projects represent 7 per cent of total certified floor area within the dataset. In the case of these 40 projects, the number of Green Star points awarded was used as a proxy for an emissions performance estimate. As the number of points awarded corresponds to greenhouse gas emissions associated with a predicted NABERS score, the predicted greenhouse gas emissions result were estimated with a reasonable degree of accuracy. Points are awarded for greenhouse gas emissions in these rating tools as follows:

Ene-2 points	NABERS result
Conditional Requirement	4 Stars
3	4.5 Stars
6	5 Stars

[3] 40 submissions accounting for 394,262m^2 which is equivalent to 7% of total certified floor area. These projects are early Green Star submissions where the compliance and documentation requirements were slightly different and all submission data was provided in printed hard copies.

9	20% CO_2 reduction on 5 Stars
12	40% CO_2 reduction on 5 Stars
15	60% CO_2 reduction on 5 Stars

The corresponding greenhouse gas emissions value was subtracted from the greenhouse gas emissions associated with a 4 Star NABERS score for the same building. The Net Lettable Area (NLA) was then multiplied to calculate the total annual greenhouse gas emissions saving for each building and fitout. This can be summarised in the following formula:

GHG savings (Scope 1,2 & 3 CO_2-e)	**=**	**NLA * (NABERS 4 Star benchmark GHG intensity – NABERS Rating Corresponding to Ene-2 Points Score)**

This formula represents a conservative estimate i.e. the emissions generated by these buildings is likely to be less than indicated by the Green Star point proxy estimate, as the NABERS rating corresponding to a Green Star Ene-2 points score represents the highest possible greenhouse gas emission levels that a project could generate while still achieving credit points.

3.1.2 DEFINITION OF STANDARD PRACTICE

Standard practice benchmarks have been determined for comparison against Green Star buildings within this study. These benchmarks are the basis for claimed savings associated with Green Star buildings. Note that benchmarks have been formulated for each building type and location. For example a Green Star office building in Brisbane is compared against standard practice office buildings in that location. Likewise a Green Star education building in Melbourne is compared against standard practice education buildings in Melbourne. There are two benchmarks used in this study. These are standard practice new construction and standard practice of existing stock. Information on each benchmark is detailed below.

Standard practice for new construction

The standard practice new construction benchmark is used in this study to compare Green Star building performance against peers that have been built at the same time in compliance with the National Construction Code.

The standard practice for new construction is defined as the conditional requirement in Green Star. This benchmark is approximately equivalent to compliance with the National Construction Code requirements for energy efficiency. Code compliance is assumed in this study to be representative of standard practice buildings, built today.

The conditional requirement for Green Star – Office Interiors v1.1, Green Star – Office v1 and v2, is 4 Star NABERS Energy. In Green Star – Office v3 the benchmark is 110kgCO_2e/m^2annum.

In all other Green Star rating tools, standard practice energy consumption for each building is determined using a Green Star Energy Calculator. The details of how the conditional requirement is calculated are included in the Greenhouse Gas Calculator Guide for each rating tool.

Average performance of existing building stock

The standard practice for existing stock is representative of average performance for all existing buildings, regardless of age. This benchmark has been used to compare Green Star buildings against the average performance of all existing buildings in Australia.

The standard practice for existing stock aligns with the average performance of existing stock or 2.5 Star NABERS Energy for office buildings and fitouts. The 2.5 Star NABERS Energy benchmark represents average in-operation performance for existing office buildings[4].
In the case of non-office buildings seeking Green Star certification, NABERS Energy rating benchmarks are not applicable, therefore cannot be used to determine the points awarded for emissions. It is assumed for buildings other than office that the average performance benchmark of existing building stock is the same percentage higher than standard practice new construction as it is in office buildings. Standard practice existing stock benchmarks for non-office buildings are scaled up from standard practice new construction using the following formula.

Average performance of existing stock	**=**	**Standard practice new construction greenhouse gas emissions**	**x**	**100%+ the % difference between 2.5 star NABERS Energy and 4 star NABERS Energy**

NABERS benchmarks vary across Australian locations. Therefore the percentage difference between 2.5 star NABERS and 4 Star NABERS is calculated for each location and applied accordingly to projects. For example in Sydney 2.5 Star NABERS energy rated building (existing stock) uses 146% more energy than a 4 Star NABERS energy rated building (new construction).
Standard practice is further defined as not including any onsite energy generation, such as co-generation, tri-generation or renewables.

3.1.3 COMPARISON OF GREEN STAR DATA TO STANDARD PRACTICE

The comparison between Green Star certified buildings and standard practice has been calculated using the following formula:

Tons CO_2e, annual saving	**=**	**GHG emissions standard practice building**	**–**	**GHG emissions Green Star certified building**

[4] NABERS Office "NABERS extended to 6 Stars" http://www.nabers.com.au/page.aspx?cid=695

	Standard practice ($tons CO_2$/annum)	Green Star ($tons CO_2$/annum)	Saving ($tons CO_2$/annum)	Relative saving (%)
All Green Star projects compared to new buildings	676,000	375,000	301,000	45%
All Green Star projects compared to existing stock	1,001,000	375,000	625,000	62%

Greenhouse Gas emission reductions by location

Reduction of greenhouse gas emissions in Green Star certified projects in comparison to standard practice for new construction

State	Standard practice ($tons CO_2$/annum)	Green Star ($tons CO_2$/annum)	Saving ($tons CO_2$/annum)	Relative saving (%)
ACT	48,400	21,600	27,000	55%
NSW	196,200	108,200	88,000	45%
NT*	1,600	1,200	400	23%
QLD	126,800	69,800	57,000	45%
SA	27,900	13,000	15,000	53%
TAS*	2,000	900	1,100	53%
VIC	238,700	136,200	102,000	43%
WA	34,800	24,400	10,000	30%
Australia	676,000	375,000	301,000	45%

* It should be noted that the sample sizes for Tasmania and the Northern Territory are very small. The findings presented should therefore not be taken as representative.

Reduction of greenhouse gas emissions in Green Star certified projects compared to the average performance of existing building stock

State	Standard practice ($tonsCO_2$/annum)	Green Star ($tonsCO_2$/annum)	Saving ($tonsCO_2$/annum)	Relative saving (%)
ACT	77,000	21,600	55,000	72%
NSW	286,200	108,200	178,000	62%
NT	2,300	1,200	1000	46%
QLD	164,300	69,800	94,000	58%
SA	43,700	13,000	31,000	70%
TAS	3,200	900	2,300	71%
VIC	375,700	136,200	239,000	64%
WA	48,300	24,400	24,000	50%
Australia	1,001,000	375,000	625,000	62%

Greenhouse gas emissions reductions by Green Star certified star rating

Reduction of greenhouse gas emissions in Green Star certified projects compared to standard practice for new construction

Green Star rating	Standard practice ($tonsCO_2$/annum)	Green Star ($tonsCO_2$/annum)	Saving ($tonsCO_2$/annum)	Relative saving (%)
4 Star	248,000	149,000	99,000	40%
5 Star	296,000	168,000	127,000	43%
6 Star	133,000	58,000	75,000	57%
All ratings	676,000	375,000	301,000	45%

Reduction of greenhouse gas emissions in Green Star certified projects compared to average performance of existing building stock

Green Star rating	Standard practice ($tonsCO_2$/annum)	Green Star ($tonsCO_2$/annum)	Saving ($tonsCO_2$/annum)	Relative saving (%)
4 Star	370,000	149,000	220,000	60%
5 Star	441,000	168,000	272,000	62%
6 Star	190,000	58,000	133,000	70%
All ratings	1,001,000	375,000	625,000	62%

Greenhouse gas emissions reduction by Green Star rating tool

Reduction of greenhouse gas emissions for Green Star certified projects in comparison to standard practice for new construction

Green Star rating tool	Standard practice ($tonsCO_2$/annum)	Green Star ($tonsCO_2$/annum)	Saving ($tonsCO_2$/annum)	Relative saving (%)
Green Star – Education	36,000	23,000	13,000	36%
Green Star – Industrial	37,000	19,000	18,000	48%
Green Star – Multi Unit Residential	17,000	11,000	5,700	34%
Green Star – Office	436,000	233,000	203,000	47%
Green Star – Office Interiors	73,000	61,000	12,000	16%
Green Star – Retail Centre	74,000	27,000	48,000	64%
All Green Star rating tools	676,000	375,000	301,000	45%

Reduction of greenhouse gas emissions for Green Star certified projects in comparison to the average performance of existing building stock

Green Star rating tool	Standard practice ($tonsCO_2$/annum)	Green Star ($tonsCO_2$/annum)	Saving ($tonsCO_2$/annum)	Relative saving (%)
Green Star – Education	56,000	23,000	33,000	59%
Green Star – Industrial	58,000	19,000	39,000	67%
Green Star – Multi Unit Residential	26,000	11,000	14,000	56%
Green Star – Office	646,000	233,000	413,000	64%
Green Star – Office Interiors	100,000	61,000	39,000	39%
Green Star – Retail Centre	110,000	27,000	83,000	76%
All Green Star rating tools	1,001,000	375,000	625,000	62%

3.1.4 GREENHOUSE GAS REDUCTION AS COMPARED TO VARIOUS NABERS RATING LEVELS

Green Star projects are below compared with various levels of performance in the NABERS energy rating scheme. The average Green Star rated building produces 62% fewer greenhouse gas emissions than a 2.5 Star NABERS rated building. NABERS energy does not cover all building types currently Green Star certified. Because the below table is representative of all Green Star projects an equivalent performance level to the quoted NABERS rating has been established for building types other than office (See footnote 5 below for further detail).

Reduction of greenhouse gas emissions of Green Star certified projects in comparison to

NABERS Energy star rating levels

NABERS performance level[5]	NABERS benchmark (tonsCO_2/annum)	Green Star (tonsCO_2/annum)	Saving (tonsCO_2/annum)	Relative saving (%)
0 Star	1,488,000	375,000	1,113,000	75%
1 Star	1,289,000	375,000	914,000	71%
2 Star	1,092,000	375,000	716,000	66%
2.5 Star (average existing stock)	1,001,000	375,000	625,000	62%
3 Star	894,000	375,000	518,000	58%
4 Star (new build standard practice)	676,000	375,000	301,000	45%

The table below compares Green Star Office Design and As Built projects to benchmarks set within the NABERS Energy for Offices rating tool. The comparison to NABERS is able to be made directly for each Green Star certified Office Design and As Built project. Green Star Office Design and As-Built projects on average produce 47% fewer greenhouse gas emissions than the 4 Star NABERS Energy for Offices benchmark.

Reduction of greenhouse gas emissions of Green Star Office Design and As Built certified projects in comparison to various NABERS Energy star rating levels

NABERS performance level	NABERS benchmark (tonsCO_2/annum)	Green Star (tonsCO_2/annum)	Saving (tonsCO_2/annum)	Relative saving (%)
0 Star	942,000	233,000	709,000	75%
1 Star	819,000	233,000	586,000	72%

[5] Note that an equivalent NABERS performance level has had to be established for building types other than Office or Office Interiors. NABERS 4 stars is defined as being equivalent to the new building standard practice benchmark set for all building types other than office. Benchmark performance for buildings other than Office and Office Interiors is scaled up to an equivalent performance level e.g. NABERS 2 star in NSW is 62% higher than NABERS 4 star in GHG intensity.

2 Star	698,000	233,000	465,000	67%
2.5 Star (average existing stock)	646,000	233,000	413,000	64%
3 Star	577,000	233,000	344,000	60%
4 Star (new build standard practice)	436,000	233,000	203,000	47%

3.1.5 GREENHOUSE GAS EMISSIONS FOR GREEN STAR OFFICE PROJECTS

Green Star - Office Design and As Built projects account for the majority (58 per cent) of projects included in this study and represent 70 per cent of rated floor area. Green Star - Office projects are a particularly good data set for comparisons on a normalised (per square metre) basis.

The below figures are greenhouse gas emissions for Green Star Office projects represented on a per square metre basis. These figures demonstrate a significant reduction in greenhouse gas emissions for Green Star certified offices. It is evident that buildings with higher Green Star ratings produce less Greenhouse Gas emissions.

Green Star - Office greenhouse gas emissions

Type	Greenhouse Gas Emissions ($kgCO_2$-e/m^2/annum)
Average performance of existing building stock	163
Standard practice for new construction	110
4 Star	73
5 Star	58
6 Star	44

3.2 OPERATIONAL ENERGY USAGE

All Green Star rating tools for buildings include an Energy category. For the Energy category, operational energy usage must be estimated, with usage broken down by fuel source (for example. electricity, and natural gas). Full details of Energy category requirements are available for each Green Star rating tool via the GBCA website.For operational energy usage, an analysis has been performed for both standard practice new construction and average performance of existing building stock in Australia.

3.2.1 DATA COLLECTION

For the purposes of this study, energy consumption modeling data was obtained from the credit submission of each individual project within the dataset for each fuel source e.g. electricity, natural gas or diesel.

Greenhouse gas emissions data was not readily accessible for 40 Green Star – Office v1 and v2, and Green Star – Office Interiors submissions[6]. These projects represent 7 per cent of the total certified floor area. For these projects an approximation of energy consumption was determined using the known greenhouse gas emission performance for each project and the average energy mix of all similar buildings in the same location (for example 60% electricity, 40% natural gas). Electricity and natural gas consumption has been scaled up to produce the carbon emission value achieved by each project while maintaining the energy mix determined (for example in NSW, 60GJ electricity, 40GJ natural gas results in approximately 16.9 tonnes of CO_2 emissions).

3.2.2 DEFINITION OF STANDARD PRACTICE

Standard practice new construction

The definition of standard practice for energy draws on the definitions for new and existing buildings in relation to greenhouse gas emissions as detailed in the section above.

All Green Star rating tools except Green Star – Office and Green Star – Office Interiors require calculations of standard practice and predicted energy consumption for each building using a Green Star Energy Calculator. The results of these calculations have been used to represent standard practice benchmark for the purposes of this study. Details of how standard practice is calculated are included in the *Greenhouse Gas Calculator Guide* for each rating tool available via the GBCA website.

For office base buildings and office fitouts, energy and operational greenhouse gas emissions estimates are modelled and compared against the NABERS Energy rating scale to determine eligibility for Green Star credit points. As a result, standard practice for operational energy usage is not readily available for these types of Green Star submissions.

[6] 40 submissions accounting for 394,262m^2 which is equivalent to 7% of total certified floor area. These projects are early Green Star submissions where the compliance and documentation requirements were slightly different and all submission data was provided in printed hard copies.

In such cases, standard practice energy consumption has been determined by scaling up energy use in the modelled Green Star building to achieve the standard practice greenhouse gas emission. For example, if the standard practice new construction benchmark (4 Star NABERS) is 40% higher than the modelled performance of a particular Green Star project. The standard practice new construction energy use is equal to the Green Star project energy usage multiplied by 140%.

The standard practice case is further defined as not including any onsite energy generation, such as co-generation, tri-generation or large scale renewables. This methodology excludes the affect of such systems by scaling up the energy usage of the proposed building using a fuel mix representative of a building of similar type (e.g. office) and location (e.g. Melbourne).

Average performance of existing building stock

The definition of average energy consumption for existing stock draws on the definitions for new and existing buildings as detailed in Section 3.1 GREENHOUSE GAS EMISSIONS.

3.2.3 COMPARISON OF GREEN STAR DATA TO STANDARD PRACTICE NEW CONSTRUCTION AND AVERAGE PERFORMANCE OF EXISTING BUILDING STOCK

For the purposes of this study, the estimated energy consumption data obtained from Green Star submissions has been compared with standard practice energy consumption benchmarks for each fuel source to determine energy savings. The following formula has been used for this calculation:

Environmental benefit of Green Star (kWh Electricity, MJ Gas, kL Diesel saved per annum)	**=**	**Energy consumption standard practice building**	**-**	**Energy consumption proposed building**

Summary of savings in operational energy usage in Green Star certified projects

Energy savings	Electricity (MWh)	Electricity (%)	Natural gas (GJ)	Natural gas (%)
All projects compared to new buildings	298,000	50%	(293,000)	(79%)
All projects compared to existing stock	580,000	66%	(100,000)	(18%)

Savings in operational energy usage in Green Star certified projects, by location

Savings in operational energy usage in Green Star certified projects in comparison to standard practice for new construction

State	Electricity (MWh)	Electricity (%)	Natural gas (GJ)	Natural gas (%)
ACT	25,800	61%	(9,300)	(19%)
NSW	89,400	49%	(87,600)	(110%)
NT	500	23%	200	57%
QLD	62,000	50%	(88,200)	(175%)
SA	17,500	53%	6,100	46%
TAS	1,900	41%	200	33%
VIC	86,300	49%	(106,800)	(63%)
WA	14,400	39%	(7,300)	(90%)
Australia	298,000	50%	(293,000)	(79%)

Savings in operational energy usage in Green Star certified projects in comparison to the average performance of existing stock

State	Electricity (MWh)	Electricity (%)	Natural gas (GJ)	Natural gas (%)
ACT	50,900	75%	20,900	26%
NSW	172,300	65%	(50,800)	(44%)
NT	1,400	46%	200	66%
QLD	98,400	62%	(72,500)	(110%)
SA	36,100	70%	13,700	66%
TAS	4,800	63%	600	58%
VIC	187,100	68%	(8,000)	(3%)
WA	28,800	56%	(4,100)	(37%)
Australia	580,000	66%	(100,000)	(18%)

Savings in electricity and natural gas for each Green Star certified star rating

Reduction of operational energy usage in Green Star certified projects in comparison to standard practice for new construction

Green Star rating	Electricity saved (MWh)	Electricity saved (%)	Natural gas (GJ)	Natural gas (%)
4 Star	94,000	42%	3,000	3%
5 Star	121,000	47%	(60,000)	(35%)
6 Star	83,000	72%	(237,000)	(242%)
All ratings	298,000	50%	(293,000)	(79%)

Reduction of operational energy usage in Green Star certified projects in comparison to standard practice for existing stock

Green Star rating	Electricity (MWh)	Electricity (%)	Natural Gas (GJ)	Natural Gas (%)
4 Star	201,000	61%	60,000	37%
5 Star	247,000	64%	34,000	13%
6 Star*	132,000	80%	(195,000)	(139%)
All ratings	580,000	66%	(100,000)	(18%)

* Many of the buildings awarded 6 Star Green Star ratings include natural gas fuelled co-generation or tri-generation systems. This results in significant reductions in grid electricity consumption and increases in natural gas consumption when these buildings are compared to their 4 Star and 5 Star Green Star certified counterparts.

Reduction in operational energy usage in Green Star certified projects in comparison to standard practice for new construction

Green Star rating tool	Electricity (MWh)	Electricity (%)	Natural gas (GJ)	Natural gas (%)
Green Star - Education	15,600	54%	(62,900)	(127%)
Green Star - Industrial	16,400	51%	4,600	74%
Green Star - Multi Unit Residential	5100	40%	(4,300)	(14%)
Green Star – Office	200,800	52%	(209,000)	(83%)
Green Star - Office Interiors	12,600	20%	(7,700)	(45%)
Green Star - Retail Centre	44,400	65%	(13,800)	(81%)

All Green Star rating tools	298,000	50%	(293,000)	(79%)

Reduction in operational energy usage in Green Star certified projects in comparison to standard practice for existing stock

Green Star rating tool	Electricity (MWh)	Electricity (%)	Natural gas (GJ)	Natural gas (%)
Green Star - Education	31,500	70%	(35,300)	(46%)
Green Star - Industrial	34,800	69%	7,500	82%
Green Star - Multi Unit Residential	11400	60%	11,800	26%
Green Star - Office	384,600	67%	(78,800)	(21%)
Green Star - Office Interiors	37,200	42%	(2,300)	(10%)
Green Star - Retail Centre	76,100	76%	(3,900)	(14%)
All Green Star rating tools	580,000	66%	(100,000)	(18%)

3.2.4 CONVERSION OF ON-SITE ENERGY CONSUMPTION TO PRIMARY ENERGY CONSUMPTION

Primary energy or primary fuels are the forms of energy obtained directly from nature. They include non-renewable fuels such as coal and natural gas as well as renewable fuels such as solar, wind and hydro. Expressing the energy use of Green Star buildings as primary energy summarises those buildings' operational impact on the finite energy resources of the world.

Electricity supplied by the grid to end users such as buildings has an associated primary energy coming from a mix of primary fuel sources. In Australia, coal accounts for approximately 80 per cent of primary energy consumption for electricity generation. Natural gas accounts for approximately 15 per cent of this mix. The remaining 5 per cent comes from a range of renewable and non-renewable sources.

For every petajoule of electricity produced in Australia, 3.20 petajoules of primary energy fuel is consumed[7]. To convert onsite electricity consumption to primary energy consumption the following formula is used:

Primary energy consumption (PJ)	=	Electricity consumption (PJ) * 3.20	+	Natural gas consumption (PJ)	+	Other fuel consumption

The below table summarises total primary energy consumption and savings associated with annual operational energy consumption for all projects included in this study.

Primary energy savings	Standard practice (GJ)	Green Star projects (GJ)	Saving (GJ)	Improvement (%)
All projects compared to new buildings	6,922,000	3,958,000	2,964,000	43%
All projects compared to existing stock	10,199,000	3,958,000	6,241,000	61%

The following table displays primary energy savings for each Green Star certification level. The savings results indicate corresponding improvements to primary energy outcomes as the Green Star certification level increases. There are two factors that influence this gradient; lower energy demand from Green Star buildings and on-site energy generation such as co-generation, tri-generation and to a lesser extent on-site renewable energy. These factors impact on-site energy consumption and by extension primary energy consumption.

Reduction in primary energy as a result of operational energy usage in Green Star certified projects in comparison to standard practice for new construction

Green Star rating	Standard practice (GJ)	Green Star projects (GJ)	Savings (GJ)	Improvement (%)
4 Star	2,543,000	1,515,000	1,028,000	40%

[7] Information sourced from 'Energy in Australia 2011', Australian Government Department of Energy and Tourism p. 14-18

5 Star	3,016,000	1,749,000	1,268,000	42%
6 Star	1,362,000	694,000	668,000	49%
All ratings	6,922,000	3,958,000	2,964,000	43%

Reduction in primary energy as a result of operational energy usage in Green Star certified projects in comparison to the average performance of existing stock

Green Star rating	Standard practice (GJ)	Green Star projects (GJ)	Savings (GJ)	Improvement (%)
4 Star	3,771,000	1,515,000	2,256,000	60%
5 Star	4,482,000	1,749,000	2,733,000	61%
6 Star	1,946,000	694,000	1,252,000	64%
All ratings	10,199,000	3,958,000	6,241,000	61%

3.2.5 OPERATIONAL ENERGY USAGE IN GREEN STAR OFFICE BUILDINGS

Green Star - Office Design and As Built projects account for the majority (58 per cent) of projects included in this study and represent 70 per cent of rated floor area. Green Star - Office projects are a particularly good dataset for comparison on a normalised (per square metre) basis.

The figures below demonstrate a significant reduction in electricity consumption for Green Star certified office buildings when compared to existing building stock and to standard practice for new buildings. The table below also illustrates a reduction in average operational electricity usage=, as the Green Star rating level increases.

Natural gas consumption is reduced for the majority of the buildings when compared to existing building stock and to standard practice for new buildings. Those office buildings certified as 6 Star Green Star demonstrate a significantly higher natural gas use than other Green Star projects and are even higher than existing and new building benchmarks. This is due to the uptake of natural gas fired co-generation and tri-generation systems in projects aiming to achieve ‘World Leadership’ outcomes for reductions to greenhouse gas emissions. This trend also increases the normalised natural gas consumption figures quoted for 5 Star Green Star projects, albeit to a lesser extent.

Green Star office operational energy usage

Green Star rating	Electricity consumption (kWh/m^2/annum)	Natural gas consumption (MJ/m^2/annum)
Average performance of existing building stock	145	97
Standard practice for new construction	98	64
4 Star	64	63
5 Star	49	62
6 Star	24	293

3.3 WATER CONSUMPTION

3.3.1 DATA COLLECTION

Green Star rating tools do not require project applicants to model detailed predicted water consumption for the entire building, instead awarding credit points for reductions across four end use categories: heat rejection, amenity potable water, irrigation and unaccounted potable water leakages[8]. For the purposes of Green Star certification, potable water consumption does not consider water consumption for processes that may occur within buildings, such as for industrial or manufacturing uses.

Each of these four end uses consume a percentage of the total amount of water consumed in a standard practice building. The capacity in a building to reduce consumption for each end use is rewarded with Green Star points. The table below outlines the potable water end use categories, the percentage of water consumed by each in a standard practice building, the corresponding number of points available in the Green Star credit for reducing the water use, and the Green Star credit name.

[8] These categories and the percentage allocation are from Australian Government Department of the Environment and Heritage, *2006 Water Efficiency Guide Office and Public Buildings*.

Potable water end use	Portion of total water consumption over standard practice[9]	Points available in Green Star credit	Green Star category / credit
Heat rejection	30%	4	Cooling tower water consumption
Amenity	40%	5	Occupant amenity potable water
Irrigation	5%	1	Landscape irrigation
Leakage	25%	2	Water meters

The points achieved in each credit were collected for each building and fitout in the sample. The predicted reduction in water consumption was then calculated for each building.

Heat rejection

The table below outlines the reduction in consumption of water for heat rejection based on the number of points achieved.

Credit achievement	Percentage reduction of water for heat rejection end use.
2 points in 'Cooling Tower' credit	50%
4 points in 'Cooling Tower' credit	90%

The 'Cooling Tower' water consumption credit awards two points to projects that can demonstrate a 50 per cent reduction in potable water usage for heat rejection and 4 points for those that can demonstrate a 90 per cent reduction.

Green Star - Office Interiors projects are assumed not to use water for heat rejection. Heat rejection water is therefore excluded from both baseline and reduction calculations for Office Interiors projects.

[9] The percentages of water consumption allocated to each end use are from Australian Government Department of the Environment and Heritage, *2006 Water Efficiency Guide Office and Public Buildings*.

Occupant amenity

Potable water associated with occupant amenity end uses is accounted for within the Green Star 'Occupant Amenity Potable Water' credit. Green Star rating tools award up to five credit points for reductions in occupant amenity water consumption. Each Green Star rating tool includes slightly different benchmark reduction levels, however the maximum points are awarded for around a 70 per cent reduction in potable water consumption. The scale presented below outlines of the approximate averages for occupant amenity end use water consumption for the different Green Star rating tools.

Points awarded in 'Occupant Amenity Water' credit			Percentage reduction of water of occupant amenity end use
Green Star – Retail Centre	Green Star – Office Interiors	All other rating tools	
1-2	**1-3**	**1**	20%
3-4	**4-5**	**2**	40%
5-6	**6-7**	**3**	50%
7-8	**8-9**	**4**	60%
9-10	**10-12**	**5**	70%

Approximately 30 per cent of Green Star – Office Interiors certified fitouts are located within buildings that have also been Green Star certified. These are all included in water reduction calculations, and represent a minor double counting of the efficiency measures for occupant amenity water efficiencies.

The combined area of these fitouts constitutes approximately 4 per cent of the total area of buildings and fitouts included in this study. Double counting only occurs in the occupant amenity section of the water consumption estimation. The occupant amenity is attributed 40 per cent of the total water consumption estimation. Therefore, the maximum possible impact of this double counting equates to less than 1.5 per cent of the total water use reported in this study, and can therefore be considered negligible.

Irrigation

The 'Landscape Irrigation' credit awards one point where a project can demonstrate a 90 per cent or more reduction in potable water consumption for site based landscape irrigation.

Green Star - Office Interiors projects are assumed not to have landscape irrigation as a water end use and this water consumption has therefore been excluded from both baseline and reduction calculations for Office Interiors projects.

Leakage

For the purposes of this study, two assumptions have been made regarding reductions in water consumption due to water metering:

- there is an assumed reduction of 25 per cent in water wastage for new buildings over the level measured in the standard practice baseline case.
- an additional 25 per cent reduction[10] in water wastage is assumed where projects have achieved credit points for water metering. This is based on the assumption that appropriately designed water metering systems will allow building management to identify and minimise water leak and wastage issues.

3.3.2 DEFINITION OF STANDARD PRACTICE

Standard practice for offices and retail centres is defined as water consumption corresponding to a 2.5 Star NABERS Water rating. Standard practice does not include any water collection for recycling or reuse.

Due to the lack of benchmark data for education facilities, public buildings and industrial buildings, NABERS Office benchmarks have been used to represent these building types, with sensitivity testing carried out to determine the impact of this assumption.

Because this subset represents less than 6 per cent of the total certified building area, the use of NABERS Office benchmarks for these building types does not significantly impact the overall environmental outcomes quoted in this study. In addition, the methodology used to calculate water savings in Green Star projects means that water consumption benchmark assumptions do not impact relative water saving (percentage savings) estimates for these projects. As a result, standard practice water consumption has been defined as 2.9kL/m^2/year for retail centres and 1.125kL/m^2/year for all other buildings.

3.3.3 CALCULATING THE WATER CONSUMPTION OF GREEN STAR CERTIFIED BUILDINGS

The water use for each Green Star certified project was calculated as follows:

kL water per annum	**=**	**Standard Practice water use**	**x**	**Building Area**	**x**	**30% x A**	**+**	**40% x B**	**+**	**5% x C**	**+**	**25% x D**

A = *Reduction in potable water consumption from achievement in 'Cooling Tower Water' credit.*

[10] In studies published by Sydney Water, CBRE have reduced water consumption at 140 Sussex St through water monitoring and reduction programs. Wollongong Campus of TAFE NSW-Illawarra Institute has achieved 20% water savings through similar programs. Similarly Pittwater High School reduced leakage from drinking water by 50%.

B = *Reduction in potable water consumption from 'Occupant Amenity Potable Water' credit.*

C = *Reduction in potable water consumption from 'Landscape Irrigation' credit.*

D = *Reduction in unaccounted potable water leakage, due to new plumbing systems, and accounted for in 'Water Meters' credit.*

Please note that in all instances below, the reduction in potable water consumption used is the most conservative value based on the credit outcomes achieved by the Green Star certified projects analysed.

Comparison of Green Star Data to minimum standard practice

Projects	Standard practice (kL/annum)	Green Star (kL/annum)	Saving (kL/annum)	Relative saving (%)
All projects	6,600,000	3,200,000	3,300,000	51%

Potable water consumption savings by Green Star rating tool

Green Star rating tool	Standard practice (kL/annum)	Green Star (kL/annum)	Saving (kL/annum)	Relative saving (%)
Green Star – Education	350,000	230,000	120,000	35%
Green Star – Industrial	270,000	200,000	80,000	28%
Green Star - Multi Unit Residential	200,000	140,000	50,000	28%
Green Star - Office	4,500,000	2,000,000	2,500,000	55%
Green Star - Office Interiors	310,000	70,000	240,000	77%
Green Star - Retail Centre	960,000	590,000	360,000	38%
All Green Star rating tools	6,600,000	3,200,000	3,300,000	51%

Potable water consumption savings by Green Star certified star rating

Green Star certification level	Standard practice (kL/annum)	Green Star (kL/annum)	Saving (kL/annum)	Relative saving (%)
4 Star	2,600,000	1,500,000	1,100,000	43%
5 Star	2,800,000	1,300,000	1,500,000	53%
6 Star	1,200,000	500,000	700,000	61%
All ratings	6,600,000	3,200,000	3,300,000	51%

3.3.4 WATER CONSUMPTION OF GREEN STAR OFFICE BUILDINGS

Green Star - Office Design and As Built projects account for the majority (58 per cent) of projects included in this study and 70 per cent of rated floor area for the dataset. Green Star - Office projects are a particularly good dataset for comparison on a per square metre basis. The below figures are area water consumption figures for Green Star certified offices. These figures demonstrate a significant reduction in water consumption between Green Star office projects and standard practice for existing building stock.

There is a significant reduction in water consumption between existing buildings and Green Star - Office certified buildings in terms of water consumption. There is also an incremental reduction in water consumption as the Green Star certification level increases; from 4 through to 5 and 6 Star Green Star.

Green Star certified office annual water consumption

Green Star certification level	Water consumption (L/m^2/annum)
Existing stock	1,130
4 Star	540
5 Star	510
6 Star	430

3.4 DEMOLITION AND CONSTRUCTION WASTE

3.4.1 DATA COLLECTION

The Green Star credit for construction waste management used in Green Star – Design assessments awards one credit point for a contractual commitment to recycle 60 per cent of all construction and demolition waste, and two credit points for a contractual commitment to recycle 80 per cent of all construction and demolition waste.

For projects with a Green Star – As Built rating, actual reported levels of construction and demolition waste and recycling rates data has been collected from the Green Star submissions. The average commitment at the design stage for those 73 projects that have a Green Star - Design rating as well as a Green Star – As Built rating was 75 per cent. The average recycling rate once construction was complete was 96 per cent. This means that the construction and demolition waste commitments made at the design stage are generally fulfilled, or exceeded for Green Star projects. For Green Star – Design certified projects, it has therefore been assumed that projects with a Green Star – Design rating have followed through on their contractual commitments throughout the construction process.

Green Star – Office Interiors projects are not included in the data sample for construction and demolition waste as the impact from these projects is very small in comparison to other Green Star projects. The quantities of construction and demolition waste for Green Star - Office Interiors projects are many times smaller than that of base building projects with sensitivity testing indicating that the contribution from Green Star - Office Interior fitouts accounts for less than 0.01 per cent of total waste figures included in this study.

3.4.2 DEFINITION OF STANDARD PRACTICE

The national average recycling rate for construction waste is used to define standard practice. According to the Environment Protection and Heritage Council's *National Waste Report 2010*, average recycling rates for construction and demolition waste by mass is 58 per cent. Standard practice waste diverted from landfill is calculated using the following formula:

Tonnes waste diverted from landfill	**=**	**Total amount of C&D waste**	**x**	**National average recycling rate**

In addition to standard practice for recycling rates, total figures for construction and demolition waste were also determined. This was done by reviewing the submission data for Green Star - As Built submissions. The average amount of construction waste generated for buildings (excluding fitout projects) included in this study is 0.5 tonnes of waste per square metre of floor area.

Green Star - Design projects

When determining waste figures for Green Star - Design projects, the above average waste figure for As Built projects has been multiplied by floor area for each project to determine a total construction and demolition waste figure.

Tonnes waste generated	**=**	**Average amount of C&D waste per m^2 floor area (taken from Green Star As Built submissions)**	**x**	**Total rated floor area (m^2)**

3.4.3 COMPARISON OF GREEN STAR DATA TO MINIMUM STANDARD PRACTICE

The additional amount of waste diverted from landfill due to Green Star has been calculated by comparing the reported figures for Green Star projects against national recycling rates for construction and demolition waste using the following formula:

Tonnes waste diverted from landfill	**=**	**Total amount of C&D waste**	**x**	**(Green Star recycling rate – National average recycling rate)**

	Standard practice		Green Star		Improvement	
Green Star rating type	**Waste to landfill (tonnes)**	**Recycling rate (%)**	**Waste to landfill (tonnes)**	**Recycling rate (%)**	**Reduction in waste to landfill (tonnes)**	**Percentage improvement (%)**
As Built Projects	326,000	58%	33,000	96%	293,000	90%
Design Projects	720,000	58%	449,000	74%	271,000	38%
Total	1,046,000	58%	482,000	81%	564,000	54%

Waste diverted from landfill, by Green Star certified star rating – all projects

Construction and Demolition Waste

Green Star certification level	Standard practice waste to landfill (tonnes)	Green Star waste to landfill (tonnes)	Reduction in waste to landfill (tonnes)	Percentage improvement (%)
4 Star	351,000	216000	135000	38%
5 Star	512,000	202000	310000	60%
6 Star	182,000	63000	119000	65%
Total	1,046,000	482,000	564,000	54%

Waste diverted from landfill, by Green Star certified star rating – As Built projects

Construction and demolition waste

Green Star certification level	Standard practice waste to landfill (tonnes)	Green Star waste to landfill (tonnes)	Reduction in waste to landfill (tonnes)	Percentage improvement (%)
4 Star	51,000	7000	43000	85%
5 Star	197,000	16000	181000	92%
6 Star	78,000	9000	69000	88%
All ratings	326,000	33,000	293,000	90%

Waste diverted from landfill, by Green Star certified star rating – Design projects

Construction and Demolition Waste

Green Star certification level	Standard practice waste to landfill (tonnes)	Green Star waste to landfill (tonnes)	Reduction in waste to landfill (tonnes)	Percentage improvement (%)
4 Star	301,000	209000	92000	31%
5 Star	315,000	186000	129000	41%
6 Star	104,000	54000	50000	48%
All ratings	720,000	449,000	271,000	38%

3.4.4 WASTE GENERATION OF GREEN STAR CERTIFIED OFFICES

Green Star - Office Design and As Built projects account for the majority (58 per cent) of projects included in this study and 70 per cent of rated floor area for the dataset. Green Star office projects are a particularly good dataset for comparisons on a normalised (per square metre) basis.

The table below includes waste generation and waste to landfill figures per square metre for 73 Green Star - Office As Built projects. The figures represent real, measured data drawn from monthly waste reporting undertaken by project teams throughout the demolition and construction process. A significant reduction in waste to landfill in comparison to standard practice for new buildings can be seen for Green Star - Office projects. The end waste to landfill figure is very consistent between 4, 5 and 6 Star Green Star projects.

There are a small number of 5 Star Green Star projects whose overall reported waste generation has increased the waste generation figure for the entire sample group. In Green Star certified office buildings there is no discernible correlation between project size and normalised waste generation. Likewise, the size of the project has little impact on reported recycling rates.

Construction and demolition waste generation in Green Star - As Built certified offices

Green Star certification level	Waste generation (kg Waste/m^2)	Waste to landfill (kg Waste/m^2)
Standard practice new construction	519[11]	218
4 Star	367	23
5 Star	675	23
6 Star	395	20

[11] The absolute waste generation figure for typical new buildings is based on an average waste generation figure for all 73 Green Star -As Built projects included in this study. This figure is based on measured waste production from these projects. This figure has been used in the absence of published data on absolute waste production for building projects based on size of the project. The figure is based on data collected from 73 Green Star Office - As Built projects, a statistically significant sample which may be considered representative of new build office projects. This waste generation figure comes from Green Star - As Built projects, all of which have waste management strategies. Waste generation for standard practice new building projects may be much higher than the figure quoted above.

4. Key Findings

KEY FINDINGS INCLUDE:

- On average, Green Star certified buildings produce **62% fewer greenhouse gas emissions** than average Australian buildings.
- On average, Green Star certified buildings produce **45% fewer greenhouse gas emissions** than if they had been built to meet minimum industry requirements.
- On average, Green Star certified buildings use **66% less electricity** than average Australian buildings.
- On average, Green Star certified buildings use **50% less electricity** than if they had been built to meet minimum industry requirements.
- On average, Green Star buildings **use 51% less potable water** than average buildings.
- The cumulative savings in greenhouse gas emissions from Green Star certified buildings equates to **172,000 cars removed from our roads** – that is 625,000 tonnes CO_2 per annum**.**
- Green Star certified buildings save enough potable water to fill **1,320 Olympic swimming pools every year** – that is, over 3,300,000 kL per annum.
- On average, Green Star - As Built certified buildings **recycled 96% of their construction and demolition waste**.
- Since Green Star's introduction to the market in 2003, more than **5.5 million square metres of building area have been Green Star certified**.
- Green Star certified buildings **save the equivalent of 76,000 average households' electricity use annually**.
- **37,600 truckloads of construction and demolition waste** has been diverted from landfill due to good waste management practices when constructing Green Star certified buildings.
- **The higher the certified rating of a Green Star building (4, 5 or 6 Star Green Star) the greater the environmental savings across all key areas** – greenhouse gas emissions, energy use, water consumption, and construction and demolition waste.

The environmental savings in Green Star certified buildings and fitouts is summarised in the graph below:

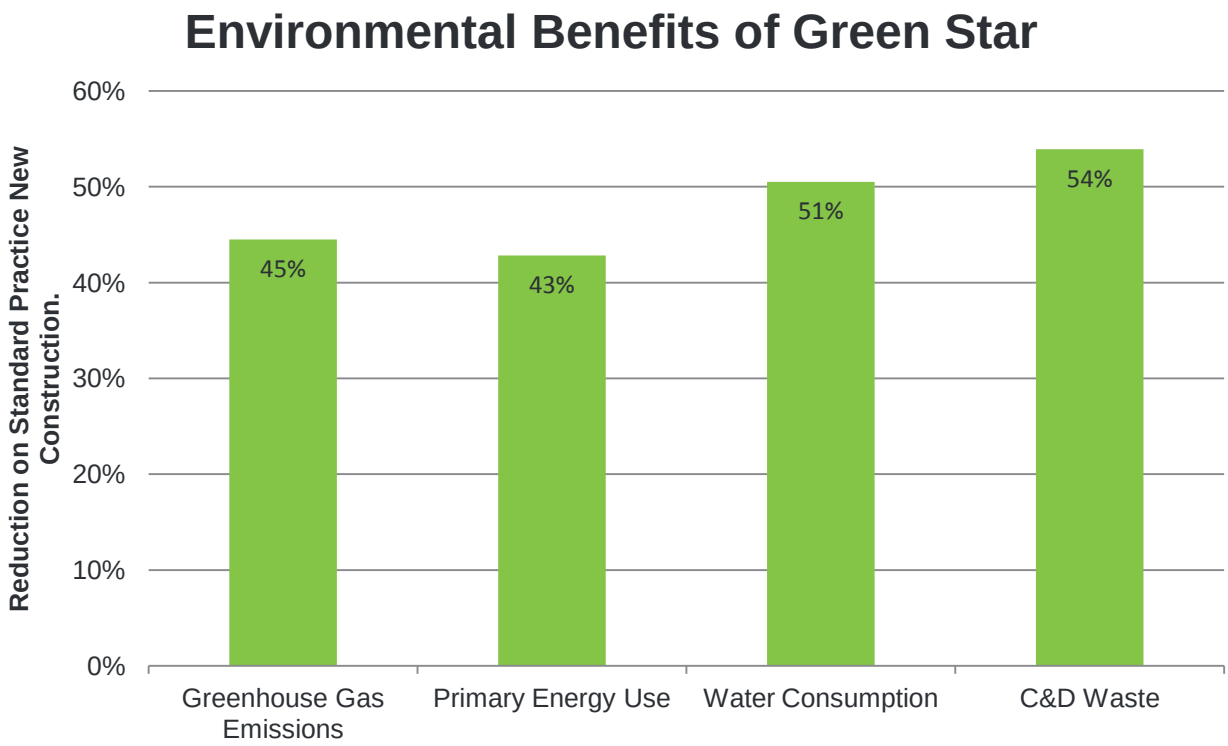

Figure 1: The average reductions in environmental impact of 428 Green Star certified buildings and fitouts when compared to standard practice for newly constructed buildings.

Figure 1 can be interpreted as follows:

- Green Star certified buildings produce 45 per cent fewer greenhouse gas emissions than if they had been built to meet minimum industry requirements.
- The average Green Star certified building or fitout uses 43 per cent less primary energy than a standard practice new building.
- Green Star certified buildings use 51 per cent less potable water than if they had been built to meet minimum industry requirements.
- On average, Green Star certified buildings sent 54 per cent less construction and demolition waste to landfill than standard practice new buildings.

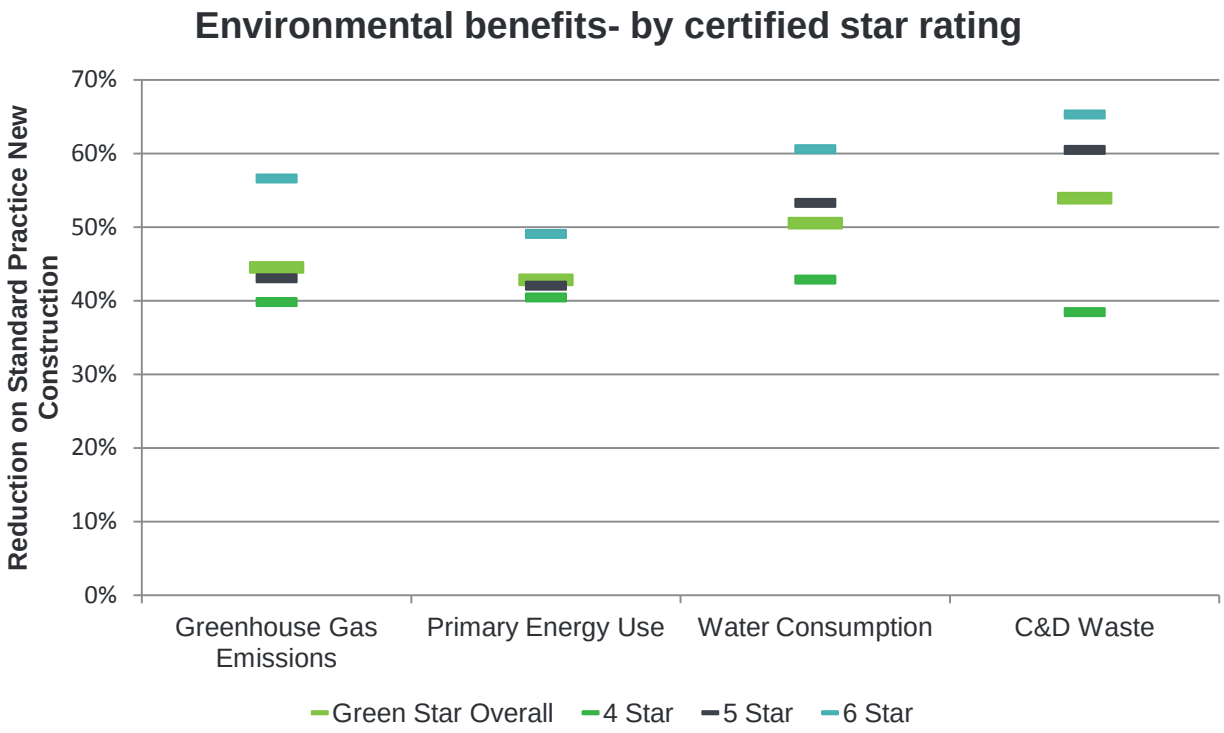

Figure 2: The average reductions in environmental impact of 428 Green Star certified buildings in comparison to standard practice for newly construction buildings, by Green Star rating.

Figure 2 illustrates the reductions in impact for each Green Star certification level. Impacts reduce progressively for 4, 5 and 6 Star Green Star certified buildings. This relationship is further illustrated in the Figures 3, 4, 5, and 6 below.

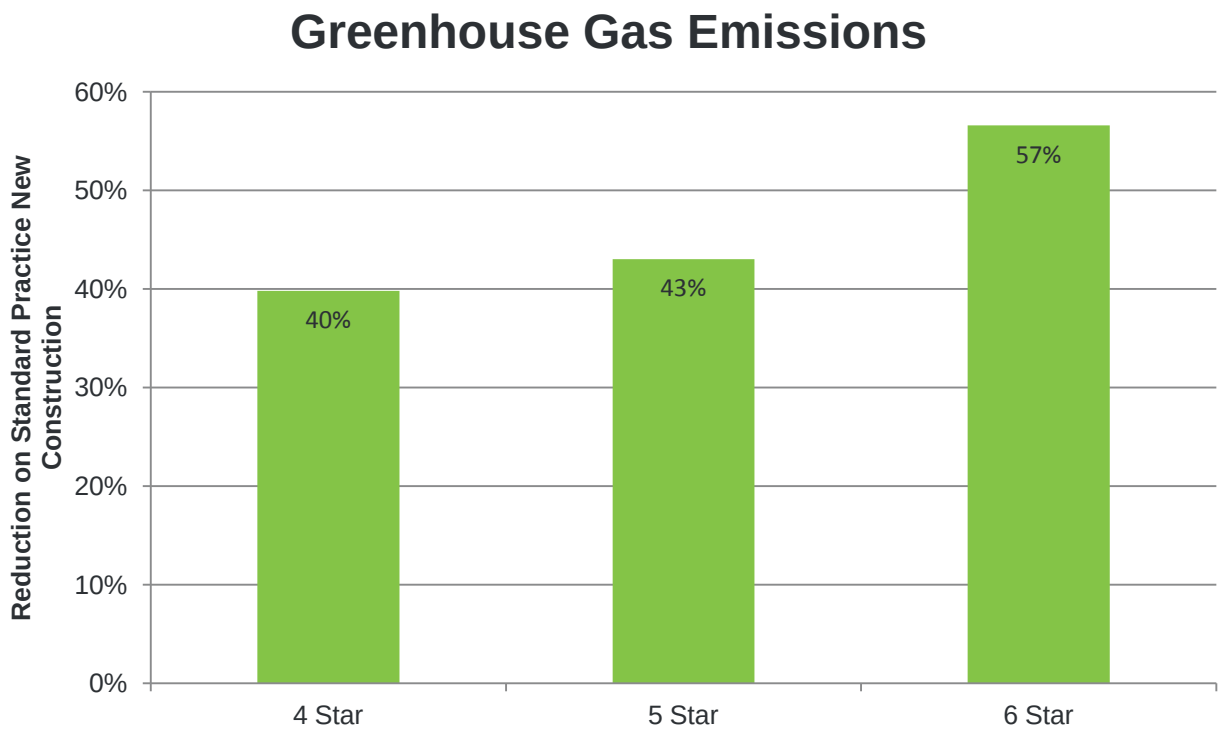

Figure 3: Reductions in greenhouse gas emissions for Green Star certified buildings in comparison to new buildings constructed in accordance with standard practice.

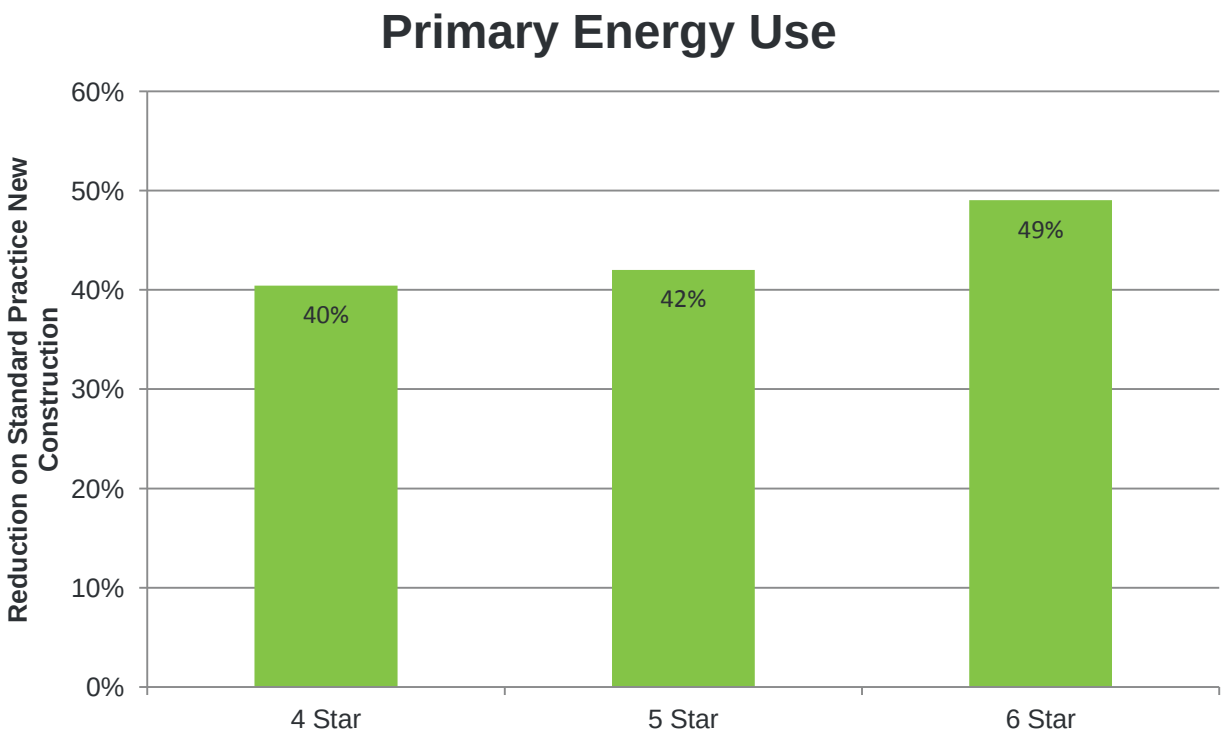

Figure 4: Reductions in primary energy use for Green Star certified buildings in comparison to new buildings constructed in accordance with standard practice.

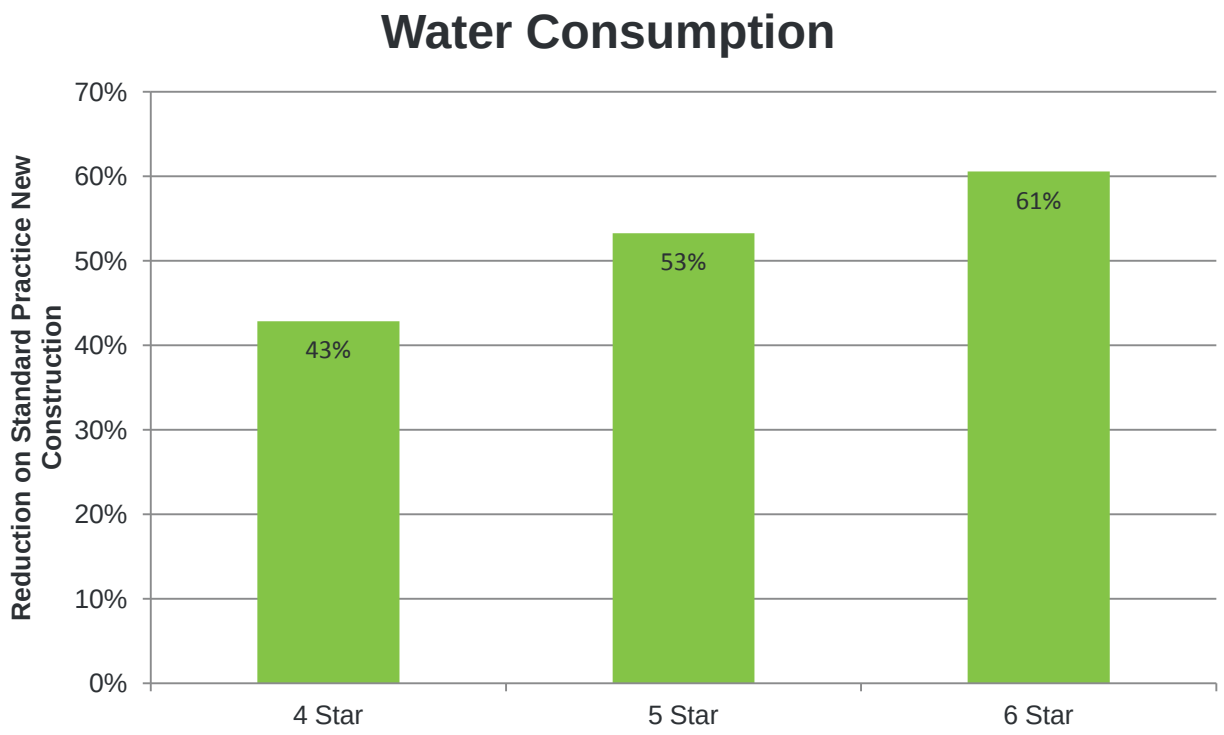

Figure 5: Reductions in water consumption for Green Star certified buildings in comparison to new buildings constructed in accordance with standard practice.

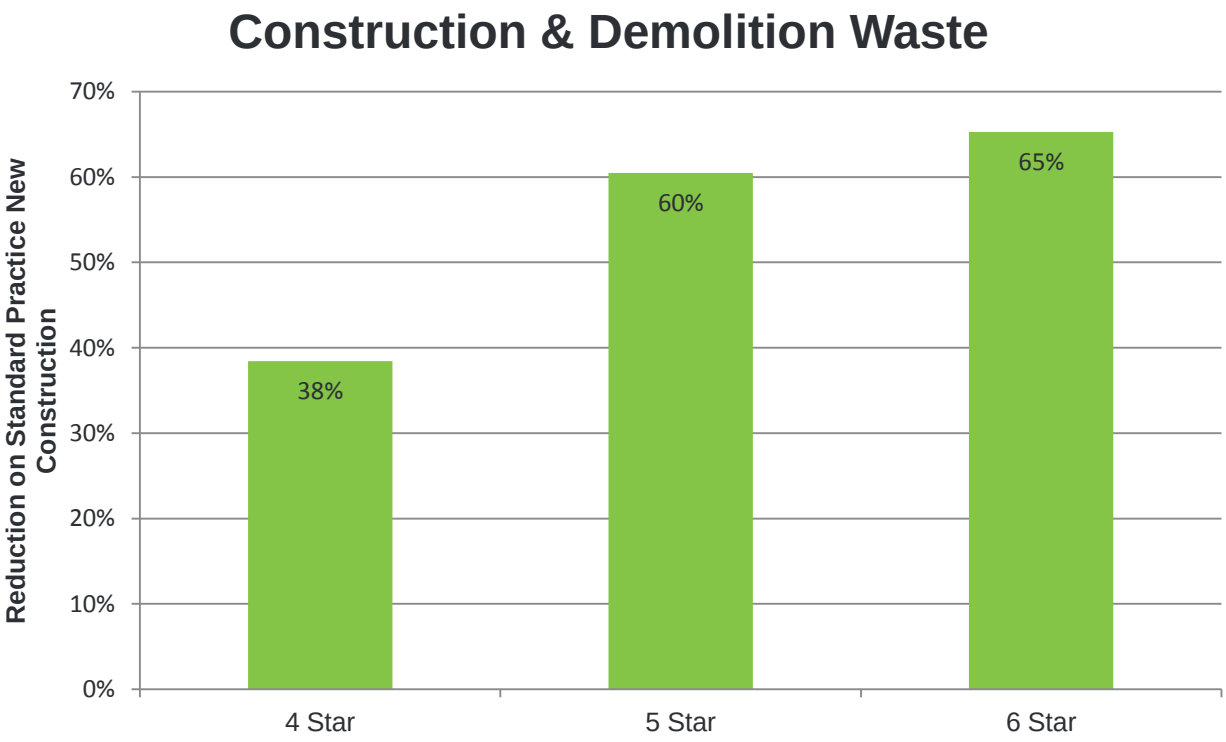

Figure 6: Reductions in construction and demolition waste sent to landfill for Green Star certified buildings in comparison to new buildings constructed in accordance with standard practice.

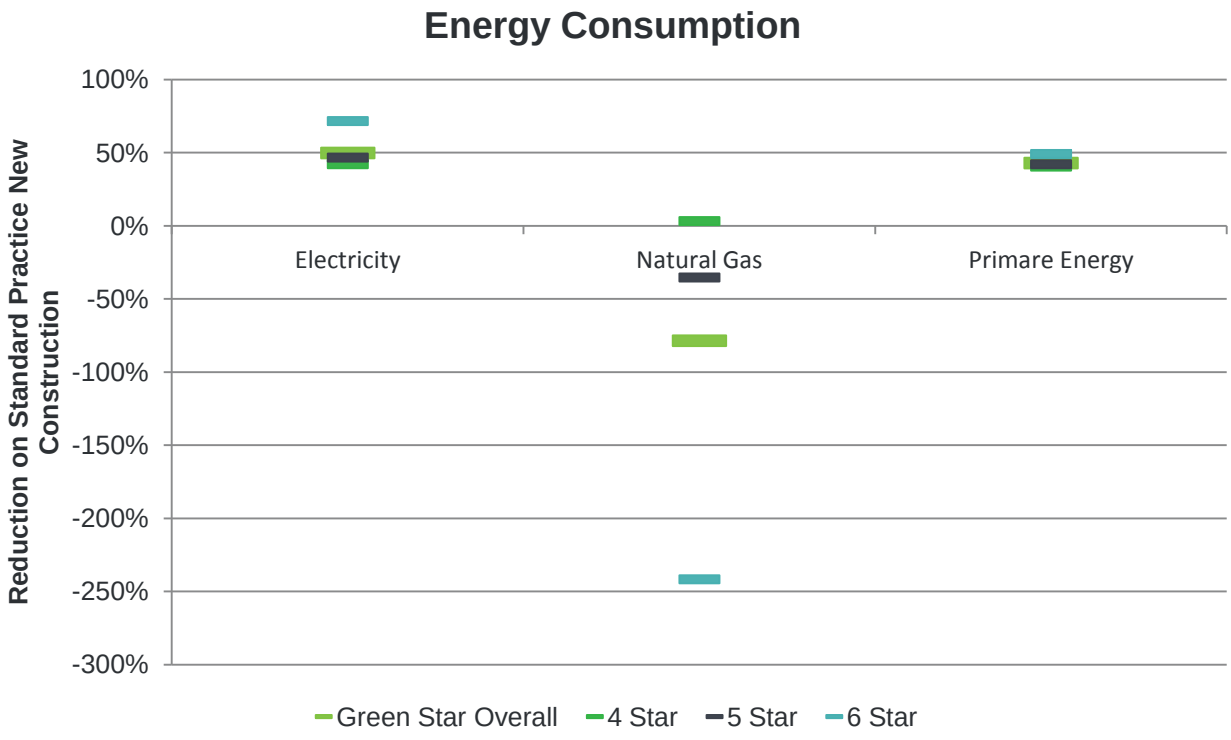

Figure 7: Reductions in energy use (electricity, natural gas and primary energy) in Green Star certified buildings in comparison to new buildings constructed in accordance with standard practice.

The primary energy associated with operating Green Star certified buildings and fitouts is reduced by 43 per cent, on average compared with new buildings constructed in accordance with standard practice. Energy use can also be represented in grid electricity use and natural gas use.

Significant reductions in electricity use are achieved in Green Star certified buildings and fitouts, however natural gas usage increases in buildings with higher Green Star ratings. These increases are attributable to the fact that many of these buildings operate co-generation or tri-generation plants fuelled by natural gas. The use of natural gas fuelled cogeneration and tri-generation systems on Green Star projects included in this report has resulted in reduced greenhouse gas emissions and grid electricity use, with an increase in natural gas consumption.

THE TRACK RECORD OF GREEN STAR

Examples of how the 'track record' of Green Star could be expressed:

- Together, Green Star certified projects save 625,000 tonnes CO_2 each year in comparison to existing stock. This saving is equivalent to taking 172,000 cars off the road every year.
- Together, Green Star certified projects have reduced electricity consumption by 580,000 MWh/year. This reduction is equivalent to 5 per cent of the Hazelwood Power Plant's total annual output.[12]
- Together, Green Star certified projects have reduced electricity usage by 580,000 MWh/year. This is equivalent to 76,000 households' annual electricity[13] consumption.
- Together, Green Star certified projects save 3,300,000 kL of water per year. This is equivalent to the annual water use of 18,000 households[14].
- Together, Green Star certified projects save 3,300,000 kL per year. This is equivalent to 1,300 Olympic swimming pools of water per year.
- Together, Green Star certified projects have diverted 564,000 tonnes of construction and demolition waste from landfill. This is equivalent to 37,600 truckloads.

The average Green Star office building

Green Star - Office Design and As Built projects account for the majority (58 per cent) of projects included in this study and 70 per cent of rated floor area for the dataset. Green Star office projects are a particularly good dataset for the comparison of area normalised (per metre square) figures with established benchmarks.

The average Green Star – Office building is 15,900 m^2, is located in a CBD and achieves the following environmental outcomes:

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[12] GDF SUEZ Australian Energy, Assests, Hazelwood Power Station and Mine http://www.ipplc.com.au/the-company/assets/hazelwood-power-station-and-mine/ Accessed 14 January 2013

[13] Government of South Australia 'How energy is used in the home' http://www.sa.gov.au/subject/Water,+energy+and+environment/Energy/Energy+efficiency/Home+energy+efficiency/How+energy+is+used+in+the+home Accessed 14 january 2013.

[14] Based on daily water use of 500L as set out in http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1345.4Feature%20Article1Jan%202011

	All projects (Average 4.72 Stars)	4 Star	5 Star	6 Star
Size (m^2 NLA)	15,900	11,200	16,900	26,500
Greenhouse gas emissions ($kgCO_2/m^2$/annum)	59	73	58	44
Electricity use (kWh/m^2/annum)	48	64	49	24
Natural gas use (MJ/m^2/annum)	116	63	62	293
Water consumption (L/m^2/annum)	500	540	510	430
Construction and demolition waste generated (kg/m^2)	519	367	675	395
Construction and demolition waste to landfill (kg/m^2)	22	23	23	20

5. Ongoing research into the environmental benefits of Green Star

The data inputs required for this research will be collected continuously as more Green Star projects are certified. An annual report will be compiled to determine the ongoing impact of Green Star upon the key impact areas outlined within this report. Subsequent reports will also include commentary on trends.

The Green Star – Performance rating tool is currently under development by the GBCA and will be used to assess the performance of buildings in operation. Once Green Star – Performance data is available, it will be used to explore the correlation between assumptions or estimates of performance made at the design and construction stage and operational reality, particularly for those projects that achieve Green Star - Design, As Built and Performance certifications.

6. References

1. Australian Bureau of Statistics, 2013 Feature Article: Household Water Consumption and Conservation Actions. http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1345.4Feature%20Article1Jan%202011 Accessed 30 January 2013

2. Australian Government Department of Climate Change and Energy Efficiency, "National Australian Built Environment Rating System (NABERS) What is NABERS? http://www.climatechange.gov.au/government/initiatives/nabers.aspx Accessed 14 January 2013

3. Australian Government Department of the Environment and Heritage, 2006 Water Efficiency Guide Office and Public Buildings p. 5, ISBN 06425 52878

4. Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2013, "Sustainable Transport, Reducing greenhouse gas emissions, Greenhouse gas emissions calculator" http://www.environment.gov.au/settlements/transport/fuelguide/environment.html Accessed 13 January 2013

5. Bell, H., Milagre, R., Sanchez, C., 2012," Predicted vs actual greenhouse gas performance in Green Star certified office buildings", AIRAH Achieving the Green Dream Conference, Sydney

6. Environment Protection and Heritage Council, and Australian Government, Department of the Environment, Water, Heritage and the Arts, 2010 National Waste Report 2010 p.25, ISBN 978-1-921173-53-0

7. Green Star rating tools Greenhouse gas emissions Calculator Guides

8. GDF SUEZ Australian Energy, Assests, Hazelwood Power Station and Mine http://www.ipplc.com.au/the-company/assets/hazelwood-power-station-and-mine Accessed 14 January 2013

9. NABERS Energy http://www.nabers.com.au/page.aspx?cid=533&site=2

10. NABERS Office "NABERS extended to 6 Stars" http://www.nabers.com.au/page.aspx?cid=695 Accessed 5 February 2013

11. \NABERS Water http://www.nabers.com.au/page.aspx?cid=532

12. Sydney Water, 2010. Fact Sheet Building blocks for sustainable water savings
13. Sydney Water, 2009, The Conserver p.4, 2009 Every Drop Counts (EDC) Business Program, Water Efficiency Awards

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INDEPENDENT ASSURANCE STATEMENT

To the Board of Directors, Management and stakeholders of Green Building Council of Australia:

Green Building Council of Australia (GBCA) commissioned Net Balance Management Group Pty Ltd (Net Balance) to provide limited assurance over the calculated benefits of Green Star certification for greenhouse gas emissions, energy consumption, waste, and water, as presented in 'Green Star: A decade of environmental benefits' (the Report). The Report presents calculated benefits from Green Star certification for the period from 2004 to 2012.

Assurance Objectives

The objective of the assurance engagement was to undertake sufficient appropriate audit procedures to allow us to form a limited assurance opinion on the following matter: that nothing became evident to us to indicate that GBCA has not, in all material respects, fairly prepared and presented the calculated benefits from Green Star certification contained in the Report in accordance with the methodology outlined within the Report.

Responsibility

GBCA's management was responsible for development, preparation and presentation of the analysis methodology and subsequent calculated benefits from Green Star certification. This statement represents the assurance provider's independent opinion. Net Balance's responsibility in performing its assurance activities was to the management of GBCA alone and in accordance with the terms of reference agreed with them. We disclaim any assumption of responsibility for reliance on this assurance statement or on the subject matter to which it relates, to any person other than the management of GBCA, or for any purpose other than that for which it was prepared. Other stakeholders should perform their own due diligence before taking any action as a result of this statement.

Assurance Standard and Scope

The limited assurance engagement was conducted in accordance with Australian Standards on Assurance Engagements ASAE3000 Assurance Engagements other than Audits or Review of Historical Financial Information ("ASAE3000") issued by the Australian Auditing and Assurance Standards Board. The engagement covered the calculated benefits from Green Star certification as presented in the Report.

Inherent Limitations

Because of the inherent limitations of any internal control framework and underlying data, it is possible that undetectable data manipulation, error or non-compliance may occur and not be detected. A limited assurance engagement is restricted primarily to enquiries and analytical procedures and the work is less detailed than undertaken for a reasonable assurance engagement.

Assurance Methodology

Net Balance's assurance methodology consisted of evaluating the reliability of the calculated benefits from Green Star certification through the review of systems, processes, information and calculations used to support the metrics. The procedures selected depend on the assurance provider's judgement, including assessment of the risks of material misstatement of the calculated benefits from Green Star certification prepared by GBCA. In making judgements, consideration was given to the internal controls relevant to the calculation and collection of Green Star certification data.

Evidence gathering for the evaluation of reliability and accuracy of the calculated benefits from Green Star certification involved the following:

- Interviews with key personnel to understand the selected performance data metric definitions, data sources, reliability of data, completeness of data and the basis for significant assumptions used in reporting of performance.
- Interviews with key personnel to obtain an understanding of the systems and the process used for data recording, collation and retention for the selected performance data.
- Review of internal and IT controls relevant to the calculation of the selected performance data.
- Re-performance of calculations for a sample of data points.
- Collection and evaluation of documentary evidence.

The engagement did not include any consideration of the reliability of source data.

The assurance engagement was undertaken in March 2013 and the procedures took place at the Head Office of GBCA in Sydney.

Our Independence

The Net Balance assurance team has the required competencies and experience to conduct this engagement. Net Balance confirms that we are not aware of any issue that could impair our objectivity in relation to this assurance engagement. Net Balance has not had any part in collecting and calculating the Green Star benefits or in drafting Report content. Further, in conducting this assurance engagement Net Balance has met the independence requirements of our Independence Policy. A copy of our Policy can be found at http://www.netbalance.com/services/assurance.

Limited Assurance Conclusion

Based on our limited assurance audit procedures, nothing became evident to us to indicate that GBCA has not, in all material respects, fairly prepared and presented the calculated benefits from Green Star certification contained in the Report in accordance with the methodology presented in that Report.

On behalf of the assurance team
22 May 2013
Melbourne, Australia

Simon Dawes
Associate Director, Net Balance