Department of Planning and Environment

dpie.nsw.gov.au

A comprehensive guide to BASIX

The Building Sustainability Index

September 2023

Acknowledgement of Country

The Department of Planning and Environment acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

Published by NSW Department of Planning and Environment

dpie.nsw.gov.au

First published: September 2023

Acknowledgements

Prepared by David Clark, Positive Zero Pty Ltd, on behalf of the NSW Department of Planning and Environment.

Copyright and disclaimer

Contents

What each section covers

Introduction

An overview of what BASIX is and how it works

Thermal performance

Minimum standards for heating and cooling of homes, based on building fabric performance

Energy

Annual energy consumption including heating, cooling, ventilation, domestic hot water, cooking, lighting, lifts, pools/spas and appliances

On-site energy generation

Water

Annual water consumption including showers, toilets, taps, appliances, irrigation, pools/spas, evaporative coolers and cooling towers

Capture and use of recycled water

Materials index (embodied carbon)

The greenhouse gas emissions associated with the production of materials and products used to construct homes and apartment buildings

Appendices

Average thermal loads for energy testing

Benchmarks and greenhouse gas emission factors

Key changes made in 2023

Introduction

What is BASIX?

The Building Sustainability Index (BASIX) has been owned and administered by the NSW Government since 2004. It is a regulatory tool used to assess the energy, water and thermal performance of new residential development as part of the development application process in NSW. The requirements apply to all residential dwelling types (and alterations / additions costing $50,000 or more):

- Class 1 – individual houses
- Class 2 – apartment buildings

Thermal performance

BASIX sets minimum standards for the heating and cooling of homes based on the design of the building fabric. As well as making homes naturally more comfortable in summer and winter, it also helps to reduce energy consumption from space heating and cooling systems. BASIX uses the results of the Nationwide House Energy Rating System (NatHERS) (or a simplified DIY dwelling methodology for houses) for the thermal performance assessment.

Energy and water

The BASIX online assessment tool is an energy and water modelling engine that uses a range of inputs, assumptions and algorithms to estimate annual consumption per person. This is then compared to benchmarks to determine the energy and water scores. Minimum energy and water targets are set for different building types and locations. These are increased periodically to drive continuous improvement in the design and construction of residential development.

Embodied carbon

In 2023 a materials index module was introduced in BASIX to estimate the greenhouse gas (GHG) emissions of materials used in the construction of new houses and apartment buildings. The data gathered will be used to inform the development of future benchmarks and targets to drive reductions in embodied carbon.

Purpose of this guide

How BASIX undertakes calculations is not widely understood. The purpose of this guide is to provide an overview of how the BASIX engine works to estimate energy and water consumption in houses and apartments, and how these outputs can be used to inform design decisions.

The guide does not provide guidance on the regulatory use of BASIX. Please refer to the BASIX website for details on how to undertake and submit BASIX assessments for planning and building approval.

The guide also provides an overview of the new embodied carbon module and the importance of reducing the greenhouse gasses (GHG) associated with the construction of residences.

By providing estimates of energy, water and GHG during the construction and operation of homes, BASIX is more than a regulatory compliance instrument. It is a tool that designers of buildings can utilise during early design stages to optimise designs and deliver homes that are more comfortable for residents, have lower energy and water bills, and significantly reduce GHG emissions.

The outputs from BASIX provide breakdown of energy, water and embodied carbon by categories. This allows users to understand where energy and water is being consumed and to test improvement opportunities. Future updates to BASIX will provide further granularity of the results of the BASIX calculations.

Table 1. How to use BASIX at each stage

Stage	Key design issues	How to use BASIX
Concept design	• Building layout and areas • Building envelope concepts • Electrification target	Consider how the concept design is likely to impact on the BASIX targets and score.
Design development	• Refine layouts • Facade optioneering • Review energy and water systems	• Set up project in BASIX. • Use average apartments to simplify testing of options.
Development application	• Finalise building fabric design • Select energy systems • Select water systems	Obtain a BASIX certificate and submit with stamped drawings to planning authority.

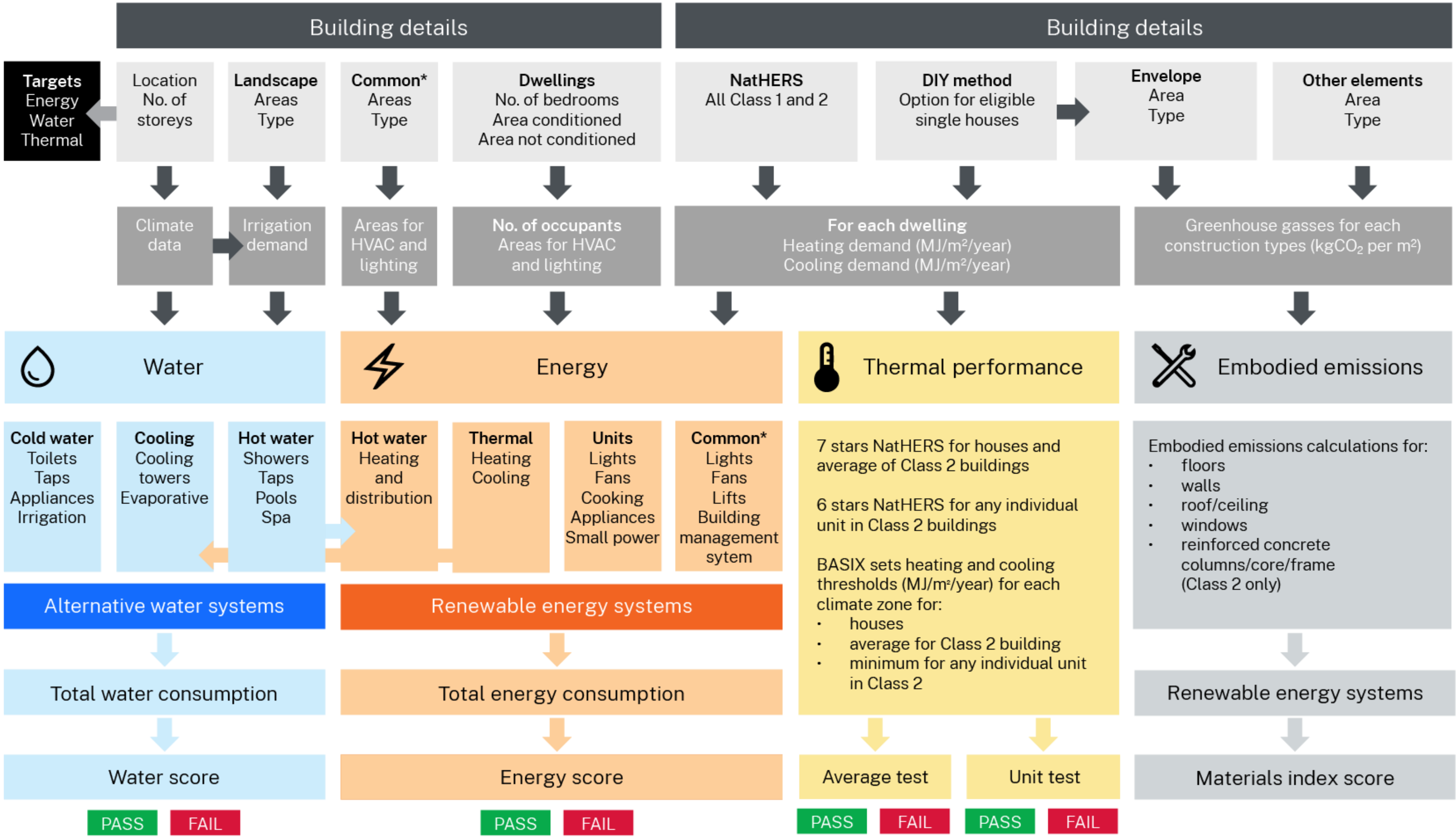
How does BASIX work?

BASIX is an online calculation engine that uses a range of inputs to calculate annual energy and water consumption per person in the home or apartment building. The energy and water scores are the percentage improvement compared to the 2003 benchmarks.

BASIX also sets minimum thermal performance standards for heating and cooling based on the design of the building fabric.

To pass BASIX the building must meet the thermal performance requirements and achieve energy and water scores not less than the minimum targets set based on building type, location and height.

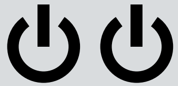
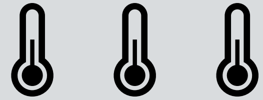
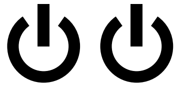
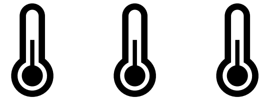
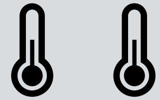
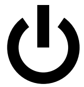
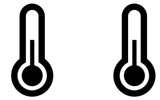
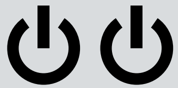
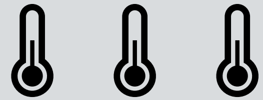
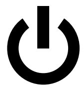
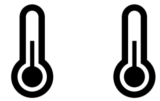
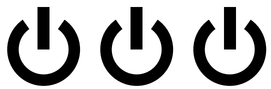
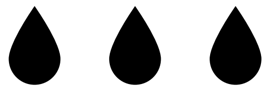
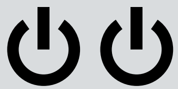
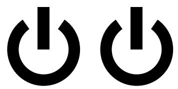
The embodied carbon of the building is also calculated but is currently not subject to a minimum performance requirement.



*common area applicable to Class 2 residential buildings only

Figure 1 How BASIX works

Table 2 Key improvement opportunities in BASIX

	Building type	Energy	Water	Thermal performance
Reduce extent of glazing				
Double glazing with thermally broken frames				
Shading to windows suitable for orientation				
Maximise effectiveness of natural cross flow ventilation				
Increase ceiling insulation				
Increase wall insulation and thermal breaks				
Ceiling fans in bedrooms				
Water efficient showers (< 7.5L/min) and taps				
Heat pumps for domestic hot water				
Energy efficient heating and cooling systems (no gas)				

Maximise natural ventilation of common areas and carparks	🏢	⏻ ⏻		
Good controls on common area ventilation and lighting systems	🏢	⏻		
Energy efficient lifts with regenerative breaking	🏢	⏻ ⏻		
Efficient appliances – dishwashers and clothes dryers	🏠 🏢	⏻	💧	
Provide clotheslines for drying laundry naturally	🏠 🏢	⏻		
Efficient washing machine	🏠 🏢	⏻	💧 💧	
Install photovoltaic panels	🏠 🏢	⏻ ⏻ ⏻		
Recycled water systems for non-potable uses	🏠 🏢		💧 💧 💧	
Cooling tower controls	🏢		💧	
Limit pool sizes and provide shading and pool covers	🏠 🏢		💧 💧	

Native landscaping and reduce lawn area				

Legend:

3 icons = largest benefit

2 icons = medium benefit

1 icon = some benefit

Key principles

BASIX sets a regulatory standard for energy (measured in GHG emissions) and water reductions based on a percentage reduction (target) from a baseline (benchmark).

The targets are set by NSW Government to deliver policy objectives of water and GHG emission reductions. These are outcomes-focused, and by avoiding a checklist or prescriptive approach, provide flexibility in how to achieve the targets.

The benchmarks are based on average energy and water consumption in NSW homes in 2002–2003 before BASIX was introduced. Although the benchmarks could be updated to reflect the level of household consumption after 2020, the approach adopted to date has been to increase the target (% reduction compared to the benchmark). This allows reduction standards to be compared over time.

BASIX estimates the water and energy consumption in houses and apartments based on the design features, typical energy and water efficiency ratings of equipment and appliances, and the assumed behaviour of average occupants in NSW. While individual behaviour of occupants can vary significantly, the performance must be based on the average because occupants can change at any time after the BASIX certificate is issued.

Many of the assumptions in BASIX were developed through a top-down approach using data from utility companies and research. For example, water use from toilets was not based on estimating the number of times a typical person flushes, but was calculated based on typical water consumption in residences due to toilet flushing and the average water efficiency of toilets at the time.

The calculation methods in BASIX will need to be updated from time to time to reflect technical improvements. These updates must be undertaken in conjunction with reviewing the targets to ensure BASIX keeps driving improvements over time. Potential considerations for future updates include:

- inclusion of new technologies that deliver measurable benefits, typically after they have been tested through alternative assessments
- changing the energy target from GHG emissions per year to kilowatt-hours per year due to the rapid decarbonisation of the NSW grid electricity doing most of the heavy lifting to reduce GHG emissions
- incorporating grid integration / stability measures into the assessment of buildings as time of use of energy becomes as important as hours of use as NSW transitions to a fully renewable electricity grid.

A brief history of BASIX

Over the last 2 decades the tool has evolved. Energy and water targets have increased, calculation methods have been refined, and the range of systems available has been expanded to keep pace with NSW Government targets. There have also been changes to the NCC Section J requirements, and new technologies have emerged. It was the first whole of house assessment in Australia, preceding the NatHERS 'Whole of Home' rating by almost 20 years.

2004 BASIX was introduced into the development approval process in Sydney on 1 July 2004 under the Environmental Planning and Assessment Act 1979. In 2005 this was expanded to all of NSW

2007 Three energy target zones introduced. BASIX also now applies to residential alterations and additions.

2009 Aligned with NatHERS 2nd generation software

2011 Aligned with NatHERS 2nd generation software

500,000 homes in BASIX saving 12.3 million tCO_2 and 340 billion litres of drinking water

2017 Energy targets and thermal comfort (heating and cooling) stringency increased

2023 Major update on 1 October 2023 to align with State Environmental Planning Policy (Sustainable Buildings) 2022 and the changes to NCC 2022 Section J.

- BASIX thermal performance will be at least 7 stars using the NatHERS rating scale
- Updated NSW electricity grid factor used in the energy calculations
- Higher energy standards based on location and building type
- New technology options and updated calculation methodologies added
- Introduction of an embodied emissions calculation for the construction of dwellings

Figure 2 History of BASIX

BASIX and NCC 2022 for Class 2 buildings

Section J of the National Construction Code 2022 establishes the following objectives:

1. Reduce the energy consumption and energy peak demand of key energy using equipment
2. Reduce the greenhouse gas emissions that occur because of a building's energy consumption and energy source
3. Improve occupant health and amenity by mitigating the impact of extreme hot and cold weather events and energy blackouts
4. Be able to accommodate the future installation of renewable energy systems, batteries and electric vehicle charging.

In NSW, BASIX is used to demonstrate compliance with many of the Section J requirements. The diagram below provides a simplified guide of the main components of a building covered by BASIX and those that are covered by Section J provisions.

In demonstrating compliance with Section J requirements, BASIX also provides energy consumption estimates so that the areas of highest energy use can be targeted.

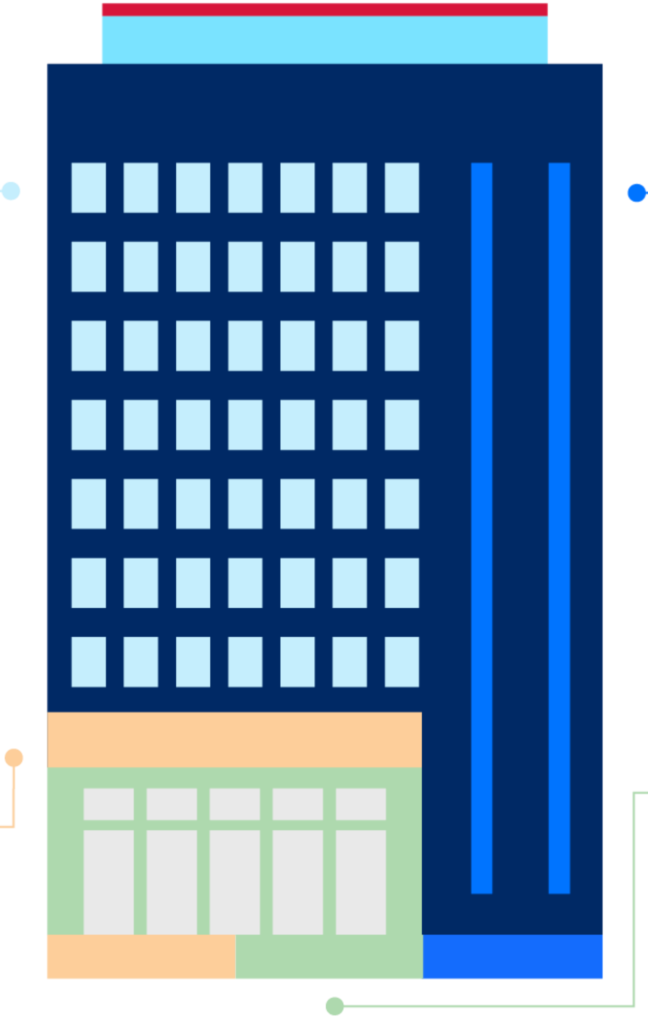
Sole-occupancy units

Assessed by BASIX
- Building fabric (using NatHERS)
- Heating and cooling
- Ventilation
- Lighting
- Domestic hot water
- Dishwashers and clothes dryers

Assessed by NCC Section J
- Slab on ground insulation
- Thermal construction
- Building sealing ($5m^3/hr.m^2$ at 50Pa or DTS)
- Air-conditioning and ventilation systems
- Energy monitoring (if >$500m^2$)

Other class types in the building

Not assessed by BASIX
Refer to NCC Section



Class 2 common areas

Assessed by BASIX
- Ventilation
- Lighting
- Domestic hot water
- Lifts
- Photovoltaic systems
- Swimming pools and spas

Assessed by NCC Section J
- Building sealing ($10m^3/hr.m^2$ at 50Pa or DTS)
- Air-conditioning and ventilation systems
- Energy monitoring
- Electric vehicle charging

Shared common areas

BASIX has methodologies to deal with common areas that are shared between different uses in the building (e.g. car parks, gyms, plant rooms, etc)

Figure 3 BASIX and NCC Section J for Class 2 buildings

Alignment with other rating tools

NatHERS Whole of Home

BASIX was Australia's first whole of home energy standard and has been operating since 2003. The new NatHERS Whole-of-Home standard, released in 2023, covers many of the elements addressed in BASIX for dwellings but is still less comprehensive. It does not estimate energy consumption due to central systems or common areas in Class 2 buildings and excludes water consumption.

The energy benchmark in BASIX is based on annual GHG emissions whereas NatHERS Whole-of-Home is based on the societal cost of energy including time of use (based on assumptions for peak, shoulder and off-peak tariffs).

The NatHERS Whole-of-Home ratings have not been adopted in NSW. However, many of the calculation algorithms in BASIX have been updated for consistency with the NatHERS standard. The table below shows a comparison of the energy use coverage of the two systems.

Table 3 Comparison of energy use coverage of BASIX and NatHERS Whole of Home

Use	BASIX	NatHERS Whole of Home
Space heating	Yes	Yes
Space cooling	Yes	Yes
Domestic hot water system	Yes	Yes
Lighting – dwellings	Fixed assumptions	Fixed assumptions
Lighting – common areas	Yes	No
Cooking appliances.	Yes	Fixed assumptions
Pool pump (pool heating future development)	Yes	Future module
Plug loads – dishwashers & dryers	Fixed – Class 1 Yes – Class 2	Fixed assumptions
Plug loads – everything else	Fixed assumptions	Fixed assumptions
Spa pump	Yes	Yes
Spa heating	Yes	Future module
On-site solar PV system	Total monthly generation	Hourly generated used in home

On-site battery storage	No	Yes
Lifts	Yes	No
Multi-residential common areas	Yes	No

Passive House (Class 1 and 2)

Passive House is a performance-based standard that sets stringent criteria for thermal comfort, space heating and cooling demand, indoor air quality and annual primary energy demand. It requires a very high performing building envelope including high levels of insulation, minimal thermal bridges, high-performance windows and doors and stringent air tightness. This is then combined with mechanical ventilation with heat recovery (MVHR). BASIX has a compliance pathway that recognises design to the Passive House standard, Homes designed to this standard will typically achieve very high BASIX energy scores.

NABERS for Apartments (Class 2)

Apartment buildings with at least four apartments on at least two floors are eligible for a NABERS energy and/or water rating of between 0 and 6 stars. The ratings are based on actual metered consumption in operation. The energy rating covers shared services such as car parks, lobbies, lifts and gyms but excludes energy consumption in individual units. The water rating can include shared water use only, or all water use including units, dependent on preference and metering arrangements.

BASIX estimates the annual energy and water consumption based on the design and construction and sets a building up for success. The NABERS rating reflects this in operation, but is also impacted by how well the systems are controlled and maintained and the behaviours of the building occupants.

Green Star Buildings (Class 2)

Green Star Buildings v1 was released in 2020 and awards 4 , 5 or 6 stars based on the sustainability of building design and construction across a wide range of environmental and social impacts. It can be used to rate Class 2 apartment buildings. BASIX is recognised as a pathway compliance with the Energy Use credit. For 5 and 6 star ratings, no natural gas can be used for heating, domestic hot water or cooking.

Green Star Homes (Class 1)

A new standard released in 2021 aimed at volume home builders to certify healthy, resilient and positive houses. Key requirements for energy, water and thermal performance include:

- 7.5 stars NatHERS (7 stars for zones 2 and 5) and comply with BASIX thermal performance.

- Mandatory requirements for: double glazing with thermal breaks; airtightness not more than $7m^3/hr.m^2$ @ 50MPa (5 in zones 5 & 7); energy efficient hot water systems, appliances and heating/cooling systems; thermal bridging; water efficient fixtures; and recycled water.
- No natural gas for cooking, space heating or domestic hot water.
- PV system installed to meet annual electricity demand.

Thermal performance

Thermal performance in BASIX

The thermal performance module of BASIX aims to:

- ensure thermal performance for a dwelling's occupants appropriate to the climate and season
- provide the potential to reduce greenhouse gas (GHG) emissions from artificial cooling and heating through good building design and use of appropriate construction materials
- reduce the demand for new or upgraded energy infrastructure by managing peak demand for energy required for cooling and heating.

Delivering a thermally comfortable home is the critical first step in the sustainable design of new homes and apartments. No amount of energy efficiency or renewable energy can compensate for a poorly designed home. Once the building envelope is constructed, it is often difficult and expensive to improve its performance later, potentially locking in higher energy bills and less comfortable spaces for the life of the building.

The key benefits of high-performance building envelopes include:

- **health and wellbeing** – provide comfortable places to live on cold winter days and during summer heatwaves
- **climate change** – mitigate the impacts of more extreme temperatures which will be experienced over the next 50 years
- **resilience** – in the event of power outages these homes maintain comfortable conditions for longer periods
- **lower energy bills** – reduce energy consumption and lower peak demand (through sizing of heating and cooling systems) to reduce household energy bills
- **carbon targets** – reduce energy consumption to reduce GHG emissions associated with production and delivery of energy to homes.

Key factors

The key factors influencing thermal comfort inside homes are outlined in Table 3.

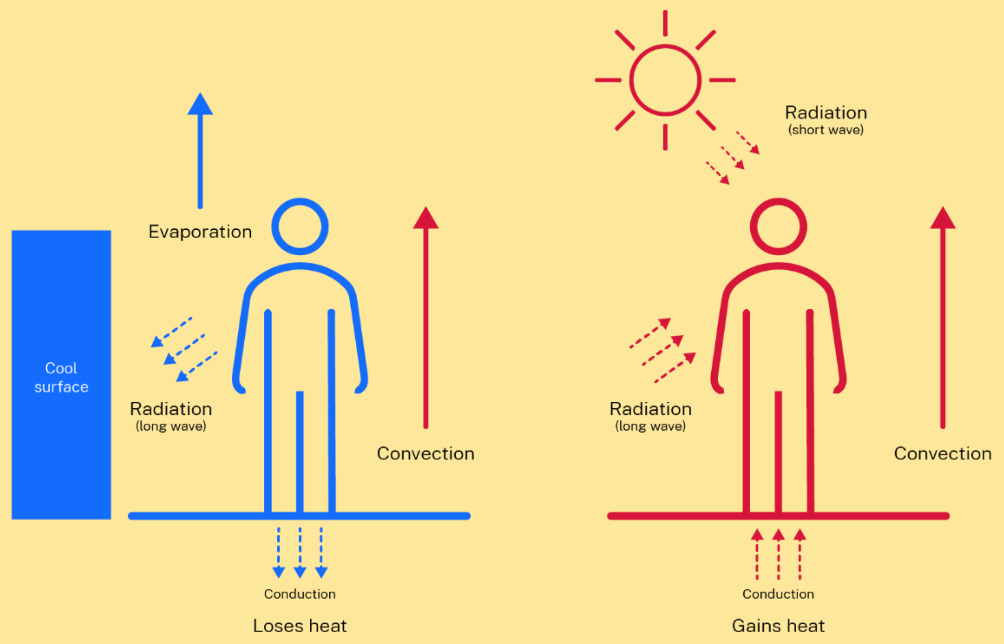
Table 4 Key factors influencing thermal comfort

	Winter	Summer
Air temperature	Retain warm air inside the home through reduced air leakage, good insulation, double glazing and reduced glazed area. Still need to maintain minimum ventilation rates.	Keep our hot air during peak summer days, but still need to maintain minimum ventilation rates.

Radiant temperature	Direct sun increases comfort. Cold surfaces such as glazing and uninsulated hard surfaces decrease comfort.	Direct sun decreases comfort. Cold surfaces, utilising thermal mass of materials, can increase comfort.
Humidity	Air leakage and poor ventilation can lead to humid conditions, decreasing comfort and also increasing risk of mould growth.	Air leakage and poor ventilation can lead to humid conditions, decreasing comfort and also increasing risk of mould growth.
Air movement	Air movement from draughts (air leakage) decreases comfort.	Air movement using natural ventilation through doors and windows, and/or use of ceiling fans, increases evaporation from the skin and increases comfort.

How the body perceives thermal comfort

Our perception of thermal comfort is influenced by a range of factors. The physical mechanisms are convection (air movement), radiation and conduction. In all cases heat energy moves from a warmer object to a cooler object.



Methods of assessment

There are three methods of assessing the thermal performance of dwellings in BASIX:

1. NatHERS – for all types of dwellings using third party software by accredited assessors

2. BASIX DIY – option for eligible single houses only and built into the BASIX tool
3. Passive House – a third party certification requiring very high performing building envelopes

These methods estimate the heating and cooling loads (the 'thermal loads'), measured in MJ/m^2 per annum based on a dwelling's:

- construction and insulation including floors, walls, ceilings and roof
- glazing and skylights based on size, performance, shading and overshadowing
- natural cross ventilation.

The heating load is the amount of heat energy that would need to be added to a space to maintain the temperature in an acceptable range. The cooling load is the amount of heat energy that would need to be removed from a space (cooling) to maintain the temperature in an acceptable range.

Lower thermal loads indicate that the dwelling should require less heating and cooling to maintain comfortable conditions, however actual energy use depends on the energy efficiency of the heating and cooling systems and the behaviours of the occupants.

BASIX uses the thermal loads as key inputs to the heating and cooling energy consumption calculation in the Energy module.

Full details of how to conduct a thermal comfort simulation, including qualifications, approved software, technical simulation requirements and documentation for certification, are contained in the **BASIX Thermal Performance Protocol** available to download from the BASIX website.

Performance requirements

The 2022 National Construction Code (NCC) increased the energy efficiency requirement for all new Australian houses and apartment buildings from 6 stars to 7 stars using NatHERS. The star rating is based on the total combined heating and cooling loads calculated in the software.

BASIX also sets maximum caps for the heating and cooling loads separately to avoid any trade-off between winter performance and summer performance to achieve the star rating. The caps are consistent with a 7-star NatHERS rating and vary based on the NatHERS climate zone the building is located in.

Table 5 BASIX thermal performance requirements

	NatHERS star rating	BASIX heating and cooling caps
Detached or attached houses	7 stars (or use DIY method which aligns with NCC DTS provisions)	House caps – different for slab-on-ground, suspended slabs and mudbrick walls
Apartment Building (average of all units)	7 stars	Average building caps

Apartment Building (every individual unit)	6 stars	Individual unit caps

Climate zones

NSW has several different climate zones. View the climate zone map on the Australian Building Codes Board website.

- Zone 2 – Warm humid summer, mild winter
- Zone 4 – Hot dry summer, cool winter
- Zone 5 – Warm temperate
- Zone 6 – Mild temperate
- Zone 7 – Cool temperate
- Zone 8 – Alpine

Calculation methods

NatHERS

Thermal simulation software such as AccuRate (formerly NatHERS), Building Energy Rating Scheme (BERS), First Rate and Hero are simulation programs used to estimate the heating and cooling loads of a home.

The programs calculate area-adjusted thermal loads using standardised behaviour by occupants for operating ventilation openings (windows and doors) and shading devices to ensure their effect on the loads is considered. The loads also include heat gains from occupants and activities such as cooking. The lower the load, the more the house can be comfortable for the occupants without needing air conditioning or heating.

The heating and cooling loads are also used by BASIX in the calculation of the energy consumption of the heating and cooling systems. BASIX removes the NatHERS floor area correction factors to avoid underestimating the energy use.

The NatHERS model is based on past meteorological records and has been updated to cover weather data up to the year 2015. It does not include future climate projections.

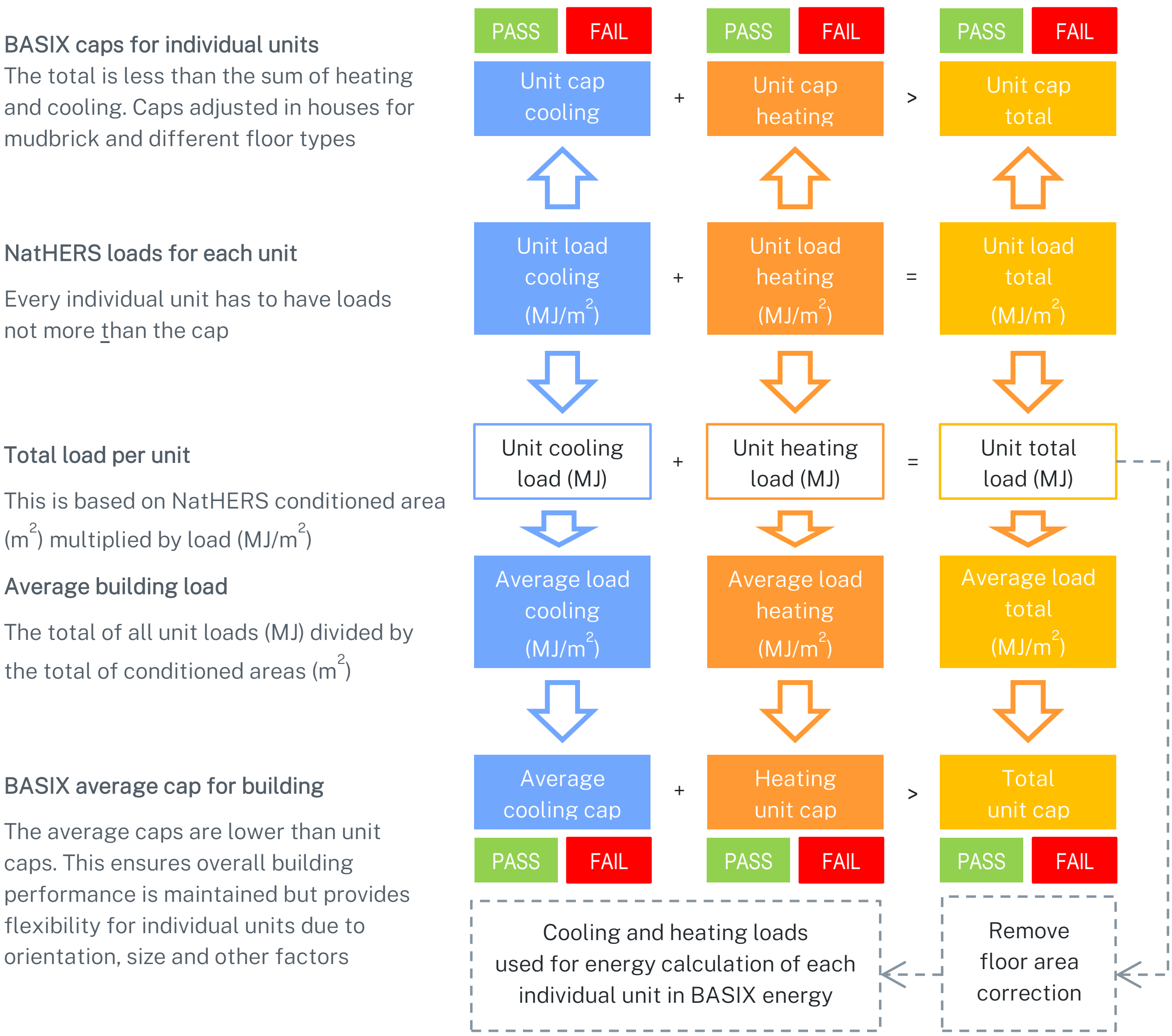


Figure 4 NatHERS heating and cooling loads to meet BASIX thermal performance standards

Passive House Standard Method

Passive House (or Passivhaus) Standard is a holistic construction certification standard that originated in Germany. It is based on a set of design principles to attain a quantifiable and rigorous level of energy efficiency within a specific quantifiable comfort level under a “fabric first” design philosophy. To achieve certification a building is designed and built based on five building-science principles.

Table 6 Five building science principles of the Passive House standard

	Principle	Comments
1	Airtightness	A very limited number of gaps and cracks within the envelope (including window frames) for air leakage and draughts. Reduces heat loss and gain and air pollutants and noise entering from outside.

2	Thermal insulation	Provides thermal separation between the heated or cooled conditioned inside environment and the outdoors. This improves thermal comfort and reduces the risk of condensation and cold internal surfaces in winter.
3	Mechanical ventilation heat recovery	The unit recovers energy from heated air (in winter) and cooled air (in summer) that would otherwise be wasted whilst also filtering the air that's coming into the building. This leads to fewer pollutants in the air and a lower risk of condensation. This does not replace natural ventilation (openable windows) which can be used anytime that external conditions are suitable.
4	High performance windows	Low-emissivity double or triple glazing with thermally broken or non-metal frames. The size of the windows should be appropriate to each orientation, to allow solar radiation to penetrate during the winter months (free heating) but not result in too much solar radiation during the summer.
5	Thermal bridge free	This means keeping penetrations through the insulation to an absolute minimum, and if not avoidable then using materials that are less conductive to heat (i.e. timber in place of metal) and/or incorporating thermal breaks (whereby a material that doesn't conduct heat well separates the two conductive elements).

The Passive House standard method is available to both single and multi-dwelling developments as a method of demonstrating thermal comfort performance in BASIX. It requires a certified Passive House designer to be engaged to simulate the dwelling design using the Passive House Planning Package (PHPP). The verification section of the PHPP software report needs to show that the dwelling satisfies the space heating, space cooling and air tightness requirements of the Passive House standard.

After the construction of the dwelling is completed, an Air Tightness Testing and Measurement Association (ATTMA) register tester is required to conduct an onsite blower door test to prove the Passive House standards have been achieved.

The energy calculated in the PHPP software is not used in the BASIX energy calculation.

DIY method

The Do-It-Yourself (DIY) method is a web-based method for completing the thermal performance section of BASIX. Most single dwellings (detached, attached or granny flat) that are built using common types of construction can be assessed using the DIY method. It has typically been used for approximately half of the BASIX assessments for single houses instead of NatHERS.

There are some limitations in the range of buildings suitable for assessment in the DIY tool:

1. The conditioned floor area of the house is 300 m^2 or less.
2. The house is either 1 or 2-storeys high, contains no open mezzanine area greater than 25 m^2 and contains no third level habitable attic room.
3. Glazing area is within 10 to 40% of the conditioned floor area.
4. The total area of skylights and sky windows is 3 m^2 or less.

Using the DIY method requires a commitment to minimum insulation levels for walls, floors and roofs calculated by BASIX, and to select glazing and shading to ensure that the estimated heating and cooling loads do not exceed the maximum allowable loads determined by BASIX.

Table 7 Required inputs to the DIY method

Elements	Element types	Details
Floors	Concrete slab-on-ground; Suspended slab; Floors above habitable rooms; Suspended floor above garage	Area; Construction type
Walls	External wall; Internal wall to garage	Construction type; Wall thickness
Ceiling and roof	Flat or raked ceiling; Flat or pitched roof	Construction type; Roof colour (solar absorption); Roof space ventilation; Insulation type
Windows	Grouped by orientation: N, NE, E, SE, S, SW, W, NW	Height & width; Opening type; Frame type; Glazing type; Shading device detail; Overshadowing
Skylights	-	Area; Frame type; Glazing type; Shading device details

The minimum insulation requirements are based on NCC 2022 Deemed-to-Satisfy (DTS) climate zones by Local Government Area, with some minor differences for Dorrigo plateau and the alpine zones.

How it works

The BASIX DIY calculation engine is a simplified method only suitable for houses. It calculates the thermal performance of the windows using the principles for external glazing in NCC Volume 2 Part 3.12 based on area, orientation, U-value, SHGC and shading, and assuming all wall, floor and ceiling insulation meets minimum requirements.

The glazing performance is then compared to budgets for heating and cooling loads that were established through multiple correlations with NatHERS house assessments for different types of house construction in different climates.

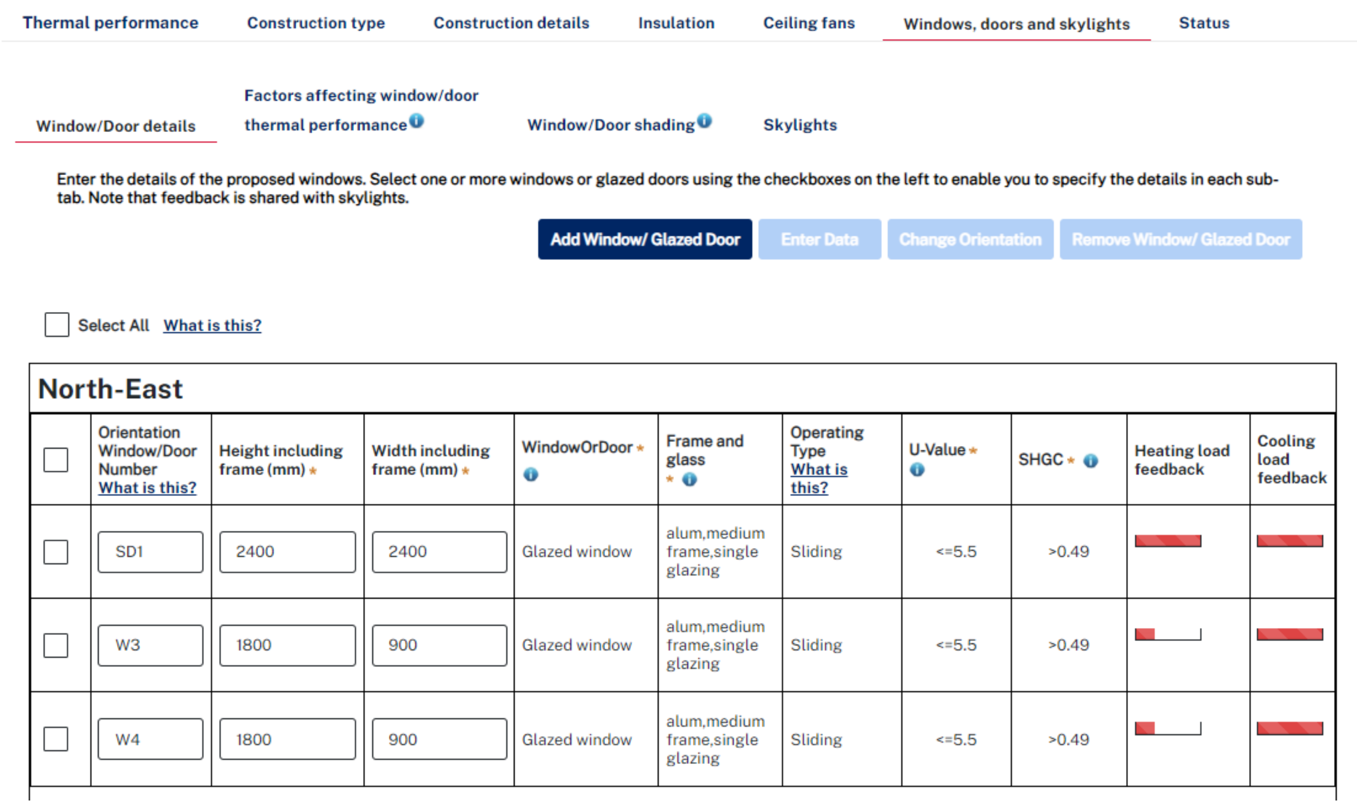
If the glazing passes both heating and cooling budgets, no further action is required and the heating and cooling loads for the house are calculated in MJ/m^2 similar to the NatHERS outputs. These are then used to confirm compliance with the thermal comfort requirements and as inputs to the energy calculation.

If the glazing exceeds the heating or cooling budgets, BASIX provides guidance on which windows are contributing most to the load so that the design can be modified by targeting these windows. The key improvement opportunities are:

- window area – height and width

- window performance – frame and glass type (U-value and SHGC)
- external shading – type, projection and height.

Selecting an adjustable shading device will reduce the cooling load but keep the heating load at the same level because BASIX assumes it is used in summer but drawn back in winter to permit solar gain. Internal louvres or blinds are not recognised in BASIX.


Thermal performance | Construction type | Construction details | Insulation | Ceiling fans | Windows, doors and skylights | Status

Window/Door details | Factors affecting window/door thermal performance | Window/Door shading | Skylights

Enter the details of the proposed windows. Select one or more windows or glazed doors using the checkboxes on the left to enable you to specify the details in each sub-tab. Note that feedback is shared with skylights.

Add Window/ Glazed Door | Enter Data | Change Orientation | Remove Window/ Glazed Door

Select All What is this?

North-East

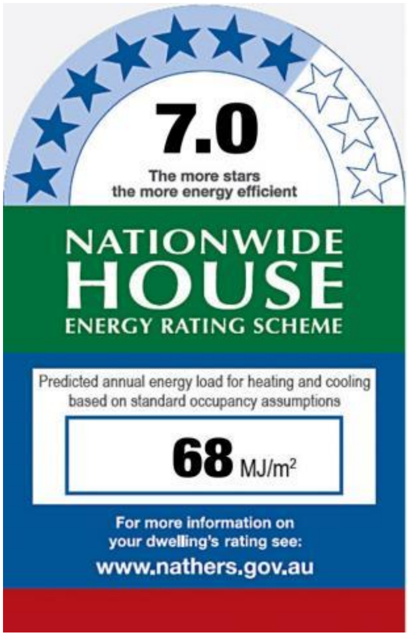
	Orientation Window/Door Number What is this?	Height including frame (mm) *	Width including frame (mm) *	WindowOrDoor *	Frame and glass *	Operating Type What is this?	U-Value *	SHGC *	Heating load feedback	Cooling load feedback
	SD1	2400	2400	Glazed window	alum,medium frame,single glazing	Sliding	<=5.5	>0.49		
	W3	1800	900	Glazed window	alum,medium frame,single glazing	Sliding	<=5.5	>0.49		
	W4	1800	900	Glazed window	alum,medium frame,single glazing	Sliding	<=5.5	>0.49		

Figure 5 A screenshot of the window input section using BASIX DIY method

Improving thermal comfort

The diagram illustrates opportunities to improve thermal comfort in a typical house. Most of the principles are also applicable to units in apartment buildings. All improvements to thermal comfort reduce the demand for energy to provide heating in the winter and cooling in the summer.

Most of the opportunities will improve the NatHERS rating. But good design is not just a number in a software tool, and designers are encouraged to go beyond looking at the stars to design comfortable homes that reduce the reliance on heating and cooling systems, particularly as the climate changes, and provide comfort to occupants all year round.



Windows

Windows should be designed to maximise daylight, reduce solar loads during the summer and capture solar benefit in the winter (free heating) while reducing heat losses.

Good design creates a balance between the following:

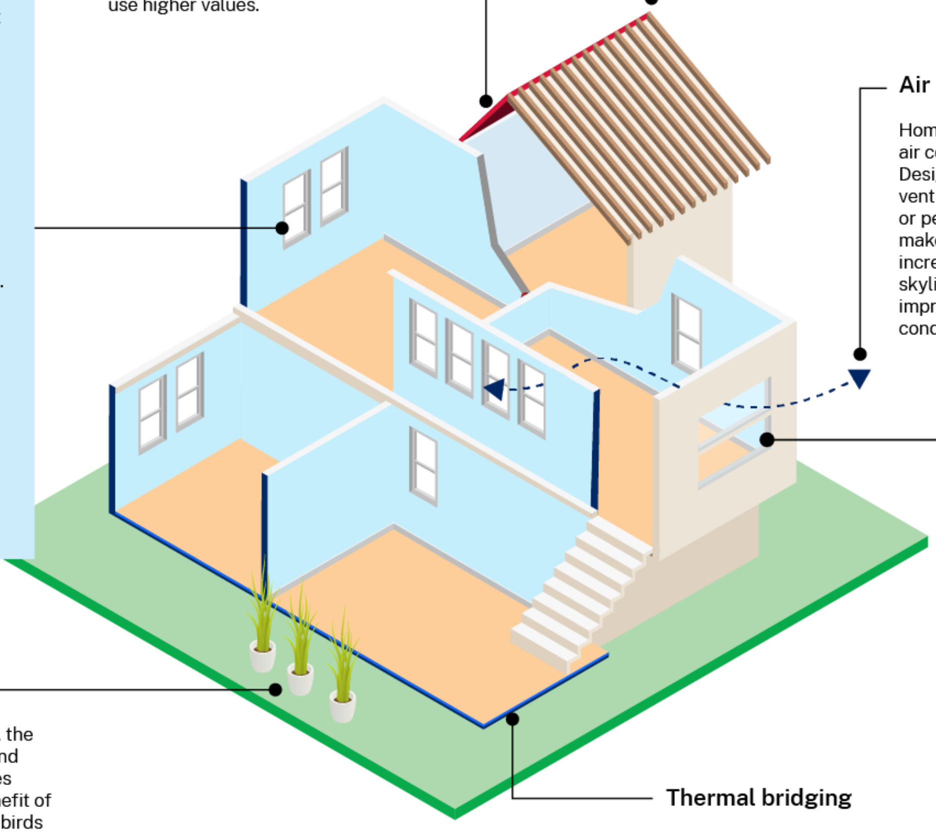
- Location – east and west facing windows are harder to shade effectively, but every room needs a window and this may be where the best views are.
- Area – more glass means more heat flow in and out of the building. To compensate for large windows higher performance glass and frames are typically needed, together with external shading.
- Shading – external devices can be fixed or operable. The aim is to keep out summer sun while allowing in winter sun.
- Performance – select the best performing window systems. Issues to consider:
- Solar Heat Gain Coefficient (SHGC) of the glass. Low-e coatings reduce solar transmission but can also reduce daylight so pick one with the highest VLT value.
- U-value of the glass, the lower the better. Double glazing should be considered a minimum for a comfortable home
- Frame conductance – reduce heat transfer through the frame by considering thermally broken frames (to minimum thermal bridging) and light coloured materials.

Insulation

Good insulation keeps heat out in the summer and keeps heat in during winter. The Deemed-To-Satisfy (DTS) R-values for walls, roofs, ceilings and floors in NCC 2022 are a minimum requirement. A well-designed home will use higher values.

Roof materials

Light coloured materials absorb less heat in the summer. They are also essential to reduce the heat island effect as large expanses of dark roofs lead to hotter air temperatures in residential communities. Light coloured roofs provide thermal comfort benefits to residents inside and outside the home.



Air movement

Homes were naturally ventilated for centuries before air conditioning and large windows were invented. Design wherever possible for effective cross ventilation, using openable and louvres on opposite or perpendicular facades. In double height spaces make use of the stack effect (hot air rises) to increase air movement, potentially using operable skylights. In summer, air movement from ceiling fans improves thermal comfort, reducing the time that air conditioning may be needed.

Air tightness

A well-sealed envelope prevents uncontrolled movement of air into and out of the building through joints in materials and at services penetrations. This reduces heat loss and draughts in winter and heat gain in summer. Air tightness less than 2 $m^3/hr.m^2$ @ 50MPa is not recommended unless whole house mechanical ventilation (with heat recovery) is provided for ventilation and moisture management. Air blower tests will show how well the envelope has been sealed.

Plants

While not being considered by BASIX, the benefit of plants to provide shading and reduce air temperatures around homes should be considered. The human benefit of connectivity to nature and habitat for birds and insects is also not a bad side effect.

Thermal bridging

Thermal bridging occurs where materials with higher thermal conductivity, such as metal or concrete, create a direct path through the insulation layer of a building's envelope. This can lead to cold spots and potential condensation issues in winter, as well as increasing heat transfer through the building fabric. Thermal bridges are often hidden but show up clearly on thermal imaging cameras. Design the building envelope to reduce thermal bridging.

Energy

Energy in BASIX

Energy benchmark

The benchmark for energy was established in 2002-03. It was based on the total annual grid electricity and natural gas consumption attributed to the residential sector in 2001 divided by the population of NSW at the time. The energy was converted to greenhouse gas (GHG) emissions using the 2002 emission factors for grid electricity and natural gas giving 3,292 $kgCO_2$ per person per year. Refer to the appendices for further details.

Energy score

BASIX calculates the annual grid electricity consumption (in kWh) and fossil fuel energy consumption (in MJ) before converting to GHG emissions ($kgCO_2e$ per person) for comparison to the energy benchmark.

The energy score is simply the percentage reduction of the calculated GHG emissions compared to the benchmark, then rounded down to the nearest integer (e.g a score of 40.9 becomes 40).

$$\text{Energy Score} = \left(1 - \frac{\text{calculated kgCO2 per person}}{3{,}292} \times 100\%\right)$$

Energy targets

The energy targets from October 2023 are based on three components:

1. The type of building and its location, including new categories for Class 2 buildings based on the number of storeys.
2. The new grid electricity factor used in BASIX which is 37% lower than previous versions to reflect the projected decarbonisation of the NSW electricity grid.
3. Increasing the energy performance stringency to align with NCC 2022 Section J energy efficiency requirements.

Future targets

The energy targets will be reviewed and updated periodically to drive further energy and GHG reduction in residential development in line with government policy objectives and pathways to zero carbon.

The NSW electricity grid is projected to rapidly decarbonise year on year to be almost zero carbon by 2045 if not sooner. This, combined with the rapid uptake of all electric buildings reducing the use of natural gas in new development, may raise the need to review the BASIX energy benchmark in the future.

Energy calculations

BASIX uses inputs, assumptions, performance characteristics and robust calculation methodologies to estimate the energy consumption for the systems in each dwelling and, for Class 2 buildings, the common areas. In Class 2 buildings some of the systems can be with the dwelling (local systems) or central or a combination of both. The total annual energy consumption is then converted to GHG emissions per person (kgCO_2/person) based on the selected fuel source and used to determine the energy score.

The diagram below summarises the key components and their interaction with the thermal performance and water modules in BASIX. For each component details of the system are either entered into the tool (e.g. size of PV system in KW) or selected from a drop down menu.

An overview of how energy is calculated for each of the systems, and opportunities to reduce energy consumption, is described in this section of the guide.

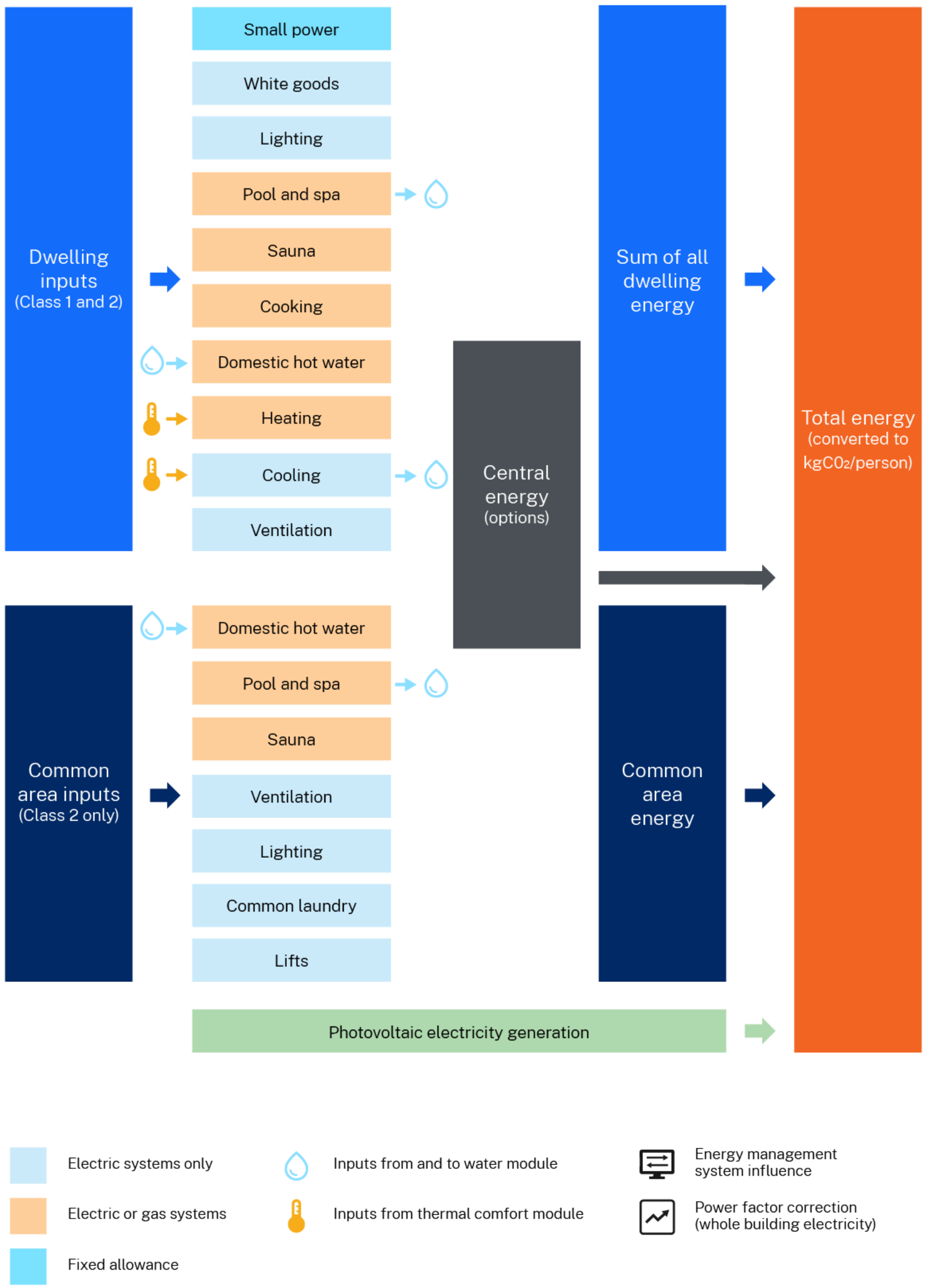


Figure 6 Key components of BASIX energy module and how it interacts with the thermal performance and water modules

Energy systems

BASIX estimates annual energy consumption in a building by calculating the energy consumption of each system separately. In apartment buildings, the energy consumption in each individual unit is calculated and then added to the energy consumption of central plant and common area systems to give the total annual energy consumption.

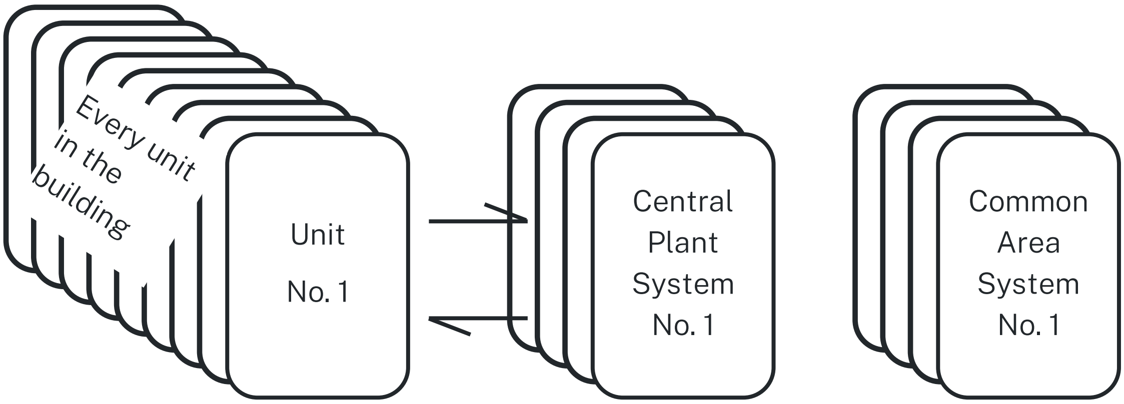


Figure 7 Systems considered in BASIX energy

Setting up a project to test concept design

For a BASIX certificate the areas, conditioned area, number of bedrooms and NatHERS outputs for every unit must be entered accurately. This is typically only possible at the end of the design process for planning as building layouts are often in a state of flux until a few weeks before submission.

To test options in BASIX during the concept design, data entry can be simplified by grouping different types of units and common areas together. For example, in a building with 150 apartments, first determine the number of units by type (studio, 1 bedroom, etc) and the average area of each. Then use the 'apply identical values" feature on the Dwelling Details page to complete the fields instead of typing these in individually for 150 rows.

Then enter the average heating and cooling loads to all units in the building based on achieving the average NatHERS rating to be targeted. Refer to Appendix for guidance on using the NatHERS star bands and BASIX heating and cooling caps to estimate average loads for all apartments.

It is important to note that this approach is only used to allow BASIX to estimate the total heating and cooling energy consumption of the building based on the dwelling heating and cooling system type and efficiency selected.

It is not used to confirm the thermal performance design of the building. This needs to be done through sample testing in NatHERS of typical and outlier apartments to identify design solutions to achieve the heating, cooling and total thermal caps in BASIX, both the average for the building (a minimum of 7 stars) and for each individual unit (in buildings greater than 6 storeys this is a minimum of 6 stars).

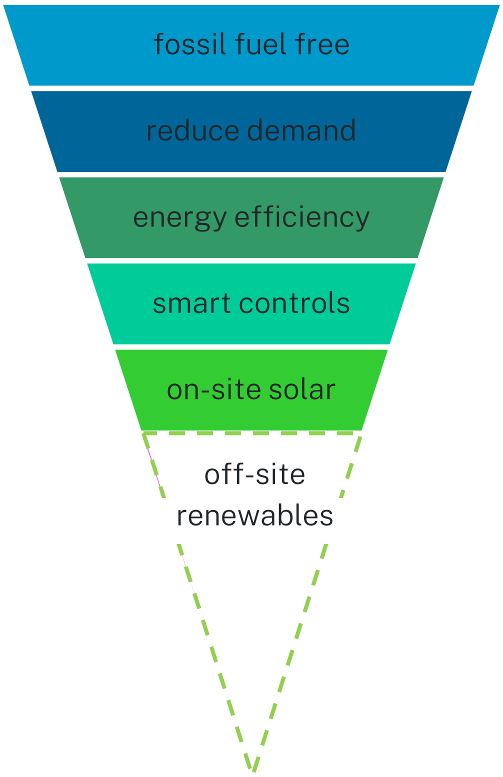
Reducing energy consumption

It is important to recognise the difference between energy consumption and energy efficiency to understand what BASIX does:

Energy consumption is the total amount of energy used per year, measured in kWh for electricity and MJ for natural gas.

Energy efficiency is the ability to use less energy to perform the same task. BASIX uses the efficiency of systems and equipment, such as energy ratings of appliances, in the calculation of energy consumption.

To reduce energy consumption and associated GHG emissions there are 5 key steps:



Select all electric alternatives to gas for heating, hot water and cooking

Improve building fabric (e.g. NatHERS rating), provide clothes lines, ceiling fans, pool blankets, etc

Select the most energy efficient options for all systems and equipment

Install smart controls for lighting, ventilation, heating and cooling to turn off or down when not required

Install roof-top solar PV to reduce electricity consumption from the grid.

The BASIX electricity factor has an assumed decarbonisation trajectory for the NSW electricity grid to 2030. While not included in the assessment, home owners and body corporates in apartment buildings can procure 100% renewable electricity (Green Power) from utility suppliers.

Figure 8 Five steps to reduce energy consumption and associated greenhouse gas emissions

Reducing peak electricity demand

An important consideration in the design of homes is to reduce the demand on the NSW electricity grid at peak times (typically 4pm to 8pm) and to make use of electricity when it is in surplus (typically at times when rooftop PV is at it most productive). BASIX does not estimate peak electrical demand as this is not required for Section J compliance.

The provision or future proofing for electric vehicle (EV) charging points and battery storage is required for NCC 2022 Section J compliance. The energy consumption of EVs and the benefit of battery storage to reduce peak demand is not assessed in BASIX.

Domestic hot water

Basis of energy calculation

The annual energy required to deliver domestic hot water in a home depends on :

- the total volume of domestic hot water needed to be delivered, considering:
    - uses – showers, bath, washbasins, kitchen and laundry
    - users – the number of people in the home
    - demand – how often hot water is needed e.g. number of showers per day and duration
    - water efficiency – the water efficiency of the fixtures (typically the WELS rating)
- the generation and distribution of domestic hot water, considering:
    - fuel source – electricity, natural gas, biomass
    - additional energy sources – solar boost, heat recovery
    - energy efficiency – heat pump CoP, boiler efficiency
    - heat losses – in systems and distribution pipework
    - pumps – primary and secondary pumps in central systems.

BASIX assumes that water is required to be heated between 45 and 50°C depending on the location (and assumed cold water supply temperature).

The amount of hot water to be generated annually is always more than the amount delivered. This is because there are heat losses in the system:

- Losses from storage tanks – losses depend on the length of time stored and the insulation performance to the tank.
- Losses in the flow and return recirculating pipework delivering hot water from central plant systems to each connected dwelling.

For solar hot water systems BASIX estimates the annual hot water generated by the sun based on solar collector area (m^2) and the solar zone (6 in NSW) less any assumed losses. The remainder of the annual hot water needed is provided from either gas instantaneous or electric storage systems.

In central plant systems BASIX calculates the electricity consumption of primary and secondary (recirculating) pumps.

Step 1: volume of hot water to be delivered

The annual volume of hot water is calculated using the water consumption per person for each fixture from the calculation in the Water module and then applying the following proportions for the mix of domestic hot water to cold water. The total annual volume of hot water to be supplied is assumed to be heated to 60°C from an average cold water temperature of 20°C.

Fixture	Proportion of hot water
Shower	60%

Fixture	Proportion of hot water
Bath taps	70%
Bathroom basin taps	60%
Kitchen sink taps	60%
Laundry trough	30%
Washing machine	15%
Dishwasher	0%
Toilet	0%

Step 2: pipework losses

The volume of water being recirculated in central plant flow and return pipework is estimated (based on a reference case) and the hot water 'lost' is then calculated based on the pipework insulation selected. The same volume of water is also used to calculate secondary circulating pump energy consumption.

BASIX does not calculate heat loss in pipes inside dwellings due to difficulty in estimating pipe lengths and the time in between each hot water fixture use.

Step 3: generating the hot water

BASIX recognises a wide range of systems including various combinations of:

- Storage systems: solar (with boost) | gas boiler | electric storage | air source heat pumps | ground source heat pumps* | wood boiler* | cogeneration**
- Instantaneous systems: gas | electric
- Location: dwelling | central plant

* - dwellings only, ** - central plant only

BASIX contains performance factors for each system (for both system standing losses and energy per litre) based on databases and published papers. These are used to calculate the energy needed to generate domestic hot water for the dwellings plus any pipework losses and pumping energy in central plant systems.

The diagram below summarises the key components of the energy calculation for the generation and distribution of domestic hot water (DHW) systems based on the steps on the previous page for a Class 2 apartment building. The methodology for a house is similar but excludes pipe losses and pumping.

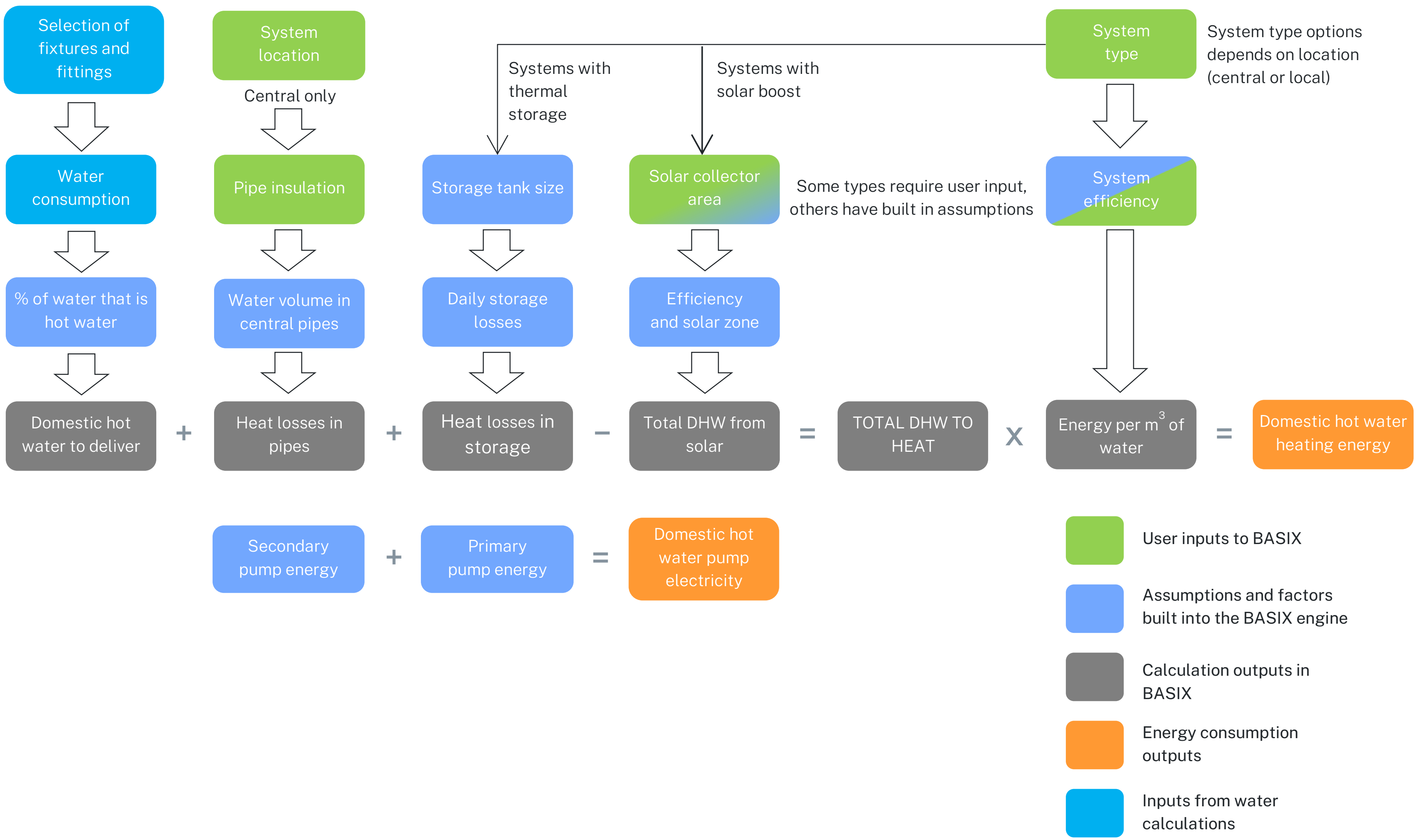


Figure 9 Key components of the energy calculation of domestic hot water systems

Energy saving tips

Domestic hot water is the largest energy use in a typical home or apartment, representing between 15% to 25% of the total energy consumption. The key opportunities to reduce DHW energy consumption in BASIX are:

- Reduce demand for hot water by selecting water efficient fixtures (taps and showers).
- Select the most efficient type of heat generator. This is typically electric heat pumps.
- Select the most energy efficient model for the type of system selected.

Other opportunities to reduce DHW energy consumption, but which are not able to change the BASIX calculation, include:

- Reduce length of pipes inside dwellings between heat source and commonly used taps and showers (dead legs) and insulate these to reduce heat losses.
- Good insulation of water storage tanks to reduce standing losses.
- Select energy efficient water circulation pumps.
- Install shower heat recovery systems.

Save energy in the shower

Showers are the single biggest use of hot water in a home, accounting for more than half of total consumption. The easiest way to save energy is to install water efficient showerheads (6 L/min use 33% less hot water than 9 L/min heads).

Shower heat recovery systems can reduce shower hot water consumption by 30% to 35% by using a heat exchanger to recover heat from the shower drain water and preheat the incoming mains water, either directly feeding into the shower thermostatic mixer tap, or the supply to the hot water heating system. These systems can be included in BASIX using an alternative assessment approach.

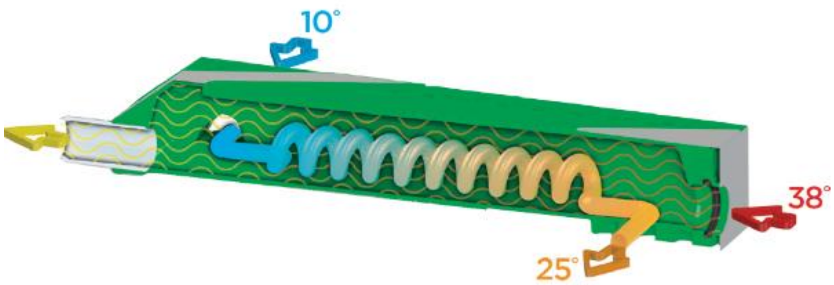


Figure 10 Working principle of a shower heat recovery system (Image courtesy of Stormtech)

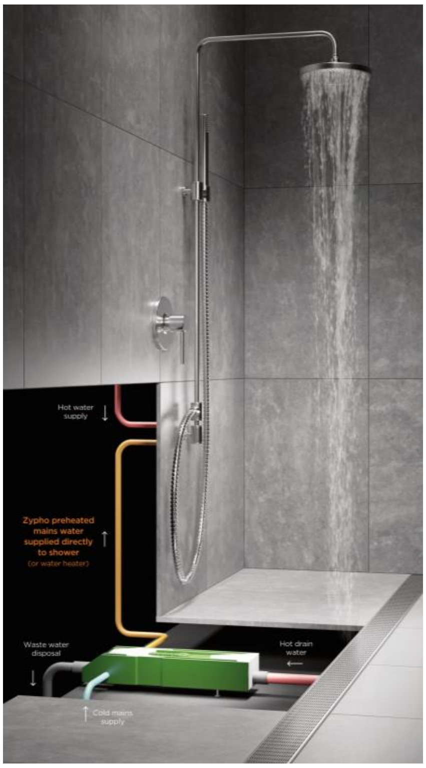


Figure 11 A shower heat recovery system as installed (Image courtesy of Stormtech)

Heating and cooling

Heating and cooling systems can be central systems or local systems or a combination of these. Different systems can be selected for bedrooms and living areas with individual systems but not for central systems. Heating and cooling of common areas is excluded from BASIX.

Individual systems

BASIX calculates the energy consumption to heat and cool bedrooms and living spaces separately then adds these together based on the following:

Energy consumption = thermal load x floor area x energy efficiency

where:

- **thermal load** is the heating or cooling thermal load calculated in NatHERS (MJ/m2 per year) – refer to Thermal Comfort section for further details.
- **floor area** is the conditioned floor area of bedrooms or living areas (m2). BASIX makes assumptions for typical bedroom floor areas and deducts this from the conditioned floor area to calculate the floor area of living spaces.
- **energy efficiency** is the ratio of energy input required to deliver a unit of heating or cooling energy based on the type of system selected in BASIX. BASIX also adjusts the calculated efficiency based on the climate zone for heat pump systems.

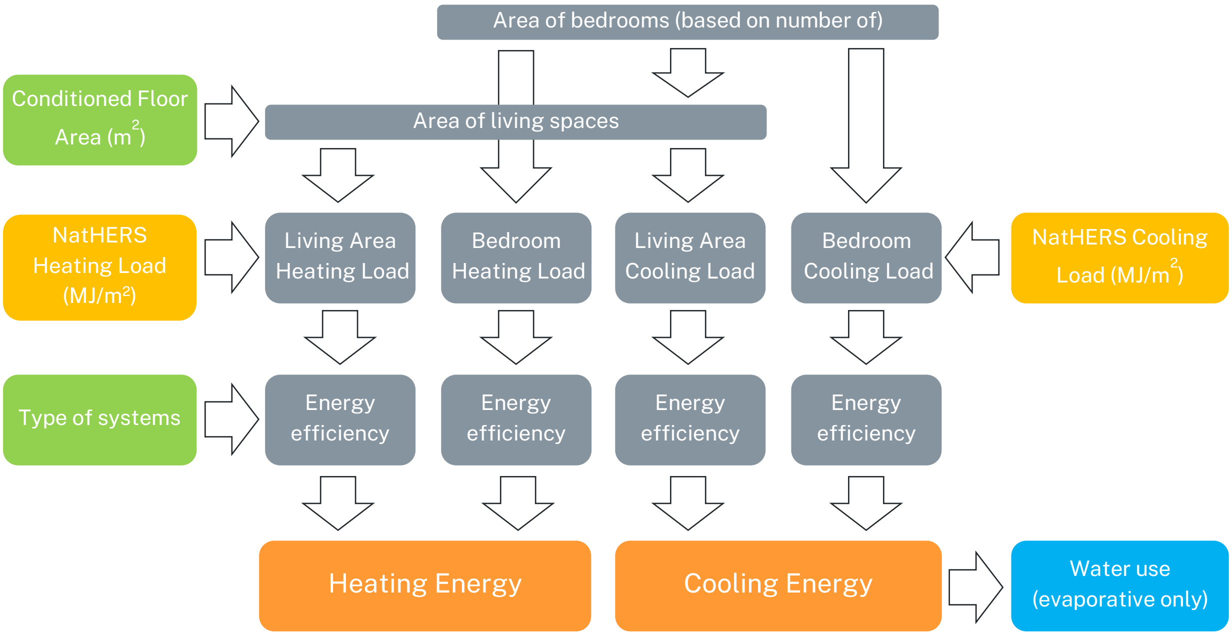


Figure 13 Key components of the energy calculation of heating and cooling systems

If no heating or cooling system is selected for a space, BASIX assesses the heating and cooling demand in that space to determine the probability that the user will need plug in a heater or cooler, or install a heating or cooling system at a later date. BASIX then makes an allowance for the energy consumption of this in the energy calculation.

Central systems

For central systems the energy calculation follows similar principles except that living and bedroom systems cannot be different and so heating and cooling energy is calculated for the total Conditioned Floor Area.

Three types of central systems are recognised:

- Full heating and/or cooling systems reticulating heating hot water and chilled water systems to fan coil units (or radiators) in individual units.
- Condenser water systems connected to water source package units (heat pumps) in individual units. The condenser water system has central heat rejection plant (e.g. cooling towers) and/or heat injection plant (e.g. heat pumps).
- Variable Refrigerant Volume systems reticulating refrigerant through pipework from indoor units to central compressor units, which are either air sourced or water sourced heat pumps

BASIX calculates energy consumption based on the thermal loads of apartments connected to each central system and the energy efficiency of each component of the central system. This includes:

- Central heating and cooling plant such as chillers, boilers and heat pumps.
- Central heat rejection systems such as cooling towers.
- Pumping energy reticulating chilled water, heating hot water and/or condenser water to individual units.
- Fans and water sourced heat pumps in individual units connected to the central plant.

Energy saving tips

To reduce heating and cooling energy consumption consider the following:

- Improve the building fabric performance to reduce the demand for heating and cooling energy. The lowest energy solution is meeting the Passive House standard. Refer to Thermal Comfort section for further details.
- Select the most efficient heating systems. This will typically be heat pumps which also deliver lower GHG emissions and lower energy bills than gas systems.
- Select the most efficient cooling systems. In apartments this is typically water sourced heat pumps connected to cooling towers – but balance this with increased water consumption.
- Set thermostats for wider temperature bands – this is set in NatHERS for regulatory energy calculation purposes, but in actual operation user choices have a significant impact on total energy consumption. In summer use a ceiling fan in bedrooms instead of air conditioning and in winter put on a jumper!

Ventilation in dwellings

There are three types of ventilation exhaust systems in dwellings – kitchen, toilet/bathroom and laundry. In Class 2 apartments these can be either individual systems (typically ducted to the façade) or central systems.

Individual exhaust systems

BASIX calculates the energy consumption for each individual dwelling fan using the following formula:

$$\text{Ventilation Energy (kWh/day)} = Q_{min} \times P_{static} \times T_{op} / \varepsilon$$

where:

- Q_{min} is the minimum air flow rates based on the type of exhaust:
  - Kitchen exhaust – 50 L/s
  - Toilet / bathroom exhaust – 25 L/s
  - Laundry exhaust – 20 L/s
- P_{static} is the static pressure for fans which varies for ducted (70 Pa) and not ducted (20 Pa)
- T_{op} is the assumed hours of operation per day which varies based on both the exhaust type and the control mechanism (e.g. interlocked to lights, manual on/off, manual on/timed off, continuous operation)
- ε is the efficiency is the combined fan and motor efficiency which varies based on exhaust type and whether ducted or not ducted

Energy saving tips

The main method of reducing fan energy consumption in BASIX is through the selection of controls. Systems interlocked to lights (particularly in daylit areas) or with timed off control run for the shortest periods of time.

Saving energy can be as simple as turning the system off when it is not needed – and also reduces throwing away heated or cooled air thereby reducing heating and cooling energy consumption. However, it is important to ensure that homes are well ventilated to avoid mould and condensation issues.

In Passive Houses the bathroom exhaust fan is typically on 24 hours per day. This is because it is connected to a whole of home ventilation system which provides filtered outside air to all rooms in the home. The supply air also passes through a heat exchanger on the exhaust air stream to capture around 70% of the heat energy. When combined with the high-performance building fabric (highly insulated and airtight) this results in super low heating and cooling energy consumption and a healthy home (thermally comfortable, clean air, no condensation or mould, quiet spaces).

Central exhaust systems

Where exhaust systems are connected to a central ducted system the options include:

- Central duct with ventilation exhaust provided by a fixed speed fan
- Individual fan vents discharging into a central duct provided with a fan running under the control of a variable-speed drive (VSD)
- Individual ventilation registers operated by means of motorised dampers with the ventilation exhaust supplied by a centralised duct provided with a fan running under control of a VSD

While the principles of the energy calculation are similar to individual fans, the calculation is more complex and is based on the hours per day the system runs at different flow rates and the corresponding electrical power of the fan at these rates.

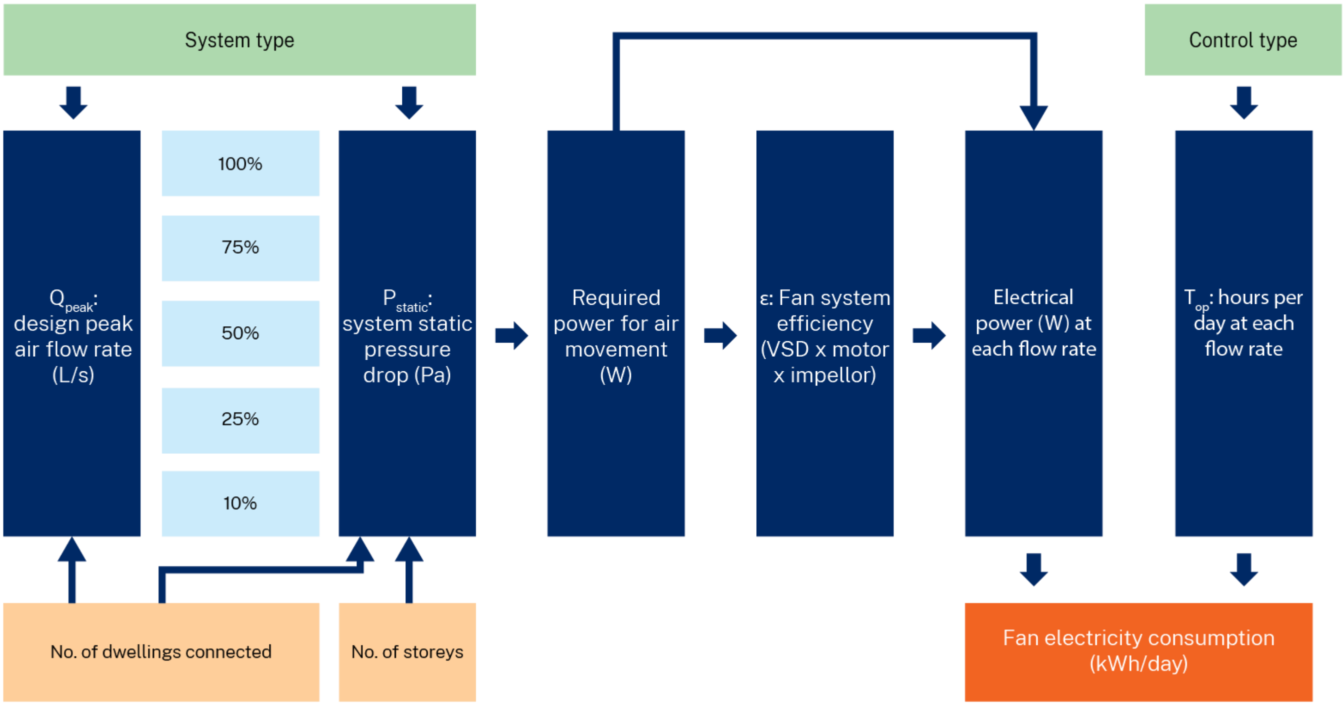


Figure 15 Key components of the energy calculation of central exhaust systems

Ventilation of common areas

BASIX estimates the electricity consumption to ventilate all common areas in Class 2 buildings based on:

- Type of space – car park, lift lobby, plant rooms, indoor pool, gym, waste room, etc
- Area of space to be ventilated (m2)
- Type of ventilation – none, natural, supply air, exhaust air, etc
- Control type – varies depending on functional use

The electricity consumption for each area is calculated separately using the following formula. These are then added together to give the total for common area ventilation.

Common Ventilation Energy (kWh/day) = Q_{min} x A x P_{static} x T_{op} / ε

where:

- Q_{min} is the assumed minimum air flow rate based on the functional use *(typically 5 L/s per m^2 except lobbies and hallways are 2.5 L/s per m^2 and plant rooms are 7.5 L/s per m^2)* multiplied by 3600 to convert to L/hour.
- A is the floor area (m^2) served by the system
- P_{static} is the assumed static pressure drop based on functional use, number of stories and ventilation type *(typically 150 Pa for exhaust air and 250 Pa for supply air, but it can vary between 125 to 350 Pa)*.

- T_{op} is the assumed hours of operation per day which varies based on functional use and the control mechanism selected. If no control, 24 hours operation is assumed.
  - Typical functional uses – time clock / BMS control (18 hours)
  - Car park with CO monitoring – VSD fan (1.38 hours) or 2 speed fan (4 hours)
- ε is the assumed combined fan and motor efficiency which varies based on functional use, number of stories and ventilation type

Heating and cooling of common areas

BASIX does not calculate the heating and cooling energy requirements of common areas as this would require a detailed energy model to be prepared based on the geometry and thermal performance of the building envelope (glazing, walls, floors, insulation, airtightness, etc).

The provisions of NCC 2023 Part J4 can be applied to the building envelope to common areas to ensure these spaces deliver thermal comfort and energy efficiency in accordance with the objectives of Part J1.

Air conditioning and tempered air systems

BASIX calculates the fan energy consumption for spaces that are air conditioned. These are assumed to have higher air flow rates and static pressure drops resulting in much higher ventilation energy consumption compared to a non-conditioned supply and exhaust system.

For lift lobbies and hallways tempered air systems can be used. These typically comprise an air handling unit with heating and cooling coils to the supply air to maintain internal temperatures within a range of 7°C (typically between 19°C to 26°C) with no humidity control. The exhaust air is typically through corridor louvres to each apartment, providing make-up air when apartment ventilation systems are turned on. The louvres also reduce air pressure differences between the corridor and the apartment which can lead to slamming doors.

Energy saving tips

To reduce common area ventilation fan energy consumption in BASIX, consider:

- Does the space require mechanical ventilation or can it be naturally ventilated?
- Select controls to reduce the hours that the fan is required to operate

While BASIX makes fixed assumptions for air flow rate, static pressure losses and fan efficiencies, the requirements of NCC 2022 Part J6 still need to be complied with for the design of common area ventilation systems. This includes:

- Mechanical ventilation system control – VSDs, heat recovery and/or time switches
- Fan efficiency requirements
- Ductwork pressure drop limits based on length of duct and components (coils, louvres, etc)
- Ductwork insulation and sealing

Lighting

Dwellings

BASIX assumes that all lights in a dwelling are LED or fluorescent. The energy calculation is:

Lighting energy (kWh/day) = IPD x A x T / 1000

where:

- **IPD** is the illumination power density – this is a fixed value of 4 W/m^2
- **A** is the total floor area (including garages) in m^2
- **T** is the assumed average hours all the lights are on – a fixed value of 1.2 hours.

The artificial lighting requirements of NCC 2022 Part J7 do not apply to Class 2 buildings in NSW. In BASIX the average illumination power density for a dwelling should not exceed 4 W/m^2. This is more stringent than the NCC 2022 Volume 1 clause J7D3(a)(i) requirement of 5 W/m^2 for sole-occupancy units.

Energy saving tips

While BASIX has removed the requirement to enter details of lighting systems, measures can be implemented to reduce lighting energy consumption.

- Design spaces to maximise daylight penetration. This needs to be balanced with reducing solar gain and heat losses through glazing and skylights which can impact on thermal comfort and heating and cooling energy bills.
- Avoid over-lighting spaces – provide the right amount of light for each space to deliver visual comfort and illuminate the tasks to be undertaken.
- Use LED lamps/globes – these are much more energy efficient than fluorescents.
- Consider the type of light fitting to maximise the distribution of light from the lamp. Recessed downlights do not spread light as evenly as other types, requiring more lights to illuminate a space.
- Use timer controls or occupancy sensors in transient spaces to reduce the hours that lights are left on unnecessarily.

Common areas

BASIX estimates the electricity consumption to light all common areas in Class 2 buildings based on the:

- type of space – car park, lift lobby, plant rooms, indoor pool, gym, waste room, etc
- area of space to be lit (m^2)
- type of lighting – varies by functional use (none, LED, fluorescent, metal halide, etc)

- control type – varies depending on functional use (none, manual, timers, motion sensors, daylight sensors, zoned switching and combinations thereof depending on type of space).

The electricity consumption for each area is calculated separately using the following formula. These are then added together to give the total for common area lighting.

Common lighting rnergy (kWh/day) = IPD_{lamp} x A_{common} x $T_{control}$ x C_{BMS} / 1000

where:

- IPD_{lamp} is the Illumination Power Density (W/m^2) = LL_{common} / ε_{lamp}
    - LL_{common} is the lighting level ($Lumens/m^2$) assumed in BASIX for the type of space being lit
    - ε_{lamp} is the lamp efficiency (Lumens/W) for the type of lamp selected using default values assumed in BASIX. An LED is assumed to be 90 Lumens/W.
- A_{common} is the area of space being lit
- $T_{control}$ is the hours per day that lights are on based on the type of space and the lighting controls selected. This can range from 1 hour in a plant room with a light switch to 24 hours if no lighting controls are specified in the space (i.e. the lights are never switched off).
- C_{BMS} is an adjustment factor if the lighting is connected to a central Building Management System (or dedicated lighting control system) as these typically further reduce the hours the lights are on. The factor varies between 0.65 to 1.0 depending on the space type and the type of lighting controls installed in the space. In a space with a BMS but no lighting control specified then CBMS is 0.5 and the lights area.

Energy saving tips

In addition to applying the principles of low energy lighting in dwellings, the other key factor to saving energy in common areas is to select good lighting controls. Common areas are primarily transient spaces and building occupants don't typically take responsibility to turn lights off as they don't pay the bills directly (the energy cost is rolled up into the body corporate fees).

Cooking and appliances

Cooking

BASIX calculates the energy consumption per person per year due to cooking based on:

- The type of cooktop – gas, electric (direct or induction) or wood combustion*
- The type of oven – gas, electric or wood combustion*
- The number of occupants – based on the number of bedrooms

* - applies to single homes only.

BASIX has assumptions for the typical annual energy consumption per person for each type of cooktop and oven, which varies depending on the number of occupants.

Induction cooktops are assumed to use 13% less electricity than standard electric cooktops. From a speed, control, safety and ease of use perspective there is no comparison – induction is orders of magnitude superior.

Wood combustion is assumed to be 40% less energy efficient than the gas equivalent.

Dishwashers

The energy star rating of dishwashers can be selected in BASIX. If a rating is not specified a default of 3.5 stars is used. The annual energy consumption is calculated based on:

- Annual energy consumption benchmarks for each energy star rating
- No. of occupants
- Allowance for standby power of 0.5W

Fridges

Until October 2023 in Class 2 buildings users were able to install fridges with better than average star ratings to improve the energy score. This is no longer an option. Fridge energy in all dwellings (houses and apartments) is calculated based on default assumptions for the fridge star rating (3.5 stars), fridge size (425 litres), fridge type (top mounted frost-free refrigerator – freezer) and number of occupants.

Other small power

BASIX makes an allowance of 255 kWh per person per year for other electrical plug-in equipment. This includes freezers, televisions, computers, monitors, microwave ovens, plug-in lamps, hi-fi systems and other plug-in loads.

Washing machines

The WELS rating for washing machines can be selected to improve the BASIX Water score, but the energy consumption of washing machines is based on default assumptions. For washing machines these are energy star rating (3.5 stars) and washing machine size (7kg wash load). The energy calculation takes into account the number of occupants.

If washing machines are provided in a central laundry in Class 2 buildings, the energy star rating can be selected. The central laundry washing machines are assumed to be used by the apartments where “no washing machine taps” is selected for the washing machine option in the water module. The calculation is performed for each of the apartment and then these are added together to give the total for the common laundry washing machines.

Clothes dryers

The energy star rating of clothes dryers can be selected in BASIX. If a rating is not specified a default of 3.5 stars is used. The annual energy consumption is calculated based on:

- Annual energy consumption benchmarks for each energy star rating
- No. of occupants
- Allowance for standby power of 0.5W
- Reduction due to clothes drying lines (internal or external)

If clothes dryers are provided in a central laundry in Class 2 buildings, the energy star rating can be selected. The central laundry clothes dryers are assumed to be used by all apartments where “not specified” is selected for clothes dryers in those apartments. The calculation is performed for these apartments and then these are added together to give the total for the common laundry washing machines.

The benefit of clothes drying lines

If occupants have no means of easily drying clothes naturally, particularly in apartment units, they will more likely use the clothes dryer. The energy consumption of clothes dryers is reduced based on:

- The type of indoor or outdoor clothes drying lines provided.
- The type of dwelling (e.g. single house, high rise apartment, etc) as this influences how likely the clothes dryer would be used.

Pools, spas and saunas

Pools

The energy consumption of swimming pools comprises of the energy consumption of the filtration pumps and the heating system including heat circulation pumps. BASIX calculates the energy consumption of common pools and individual pools using the same methodology with slight variations – refer to the diagram below.

The heating energy demand for pools is based on a dataset of monthly values (MJ/m^2 per day) created using detailed pool software modelling for each climate zone in BASIX. The dataset contains, for each climate zone, values for pools with and without heating and for different exposure conditions (indoors or outdoors, shaded or unshaded, sheltered or unsheltered, pool cover or no cover). The dataset also contains evaporative energy losses per day which are used in the Water module.

The demand for energy met by any solar pool heating system is calculated based on assumptions for the average monthly energy collected per m^2 of collector area with a water inlet temperature of 20°C. This is then deducted from the total monthly heating energy demand to calculate the annual energy demand for heating to be provided by the heating system.

The energy efficiency of the heating systems and pumps used in BASIX are based on typical industry values. The exception is individual pools where the energy rating of a domestic pool pump can be selected.

Spas

The energy consumption of spas follows a similar process to that of pools. The heating energy required and daily evaporative losses from spas are higher than pools as they operate at higher water temperatures.

Saunas

Saunas are an option for Class 2 apartment buildings. The uncontrolled heating time of saunas is assumed to be 12 hours per year per dwelling unit. In a building with 100 apartments this means the sauna is assumed to be on for 3 hours per day. These hours are reduced based on the controls selected – manual on/off, BMS control and standby-by function.

BASIX has default values for the power (kW) of heating and air circulation sauna systems which are multiplied by the operating hours to give the energy consumption (kWh).

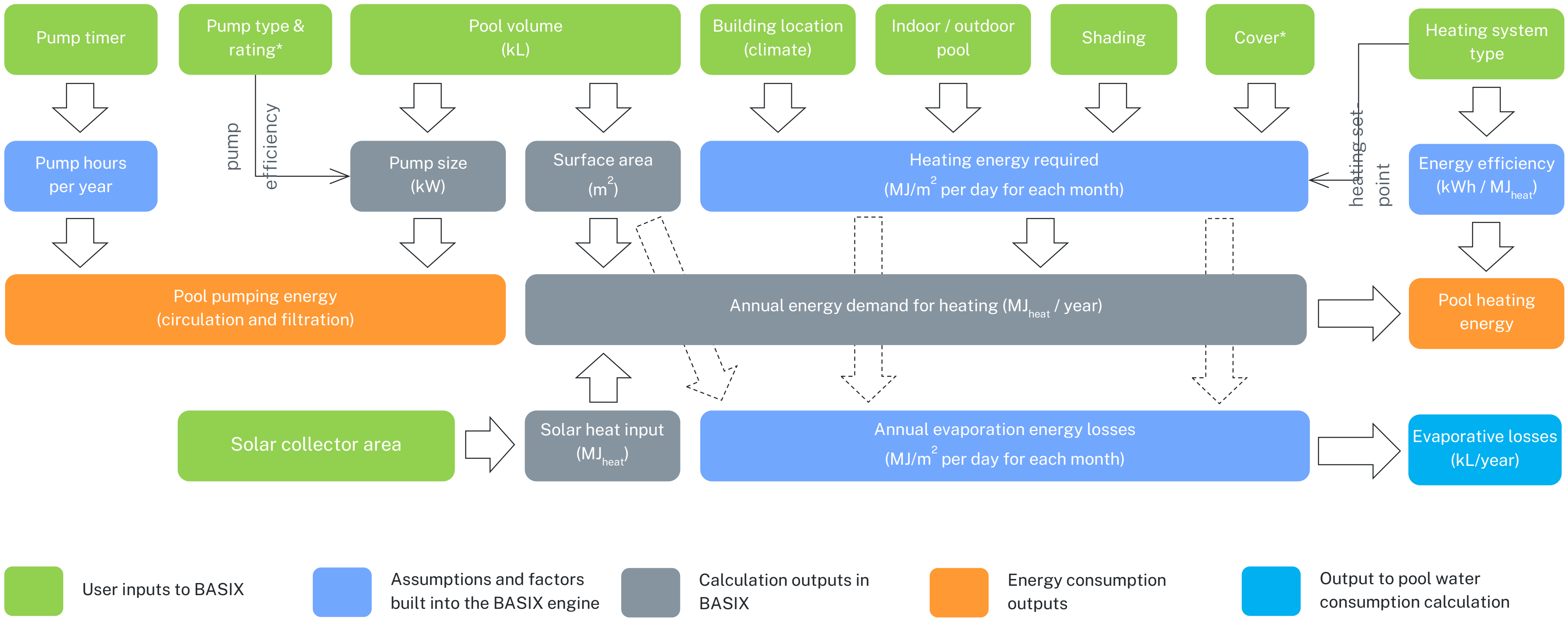


Figure 16 Key components of the energy calculation of pools

Lifts

Annual lift energy consumption in Class 2 buildings is influenced by many factors including lift type, number of lift trips per year, number of levels each lift serves, grouping of lifts serving the same levels (lift banks) and express travel zones in high rises. In BASIX, lifts are grouped into banks of lifts serving the same levels. For each lift bank the following information is entered:

- No. of lifts in the lift bank (N_{lifts})
- No. of levels with apartments served by the lift bank
- No. of levels from bottom of lift shaft to top of lift shaft
- Type of lift technology
- Lift load capacity (kg)

The annual energy consumption per lift bank is based on the following formula:

$$\text{Energy (kWh/annum)} = Q_{avg} \times T_{trip} \times N_{trip} + Q_{standby} \times T_{standby} + E_{vent}$$

where:

- Q_{avg} is the average motor load (kW)
- T_{trip} is the average time per trip (hours)
- N_{trip} is the number of lift trips per lift bank per year
- $Q_{standby}$ is the standby power (kW) = 0.4 kW assumed
- $T_{standby}$ is the hours of standby operation (hours/year) = (24 x N_{lifts}) – (T_{trip} x N_{trip})
- E_{vent} is lift car ventilation energy = 0.04 kW x 12 hours/day x 365 days x N_{lifts}

This formula is a simplified methodology to reduce the level of detail required to be entered into BASIX. More complex lift calculation methodologies are available including ISO 25745:2, CIBSE Guide D and proprietary lift energy calculation software. These can be used to replace the BASIX calculation via the BASIX alternative assessment process and require a detailed lift energy report to be prepared by a qualified professional.

Average motor load (Q_{avg})

Default values for average rated motor loads (kW) are assumed in BASIX based on:

- The lift car maximum load capacity (kg)
- The type of lift technology and reductions due to benefit of regenerative braking

Average trip time (T_{trip})

The average trip time is the based on:

$$T_{trip} \text{ (hours)} = \text{Average speed of lift (m/s) x average travel distance (m) / 3600}$$

The average speed of the lift is based on default values in BASIX for the type of lift selected (hydraulic or traction) and the number of storeys. Hydraulic lifts are slower and are limited in the no.

of storeys they can serve. The speed of traction lifts varies with number of storeys to account for the time taken to speed up and slow down and the proportion of the trip reaching the lift's peak speed.

The average travel distance is based on the number of levels with apartments served by the lift bank, the number of levels from bottom of lift shaft to the top, and an assumed storey height of 3.15m. The diagram below shows the assumed travel distance calculation methodology.

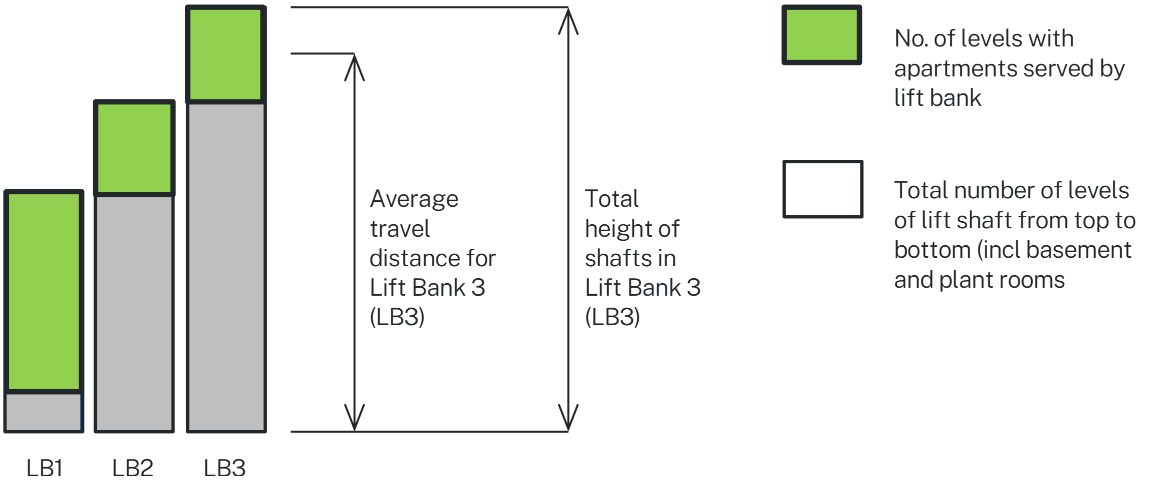


Figure 17 Average travel distance for lift banks

Number of lift trips (N_{trip})

The number of lift trips is primarily based on the number of people in the building and not the number of lifts. Whether a lift bank has two or three lifts does not change the number of people using the lift bank. More lifts in a bank reduce waiting times and also increase redundancy when a lift is taken out of service for repair.

To estimate the number of lift trips per day, BASIX uses the number of apartment levels served by each lift bank and allocates the total population of the building to each lift bank in proportion to the levels served. Each occupant is then assumed to use the lifts 3.5 times per day on average (1.75 up and 1.75 down). This is multiplied by 365 to give total trips per year.

Energy saving tips

The main method of reducing lift energy consumption in BASIX is to select the most energy efficient type of lift available for the levels being served. Other opportunities, outside the scope of the BASIX lift energy calculation, include:

- Select lifts with Class A energy efficiency rating
- Make stairs easy and attractive to use to reduce lift use in low to medium rise buildings
- Smart lift controls, such as destination control, to optimise lift trips in each lift bank.

Alternative energy generation

Photovoltaic panels

BASIX calculates the annual energy generated by photovoltaic (PV) systems installed on both individual dwellings and central systems in multi-dwelling developments.

BASIX allows up to 2 separate PV systems to be installed on a dwelling. For example, on a pitched roof panels can be installed on an east facing roof (to generate electricity in the morning) and a west facing roof (to generate electricity in the afternoon).

For all systems the electricity generated by each system is calculated using the following formula:

Electricity generated per system (kWh/year) = $PV_{peak} \times R_{gen}$

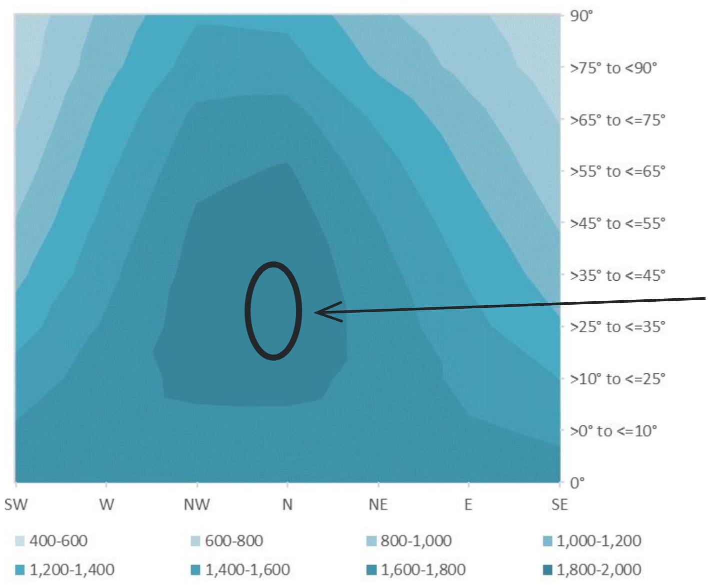
where:

- PV_{peak} is the rated peak capacity of the PV system installed (kW)
- R_{gen} is a PV generation factor (kWh/kWp) which is calculated differently for dwelling and central systems.

Dwelling systems

The value for R_{gen} is taken from calculations using NatHERS Whole-of-Home algorithms based on:

- **NatHERS climate zone** – based on the building's location (postcode)
- **Slope** – the angle the panels are installed from vertical (0° is horizontal, 90° is vertical). If not specified a default of 30° is assumed.
- **Orientation** – the direction the panels are facing. If not selected a default of south-west is assumed. This has a low solar output.



Optimum orientation for maximum annual electricity generation.

Note: orientation to the NE will generate more electricity in the morning, and orientation to the NW will generate more in the afternoon.

Central systems

The value for R_{gen} is set for three solar zones in BASIX. For 90% of NSW postcodes (including Sydney) this is 1,382 kWh/kWp per year.

Surplus electricity generated

The electricity generated by PV systems is deducted from annual electricity consumption. Any surplus electricity generated above consumption is not included in the BASIX Energy calculation. The deductions and surplus caps are based on:

- Dwelling systems – individual dwelling energy consumption.
- Central systems – total building energy consumption

Maximising use of photovoltaic electricity

Photovoltaic (PV) electricity generation and electricity consumption vary by the time of day and time of year. BASIX uses a simplified average annual calculation as it would be too complex to develop an energy model for 8,760 hours per year.

To optimise the use of electricity generated by a PV system the following can be considered:

- Set appliances such as washing machines, clothes dryers and dishwashers to run during peak PV generation periods.
- Use heat pumps to generate domestic hot water during the day and store in larger hot water tanks. The water can then be used in mornings and evenings when there is no sun.
- Install a battery to avoid exporting electricity to the grid, then use the stored electricity when needed.
- If you have an electric vehicle, charge these during the day whenever possible.

Cogeneration

BASIX recognises cogeneration systems, which generate heat and power from gas, diesel or biodiesel, and does lots of complex calculations depending on whether they are used for domestic hot water, pool heating, space heating and/or space cooling (via an absorption chiller).

However, these systems are rarely a commercially viable solution for any residential building in NSW due to the high upfront capital costs, the on-going maintenance costs, and the cost of the fuel source. They only result in lower GHG emissions if renewable fuels are used. However, biodiesel is far more beneficial in the transport and construction sector and will be more expensive than using other fuel sources for buildings, such as grid electricity.

Before considering a cogeneration system, it is recommended that a detailed feasibility study is undertaken, including analysis of efficiencies, maintenance costs and projected electricity and fuel cost scenarios, to justify the upfront capital cost and the annual operating costs.

Building management system (BMS) and power factor correction

Power factor correction

Electrical power (apparent) is composed of two orthogonal components:

1. Real power (kW) – the component that powers appliances
2. Reactive power (kVAr) – the component that develops and maintains the electromagnetic field

Although the current through the reactive component does not dissipate power, it still needs to be transmitted through the electricity grid and will dissipate energy through other resistive components, such as cabling and switchgear, in the system.

Power factor correction (PFC) systems do not reduce the real power consumption. However, by generating or providing a reactive current locally through PFC, less power needs to be provided by the grid network and this results in lower losses.

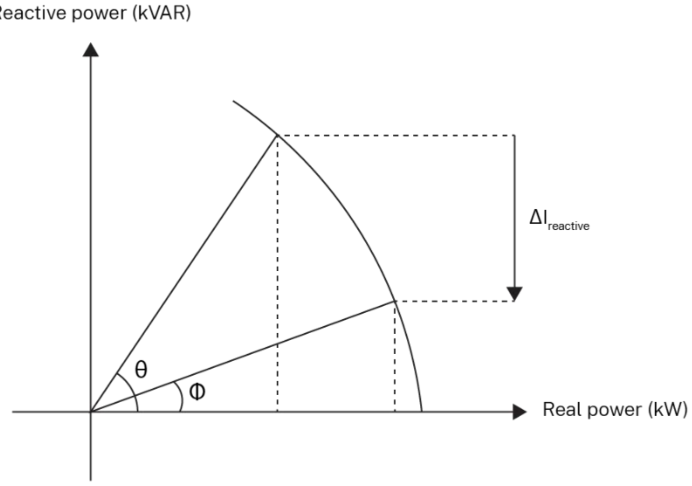
Houses are assumed to require no PFC. BASIX recognizes the electricity savings from PFC systems in Class 2 buildings by assuming that the system is able to return the building to a corrected power factor of 0.95 from a 'worst case' average of low rise (0.85), mid-rise (0.75) and high rise (0.7).

Power factor is the ratio of reactive power to apparent power. The reduction in reactive power ($\Delta I_{reactive}$) is due to the difference between the reactive power demand with and without correction. The formula is:

$$\Delta I_{reactive} = P_{avg} \times [\tan\theta - \tan\Phi)]$$

where:

- P_{avg} is the average power demand $= \frac{\text{net annual lelectricity consumption (kWh/year)}}{\text{8760 hours (or 24 hours} \times \text{365 days)}}$
- $\theta = \cos^{-1}$ (uncorrected power factor)
- $\Phi = \cos^{-1}$ (0.95)



The electricity consumption saving is then calculated using an assumed energy saved in transmission arising from reduced reactive power of 60 kWh/year per kVAr using the following formula:

$$\text{PFC Electricity Consumption Reduction} = \Delta I_{reactive} \times 60$$

Building management system

A building management system (BMS) can be used to control central and common area systems. BASIX recognises the energy saving benefit of such systems. BASIX reduces the calculated energy consumption of the following systems when a BMS is installed:

- Common area ventilation
- Common area lighting
- Pools
- Spas
- Sauna

A typical reduction of between 3% and 10% is applied, which varies by building size, type of system and the type of controls. How the BMS will work alongside other control measures (e.g. lighting control sensor types) is also considered to avoid potential double counting of benefits.

The power factor correction calculation is adjusted to avoid double counting of the energy reduction benefit of a BMS.

A BMS (or similar) is already assumed to control central cooling, heating and domestic hot water systems. The calculated energy consumption for these systems does not change if the BMS option is selected or not.

Energy controls – an essential step to reducing energy

The energy consumption (kWh) of equipment delivering a service (heating, cooling, ventilation, lighting, etc) is simply the energy power demand (kW) multiplied by the hours it operates for.

Energy efficiency means using less energy to provide the service. For example, providing 1,100 lumens of light with LEDs (12W) uses one fifth of the electricity compared to an incandescent lamp (75W). But if the light is left on 24 hours a day when it only needs to be on for 4 hours it will consume six times more energy than is necessary. This is why controls are also essential – they allow energy efficient systems to also be operated efficiently!

The two key control strategies related to hours of use are:

- **Turn it off** when it is not needed. Sounds simple, but how often are things left running when they don't need to be?
- **Turn it down** to match demand. This reduces the time that the system operates at peak load. Examples include car park ventilation systems with CO control to ramp up and down as required, and lighting with daylight dimming.

Water

Overview

Water benchmark

The benchmark for water consumption was based on the total annual water consumption attributed to the residential sector in 2002/03 divided by the population of NSW at the time. This was then converted to an average daily use to give **247.5 litres per person per day.**

Water score

BASIX calculates the annual water consumption then converts to litres per person per day.

The water score is simply the percentage reduction of the calculated water consumption compared to the benchmark, rounded down to the nearest integer (e.g. a score of 40.9 becomes 40).

$$\text{Water score} = \left(1 - \frac{\text{calculated mains water litres per person per day}}{247.5} \times 100\% \right)$$

Water targets

The water targets were established in 2003 and range from 0% to 40% depending on the climatic zone. They were determined from data provided by state and federal water utilities, as well as long-term climate data from the Bureau of Meteorology.

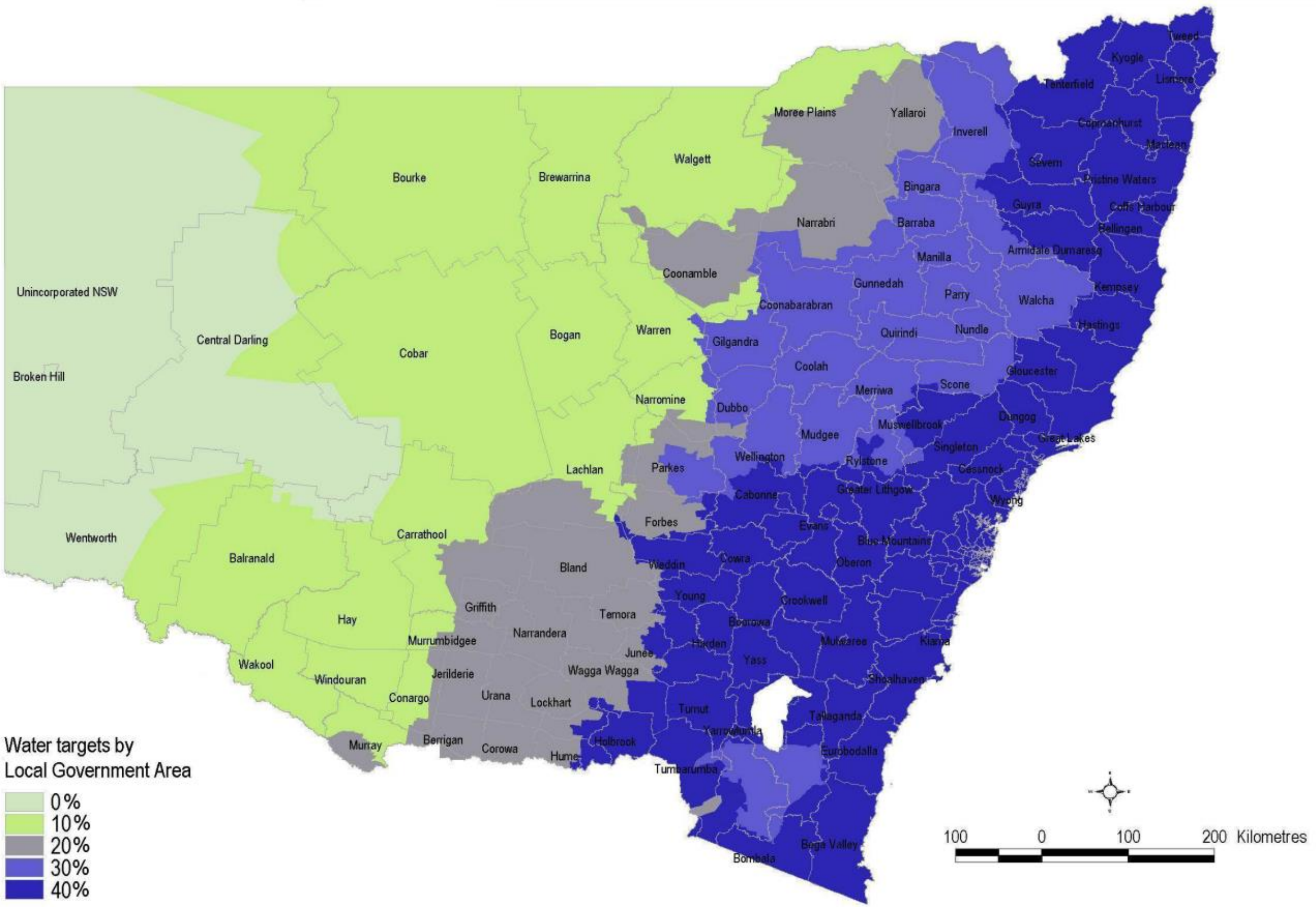


Figure 19 Water target zones in NSW

Water calculation

BASIX uses inputs, assumptions, performance characteristics and robust calculation methodologies to estimate the water consumption for the systems in each dwelling and, for Class 2 buildings, the common areas. The total annual water consumption is then converted to litres per person per day.

The diagram below summarises the key components and their interaction with the energy modules in BASIX. For each component details of the system are either entered into the tool (e.g. size of stormwater tanks) or selected from a drop down menu.

An overview of how water is calculated for each of the systems, and opportunities to reduce water consumption, is described in this section of the guide.

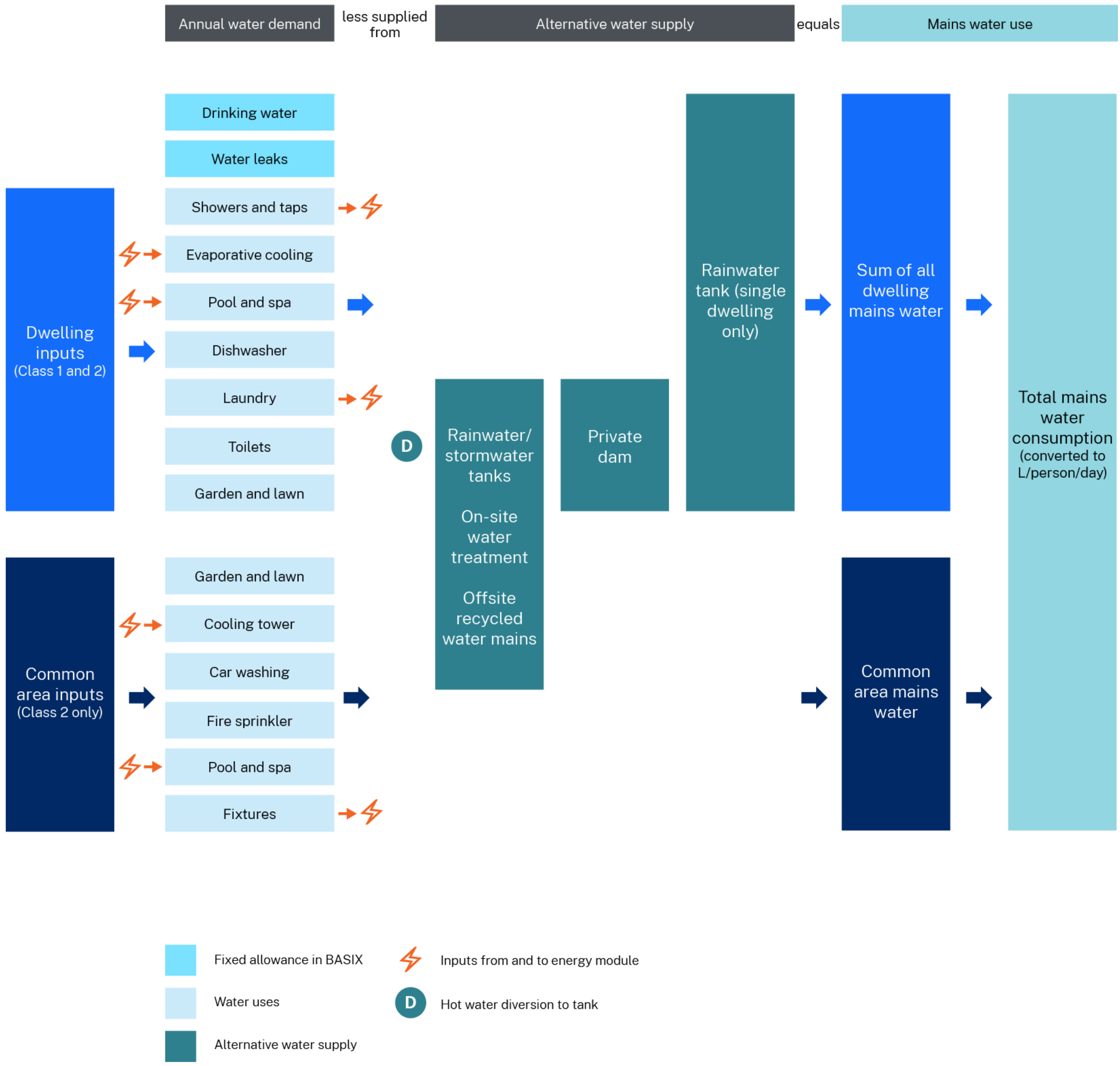


Figure 20 Key components of BASIX water module and how it interacts with the energy module

Taps, showers and toilets

Basis of water calculation

BASIX estimates water consumption per person using a combination of water efficiency of fixtures (based on the WELS rating) and estimated usage based on consumption benchmarks and typical fixture efficiencies from Sydney Water in 2003 (when the BASIX water benchmark was established).

Table 8 BASIX water consumption benchmarks from fixtures

Fixture	WELS rating used?	Assumed usage per person per day	Fixed water use L/(person.day)
Shower	Yes	3.16 mins	n/a
Toilet	Yes	5 flushes	n/a
Washbasin taps	Yes	0.71 mins	n/a
Kitchen taps	Partial	0.36 mins	3.6 for dishes * 2.4 for drinking/cooking
Laundry trough	No	n/a	4.8
Bath	No	n/a	8.7

* - this value only applies if no dishwasher is installed

Showers, toilets and bathroom basin taps

The daily water consumption per person is based on the selected water efficiency of the fixture (W_{eff}) multiplied by the assumed usage (based on data from Sydney Water when the benchmarks were established in 2003):

$$\text{Water consumption (L/person/day)} = W_{eff} \times \text{Usage}$$

For showers the water consumption is then multiplied by a Behaviour Multiplier (1.3 to 1.38) to increase average showering time per day to between 4.1 to 4.4 minutes for lower flow showers compared to the 18 L/min average showerheads in 2003.

Kitchen sink taps

The calculation of water consumption is based on the above formula for assumed usage with an additional allowance added for drinking/cooking water and for washing dishes in Class 1 houses and in Class 2 units if no dishwasher is installed or the dishwasher is not WELS rated. Domestic hot water consumption used in the Energy module is estimated based on usage from Sydney Water data and the water efficiency of the fixture.

Laundry troughs

BASIX assumes a laundry trough has a fixed use of 4.8 litres per person per day.

Baths

BASIX assumes every dwelling has a bath with a fixed use of 8.7 litres per person per day. As bath water usage is based on the bath size the water efficiency of the taps is not relevant. More water efficient taps just mean the bath takes longer to fill!

Common area water fixtures

The usage of common fixtures (showers, wash basin taps and toilets) is calculated using a similar methodology to individual dwellings. The actual number of occupants using the fixtures is based on assumptions related to the size of common facilities – swimming pool, spa and gym. The usage of common area fixtures is deducted from the total calculated water consumption of the individual dwellings to avoid double counting.

Water saving tips

The key opportunities to save water are:

- Select water efficient showerheads no more than 6 L/min (4-star WELS) – alongside washing machines (see next section) these represent the biggest water saving opportunity. In a typical building showers account for around 25% of total water consumption and over 50% of domestic hot water (a big energy saving opportunity).
- Select low flush toilets no more than 3.5 L/flush average (4-star WELS) – these are the third highest water use in typical dwellings. They are also easily connected to recycled non-potable water systems (refer recycled water section).
- Select water efficient taps for wash hand basins and kitchen sink.

6.5 L/min smart shower with LED lights to show water usage in real time to encourage reducing time spent in the shower. Shower timers can also be used instead.

Image courtesy of Hydrao

Dishwashers and washing machines

Washing machines

BASIX uses a default value for washing machines in Class 1 homes. No user input is required.

The water consumption calculation for Class 2 buildings assumes that there is a probability of 30% that the washing machine installed at the time of certification will be replaced with a machine with average water use. The average reflects 2003 performance and will be updated when the BASIX water targets are next updated.

The calculation is:

Water consumption (L/person/day) = [WM_{eff} x 0.7 + B_{eff} x 0.3] x Usage

Where:

- **WM_{eff}** is the water efficiency in L/kg (dry load) based on the WELS star rating of the machine installed
- **B_{eff}** is the benchmark water efficiency of 30.7 L/kg (dry load), equivalent to a 1 star rated washing machine
- **usage** is assumed usage of 1.48 kg (dry load) per person per day.

Common area laundry

If washing machine connections are provided in a unit then occupants are assumed to use their own washing machines and not the common laundry. The usage of common laundry is calculated using a similar methodology to individual dwellings based on the number of occupants without washing machine connections in their unit.

Dishwashers

BASIX uses a default value for dishwashers in Class 1 homes. No user input is required.

The water consumption calculation for Class 2 buildings is based on 21.7 litres per wash with a capacity of 12 place settings. The WELS star ratings of the selected dishwasher are used by BASIX to determine the average litres per wash. These are then converted to water efficiency per place setting (DW_{eff}) by assuming the same dishwasher capacity as the benchmark (i.e. by dividing by 12). The assumed usage is 2.82 place settings per person per day.

The calculation is:

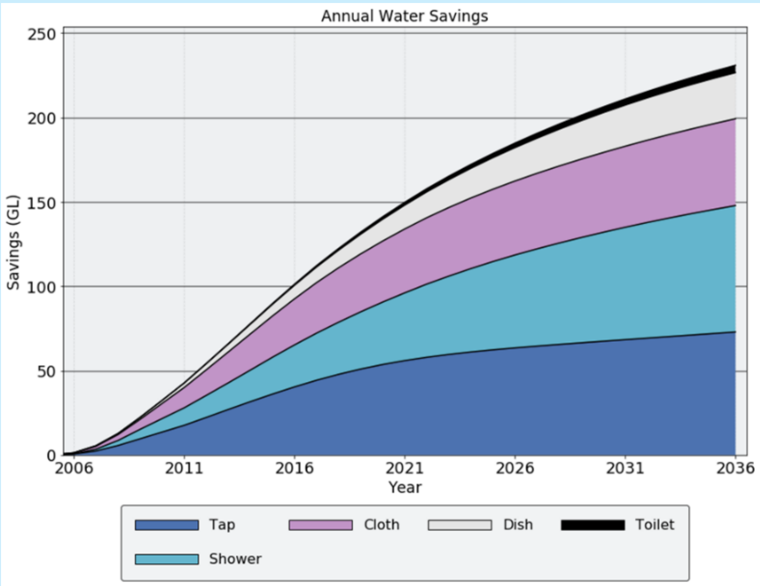
Water consumption (L/person/day) = DW_{eff} x Usage

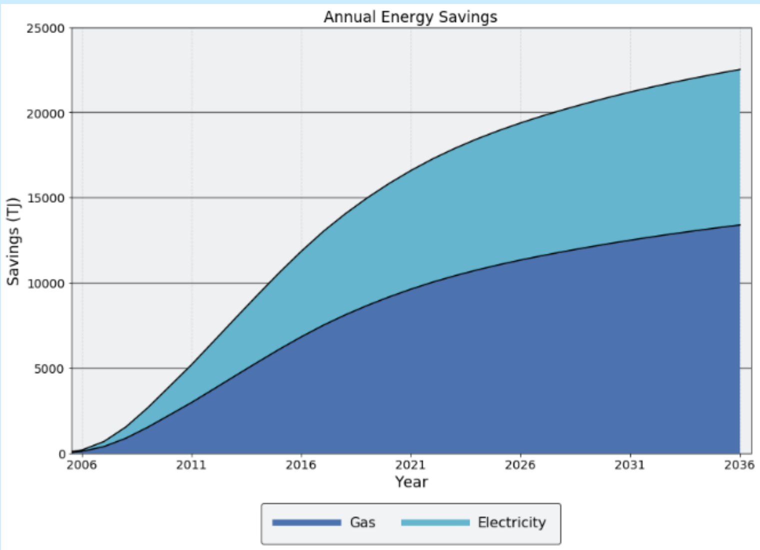
where a dishwasher is installed but not rated then the consumption is assumed to be 7.9 litres per person per day.

The benefit of WELS

The Australian Government's Water Efficiency Labelling and Standards (WELS) was launched in 2006. A study in 2019 modelled annual water savings for each year of operation and projected the estimated water savings to 2036. The largest proportion of the water savings came from taps, followed by showers and then clothes washers. Over the whole period, a growing proportion of savings was projected to come from clothes washers, dishwashers and toilets.

In 2018 the estimated saving due to WELS was 112 gigalitres (GL)/year across Australia. This is the equivalent of 21% of the water supplied for all purposes in Greater Sydney or approximately 25% of the total volume of Sydney Harbour. The savings are anticipated to grow to 185 GL/year in 2026 and 231 GL/year in 2036. The study also estimated the annual energy savings due to reducing the demand for domestic hot water.





Source: Evaluation of the environmental and economic impacts of the WELS scheme, UTS Institute for Sustainable Futures, 2019

Landscape irrigation

Basis of water calculation

BASIX undertakes a daily soil balance model for a year to determine how much irrigation is required for lawn and landscaped garden areas each day. The model uses daily rainfall, daily evaporation, soil type and landscape irrigation zone data based on the location of the building (from the postcode). The calculation considers root depth, moisture storage in 3 layers of soil, evaporation rates, total available water in root zone, water stress of soil, percolation through the soil and water entering the soil from rainfall and irrigation.

When it rains, BASIX estimates surface runoff ('infiltration excess') and also run-off if the soil is saturated and cannot absorb more. If stormwater tanks are provided and collect from this area, this run-off feeds into the recycled water calculations. If the root zone of the soil has sufficient moisture, or there has been more than 0.5mm of daily rainfall, then no irrigation is assumed. On other days irrigation is assumed, which then contributes to the soil moisture calculation the following day.

The BASIX user inputs are:

- Area of lawn – these have shallow root depth than gardens and require more irrigation than landscaped areas
- Area of landscaped area and proportion that is native plants – native plants are assumed to require 40% less irrigation water than non-natives
- Irrigation type – assumed efficiency of spray/sprinklers is 77% efficient and drip irrigation is 90%

Opportunities to save water

Key opportunities to save water in landscaped areas are:

- Reduce area of lawns and maximise area of gardens instead – both to reduce water and also to create more habitat for flora and fauna
- Use plants native to the area as much as possible – they are more resilient to drought and will require less irrigation
- Install sub-soil drip irrigation.
- While not being considered in BASIX, timers and soil moisture sensors can also reduce water consumption.
- Mulching garden beds reduces evaporative losses from the soil.
- Use collected or recycled water for all irrigation.

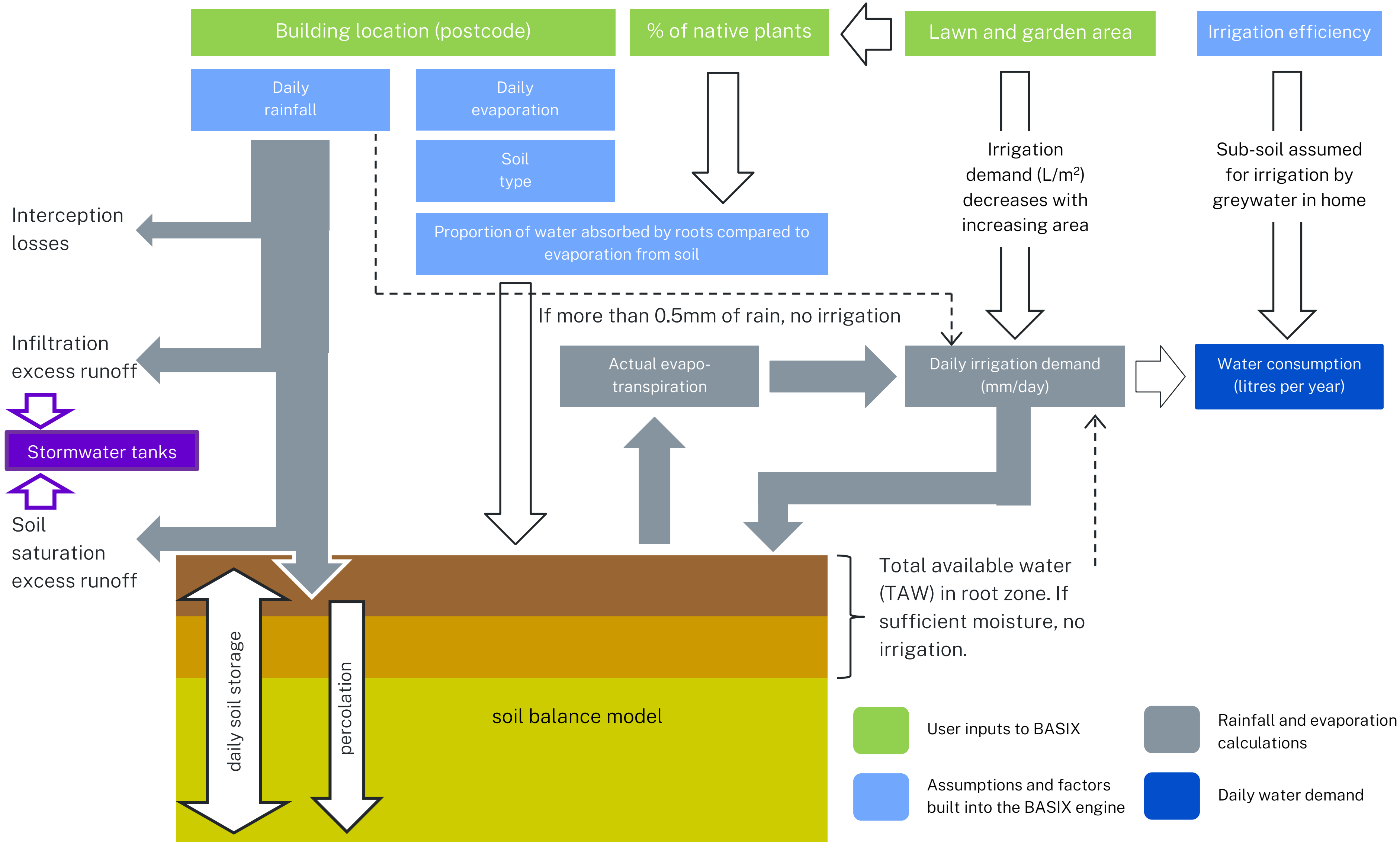


Figure 21 Key components of landscape irrigation calculations in the BASIX water module

Pools and spas

Pools

Water is consumed in the backwashing, draining and re-filling of pools. It is also used for top-up when the water levels become too low due to evaporation, or after backwashing. In BASIX users can enter data in the green boxes.

	Common area pools	Individual pools
Pool volume	Enter kL	Enter kL
Pool location	Indoors / Outdoors	Indoors / Outdoors
Shading to pool	Yes / No	Yes / No
Pool cover	Fixed (no cover)	Yes / No
Pool heating system	Entered in pool energy module	Entered in pool energy module

The total annual water consumption of a pool is the sum of the following:

Litres per annum = backwash + drain/refill + evaporation – rainwater

<table>
<tr><th></th><th>Common area pools</th><th>Individual pools</th></tr>
<tr><td>Evaporation</td><td>annual evaporative water losses from pool energy calculation</td><td rowspan="3">The pool level is calculated daily based on evaporation losses (from pool energy calculation) and rainfall. It is topped up daily to 1.1m if the level falls below 1.1m based on daily. Every month the pool level is reset to 1.2m during backwashing of 0.4% of pool volume.</td></tr>
<tr><td>Backwash</td><td>0.4% x pool volume x 12 times per year</td></tr>
<tr><td>Rainwater</td><td>annual rainfall (mm) x surface area of pool</td></tr>
<tr><td>Drain / refill</td><td colspan="2">100% x pool volume x 10 times per year</td></tr>
</table>

Water from rainwater tanks cannot be used to supply common area pools or spas, but can be used for individual dwellings.

Spas

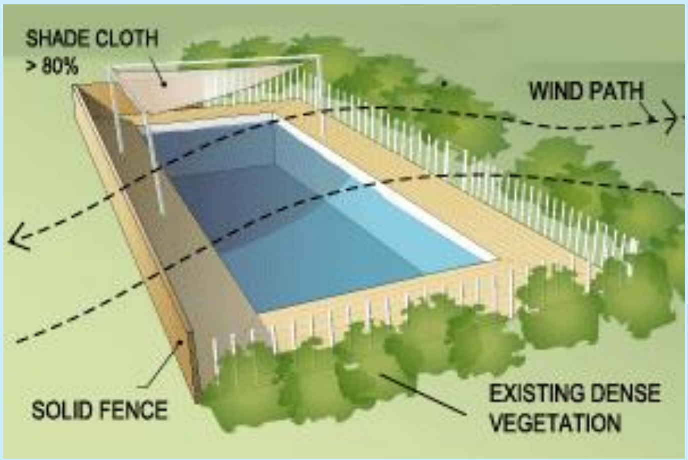
The water consumption of spas follows a similar process to that of pools except average spa depth is assumed to be 0.7m, refilling occurs three times a year, and spas cannot collect rainwater if they are covered. The daily evaporative loss from spas is higher than pools as they operate at higher temperatures.

Water saving opportunities

The primary way to save water in pools and spas is to minimise losses due to evaporation from the pool surface. The key initiatives are

- Install well insulated pool covers to reduce evaporative heat losses. Pull them over when the pool is not being used. Lightweight covers to reduce litter and leaves do not provide much benefit.
- Install shading to the pool to reduce evaporative losses due to direct sun on the surface.
- Provide wind protection to the surface of the pool including walls, solid fencing (also needed for safety), and dense vegetation.

Covers also reduce frequency of maintenance and cleaning including filter backwashing.



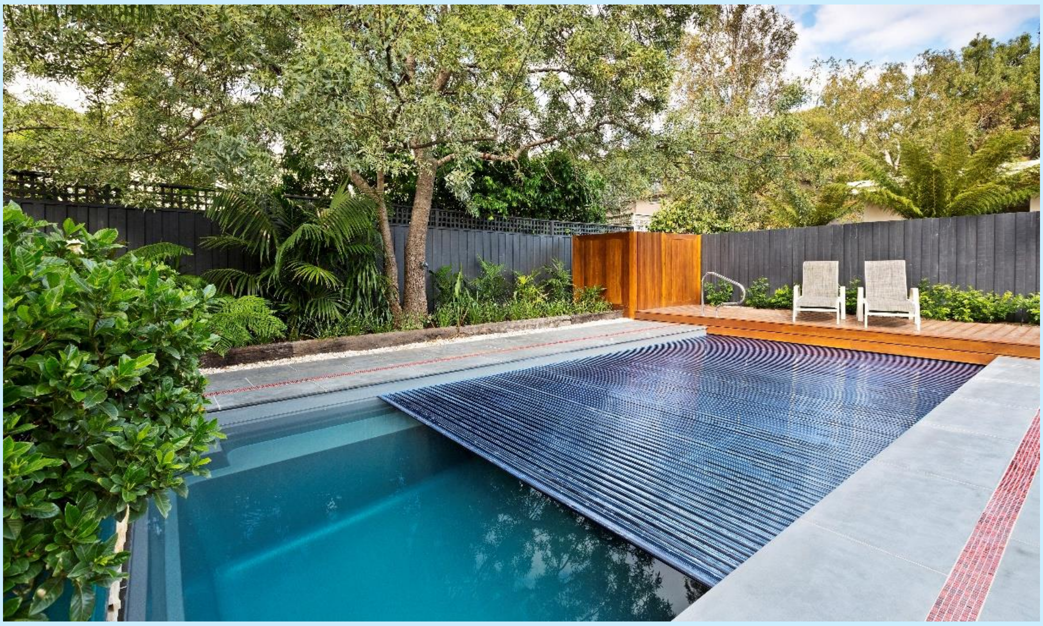


Image courtesy of Remco Pool Covers

Other water uses

Heat rejection systems

BASIX assesses the water consumption of two types of cooling systems:

- Class 1 homes: evaporative cooling units
- Class 2 buildings: heat rejection from central cooling systems via cooling towers, evaporative fluid cooler and evaporative cooled condenser

House evaporative coolers

Evaporative cooling water consumption is based on 1.365 litres for every MJ of heat to be removed. The heat is estimated in the energy module.

Central cooling towers

For central heat rejection systems, water consumption is based on make-up water requirements due to evaporation loss, drift losses and blowdown to manage dissolved solids. BASIX calculates these based on the heat to be rejected by the condenser water system calculated in the energy module.

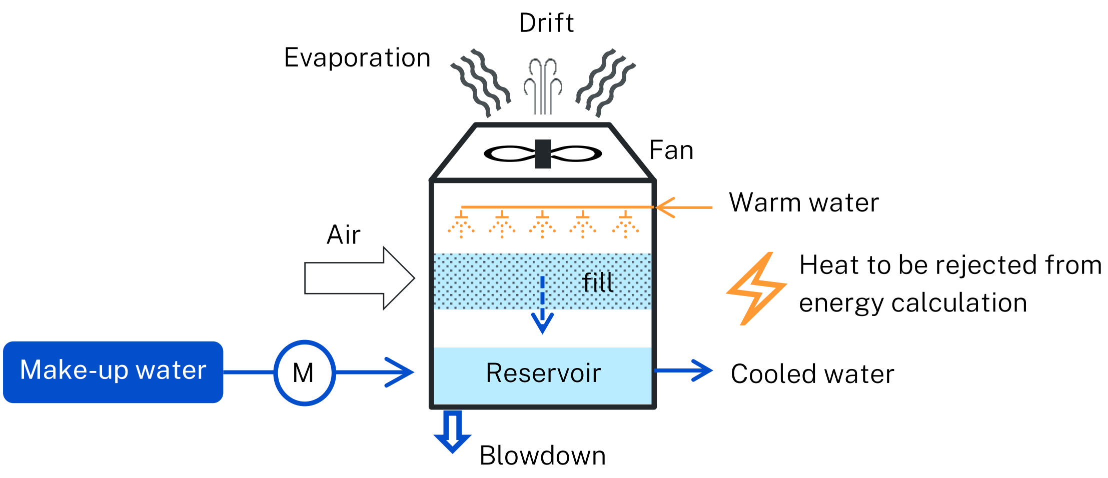


Figure 22 Water and energy balance of central cooling towers

The methods of reducing water consumption in BASIX due to cooling towers include:

- Reduce cooling energy demand
- Provide water meters on the water supply to the cooling tower
- Select a conductivity probe to manage cycles of concentration

Cycles of concentration is the ratio of dissolved solids in the recirculating water to dissolved solids in the makeup water. To keep this to acceptable levels a portion of the concentrated water must be discharged. Optimising this through monitoring, controls and regular maintenance provides the best opportunity to reduce water consumption in cooling towers.

Fire sprinklers

Mandatory fire sprinkler testing in Class 2 buildings includes a regular checks of flow switches in the water supply to each sprinkler sector and an annual test of the fire pump under conditions of full flow.

BASIX calculates the water consumption by first estimating the number of sprinkler heads in individual dwellings and residential car parking based on area, and then using this to estimate the flow rate of the fire pump. From this, and assumptions regarding the frequency and duration of the testing, the total annual test water consumption is calculated.

Instead of discharging the test water to the drain, the water expelled in these tests can be captured and reused in closed systems. By selecting a closed system for test water, the annual water consumption in BASIX is zero.

Car washing

For single dwellings, the water demand for car washing is based on 0.7 litres per person per day.

In multiple-unit dwellings the average daily water load for washing each car on-site is estimated based on:

- 90% of car parking spaces have cars that will be washed
- 70% of these are assumed to be washed on site every two months using 100 litres of water (which equates to 1.2 litres per car per day).

Leakage

BASIX makes an allowance for water leakage in Class 2 apartment buildings of 15 litres per person per day.

Alternative water suppliers

Types of alternative water and where it can be used

BASIX recognises a range of alternative water supplies. The tables below show the alternative water types and where they can be used in Class 1 (houses) and Class 2 (apartment) buildings.

Table 9 Alternative water connections in Class 1 Homes recognised by BASIX

Class 1 homes	Garden and lawn	Toilets	Laundry (cold)	Pool and spa	Domestic hot water	All uses incl. drinking
Rainwater	x	x	x	x	x	x***
Stormwater treatment	x	x*	x*			
Stormwater untreated	x					

Greywater treatment	x	x*	x*			
Greywater diversion	x					
Private Dam	x	x	x			
Off-site recycled water	x	x**	x**			
Hot water diversion		x				

Table 10 Alternative water connections in Class 2 apartments recognised by BASIX

Class 2 apartments	Garden and lawn	Toilets	Laundry (cold)	Cooling towers	Car wash
Rain and stormwater	x	x*	x*	x*	x*
On-site water treatment	x	x	x	x	x
Off-site recycled water	x	x**	x**	x**	x**

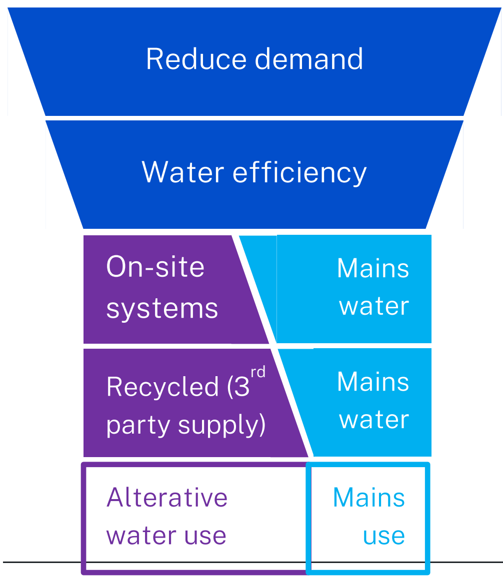
** - subject to local council and/or system manufacturer approval of treatment system*
*** - only if permitted by the recycled water scheme provider*
**** - NSW Health does not recommend the use of rainwater for drinking purposes where a reticulated potable water supply is available*

In Class 1 houses BASIX does not have the ability to supply each water use from multiple alternative water sources so users need to select only one for each. Rainwater tanks have an option to overflow into stormwater tanks to minimise wasting any collected rainwater.

In Class 1 multi-dwellings and in Class 2 apartment buildings up to two sources of alternative water can be selected for each use. BASIX assumes each will supply 50% of the demand.

How to optimise alternative water uses

Maximising the use of alternative water supply is a key component to reduce mains water consumption and provide more resilience during times of water scarcity. The diagram shows the principles of minimising mains water use and the role of alternative water.



Reduce requirement to use water – low water landscaping, small or no pool,

Select water efficient fixtures and fittings

Maximise on-site sources of alternative water supply with rainwater and stormwater being the simplest methods

Connect to local third party recycled water networks where available

Metering and monitoring systems to report against targets and identify further water reduction opportunities in operation

Figure 23 Principles of minimising mains water use and using alternative water

The optimum selection of alternative water systems will depend on the type of development, the ability to collect water for reuse and whether a 3rd party recycled water supply is available to the building. BASIX can be used in the early design stages to quickly test the benefit of different alternative water strategies.

In developing a strategy, key issues to consider include:

- Collection area to floor area ratio – a single storey house can have a collection to floor area ratio greater than 100%, particularly if it has verandas or roof overhangs. A large proportion of water use can come from rainwater depending on the climate. In tall apartment buildings the ratio can be less than 1% so rainwater collection may only be sufficient for landscaping irrigation and car washing.
- Location and size of tanks to maximise both capture and storage – in many developments space is at a premium so basement and below ground tanks may be the best solution.
- Annual cost – on-site stormwater and greywater treatment systems require energy to operate and need regular maintenance. Using rainwater from non-trafficable roofs reduces the treatment required.
- Third party recycled water supply should be provided at a cost no more than mains water per kL but need to check this.

Rainwater and stormwater tanks

Type of systems

In BASIX rainwater means rainfall collected from non-trafficable roofs. In Class 1 houses this can be used for all uses including drinking water, although when reticulated mains water is available NSW Health recommend using this for drinking and other household cold water uses.

Stormwater is rainfall runoff collected from any surface including roofs, hard surfaces (paths, balconies, driveways, etc) and landscaped areas. Due to the risk of contamination, including oils from driveways, it can only be used for non-potable purposes.

The types available depend on the property type:

- Class 1 houses can have both types of tanks. Overflow from the rainwater tank can be directed to the stormwater tank.
- Class 2 buildings can have up to five stormwater tanks. Rainwater from roofs is considered the same as stormwater as it can’t be used for potable purposes in multi-occupied buildings.

For all systems, collection, storage, treatment and maintenance is required to meet relevant water standards which will depend on the sources and uses. BASIX assumes appropriate treatment will be provided to meet the relevant standards and authority requirements.

Basis of calculation

For every tank installed users select where the water will be collected from and where it will be used. BASIX then calculates inflows and outflows for each water tank based on daily rainfall, flows diverted to the tank, and the daily demand for the water. When a tank is full the overflow can be diverted to another tank.

Key assumptions in the calculations include:

- Rainwater from roofs is assumed to pass through a first flush device (to minimise contaminants from a dry roof entering the water tank). The first 1.5mm of rain is discarded.
- The runoff coefficient for roofs is 98% and for paved surfaces is 90%. This is because water collection is not 100% efficient.
- The runoff from landscaped areas is calculated in the daily soil balance model (see Landscape Irrigation section)
- Tanks are topped up with mains water when the level falls below 10% of the capacity of the tank or 700 litres, whichever is the greater. Top-up is deducted from the daily alternative water supply
- Tanks are 50% full at the start of the year to ensure no top-up is required for the first day.

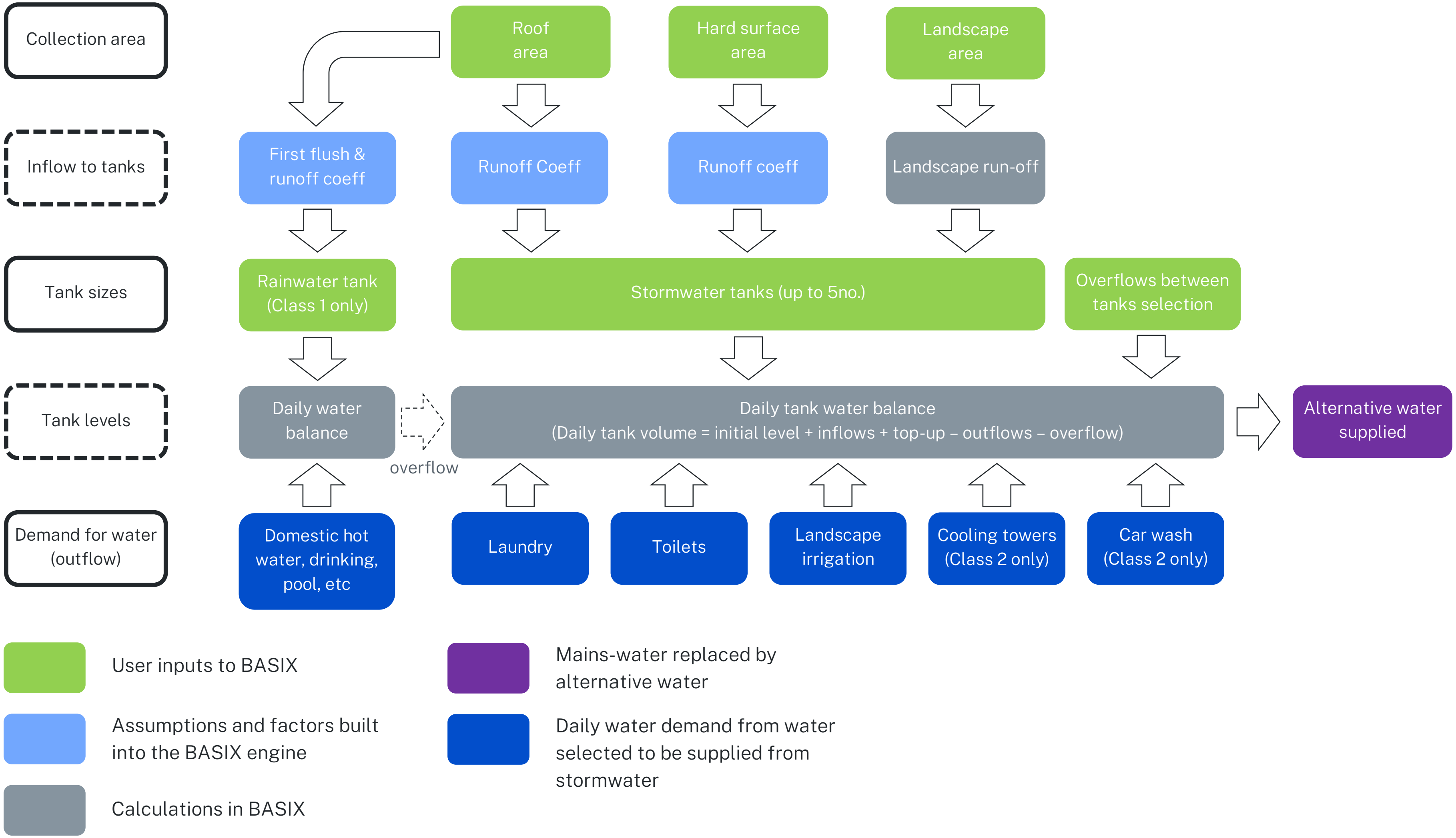


Figure 24 Key components to calculate the supply of alternative water from rainwater and stormwater tanks in the BASIX water module

On-site recycled water systems

Greywater

Greywater means wastewater that does not contain human excreta. Greywater includes wastewater from the laundry, bath, shower and bathroom basin, but not the toilet. Kitchen sink wastewater may only be included if it is treated, because it may be heavily polluted with food particles, oils and fats.

BASIX recognises two types of greywater systems:

1. Greywater diversion – untreated water is not stored and is used directly for subsurface garden irrigation in Class 1 single homes only.
2. Greywater treatment – treated water re-used for garden irrigation, clothes washing and/or toilet flushing depending on the level of treatment provided.

Class 1 homes

In Class 1 homes users can select the sources of greywater and, if treated, what it is connected to as shown in the diagram below. BASIX calculates the amount of greywater that can be supplied to meet the demand. Surplus greywater is rejected to sewer.

All forms of greywater are capable of transmitting disease and can have a negative impact on gardens and human health if not installed and managed correctly. Additional guidance on greywater reuse in single dwellings is available from NSW Water and NSW Health.

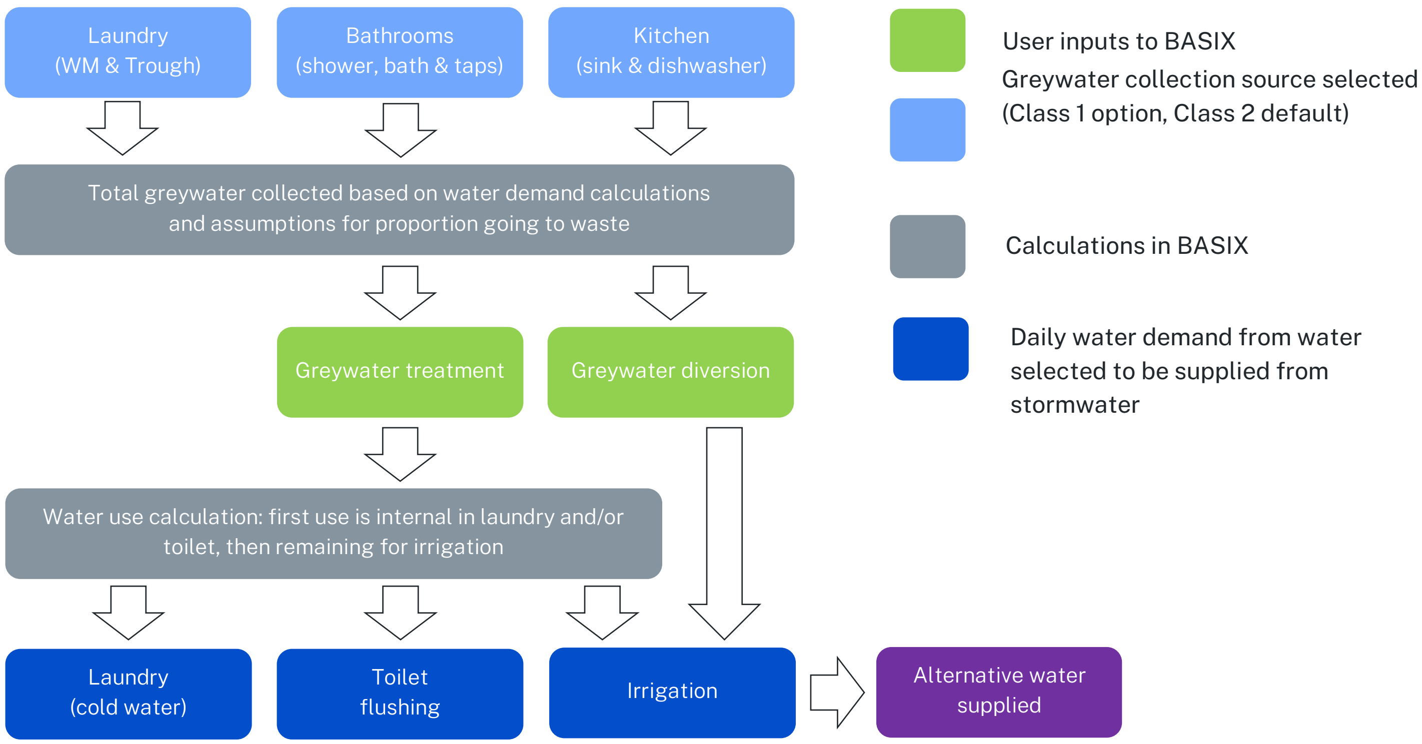


Figure 25 Key components to calculate the supply of alternative water from on-site recycled water systems in Class 1 Homes

Class 2 apartments

In Class 2 apartment buildings can provide up to 5 on-site water treatment systems. BASIX assumes these are supplied from wastewater sourced from laundries and bathrooms (as per Class 1) but excluding kitchen sinks.

Users can enter the output in litres per day for each system, otherwise the greywater collection volume calculated by BASIX is adopted. If the user nominated output is more than the BASIX volume, the BASIX value is used. Blackwater treatment systems can also be used but require an alternative assessment to override the greywater volume limit in BASIX.

Treated recycled water can be used in dwellings and for central systems as shown in the diagram below. BASIX calculates the amount of greywater that can be supplied to meet the demand.

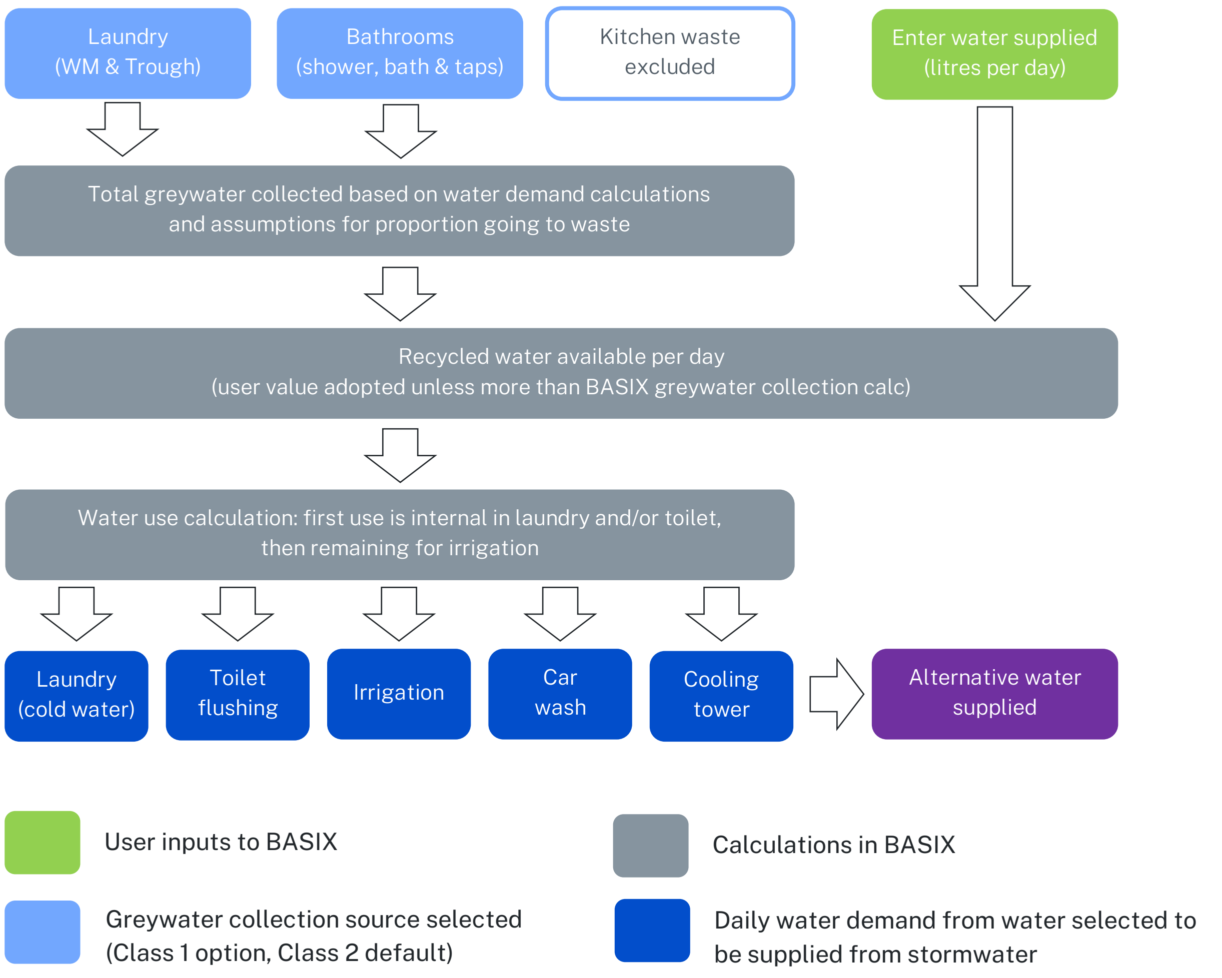


Figure 26 Key components to calculate the supply of alternative water from on-site recycled water systems in Class 2 Apartments

Other alternative water systems

Private dams

Private dams can be selected for Class 1 single homes only. The calculation is similar to that of stormwater tanks. Water stored for agriculture, stock watering, firefighting, or stormwater detention purposes. Dam water can be used for:

- Toilet flushing
- Laundry (cold water)
- Landscape irrigation

Off-site recycled water

Reticulated recycled water is recycled water supplied by a water authority or central authority for non-potable use. BASIX is regularly updated with details of the schemes currently in operation in NSW and including their allowable uses:

- All non-potable uses – garden, toilets, laundry, cooling towers and car wash
- Garden and toilets only
- Garden only

The option to select a named scheme is only available if the building is in a postcode with a scheme in operation.

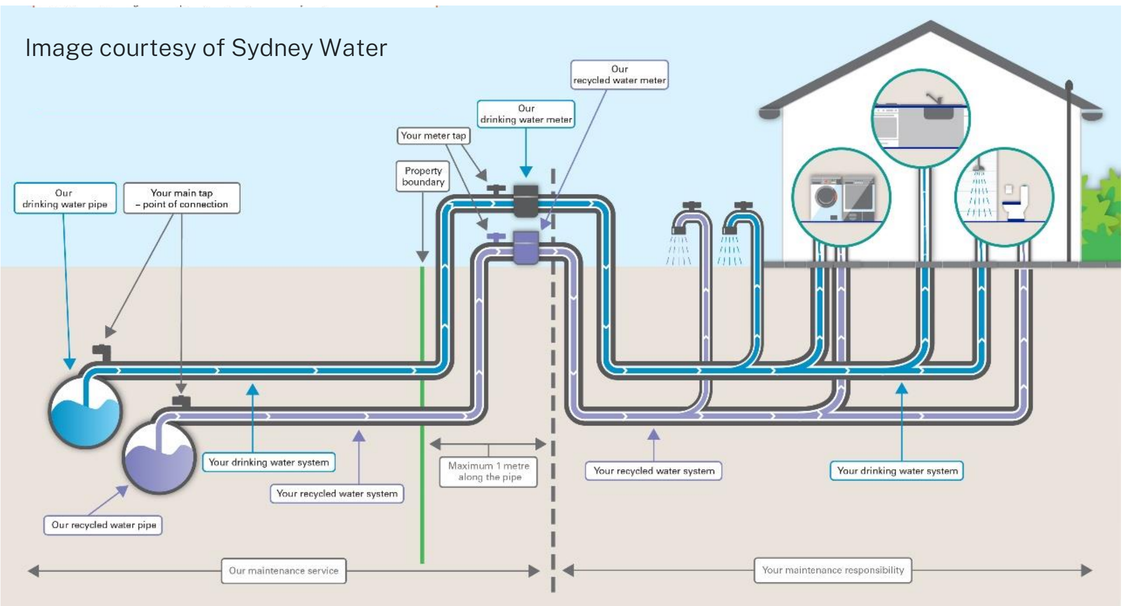


Figure 27 Reticulated recycled water – connections and end-uses (Image courtesy of Sydney Water)

Hot water diversion and recirculation systems

Hot water in pipes will cool down in between uses. Water is wasted when a hot water tap or shower is turned on with the cold water standing in the pipe typically going to waste until hot water reaches the user.

There are 3 systems in BASIX that reduce this water going to waste:

1. Hot water diversion system – the cold water in the pipe is diverted to a tank and is available as an alternative water source for toilet flushing.
2. Hot water recirculation systems (on-demand) – the cold water in the pipe is recirculated back to the water heater in response to a switch or sensor.
3. Hot water recirculation systems (continuous/timed) – the cold water in the pipe is recirculated to the water heater continuously or in response to a timer.

In diversion systems, when a tap is turned on there is no water available until all the cold water has been displaced with hot water. With recirculation systems the water is kept at a hot temperature so there is no delay in service.

For both systems, BASIX calculates the cold water that would have been wasted without these systems, using assumptions on the number of “cold starts” each day (based on the number of occupants) and the volume of cold water in the pipe (length and pipe diameter).

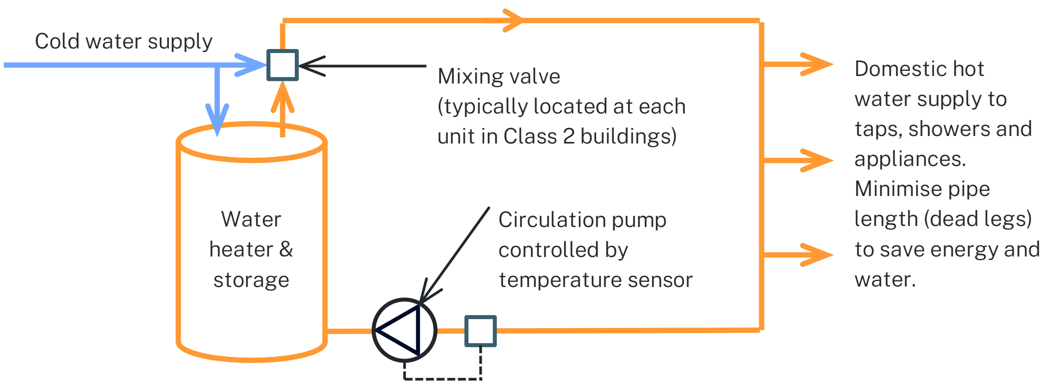


Figure 28 Schematic diagram of a hot water recirculation system

Energy saving tip

While these systems save water, they do not save the hot water energy that is wasted when the water cools in the pipe. To reduce heat energy losses (which is not calculated in BASIX) in hot water pipework the following can be considered:

- Locate the hot water heaters as close to the major uses of hot water to reduce the length of pipework.
- Provide good insulation to the pipes to minimise heat losses.

Materials index

Embodied emissions

Introduction to embodied greenhouse gas emissions

The materials used to construct buildings contribute to a range of significant environmental impacts including climate change, resource depletion, biodiversity loss and pollution of air, land and water. In addition, some can have adverse impacts on human health.

The greenhouse gas (GHG) emissions from the manufacture of construction materials and products (also known as embodied emissions, embodied carbon or upfront carbon emissions) are a particularly urgent focus. In 2021, approximately 16% of the Australian building sector's total emissions resulted from manufacture of construction materials[1].

Embodied emissions can be considered over the life of the building, from production of materials to delivery to site (or known as cradle-to-gate) and construction (or cradle-to-site), in-use including repair and maintenance, and finally to its end-of-life (cradle-to-grave but preferably cradle-to-cradle). The diagram below illustrates these stages in the life cycle of a concrete block[2].

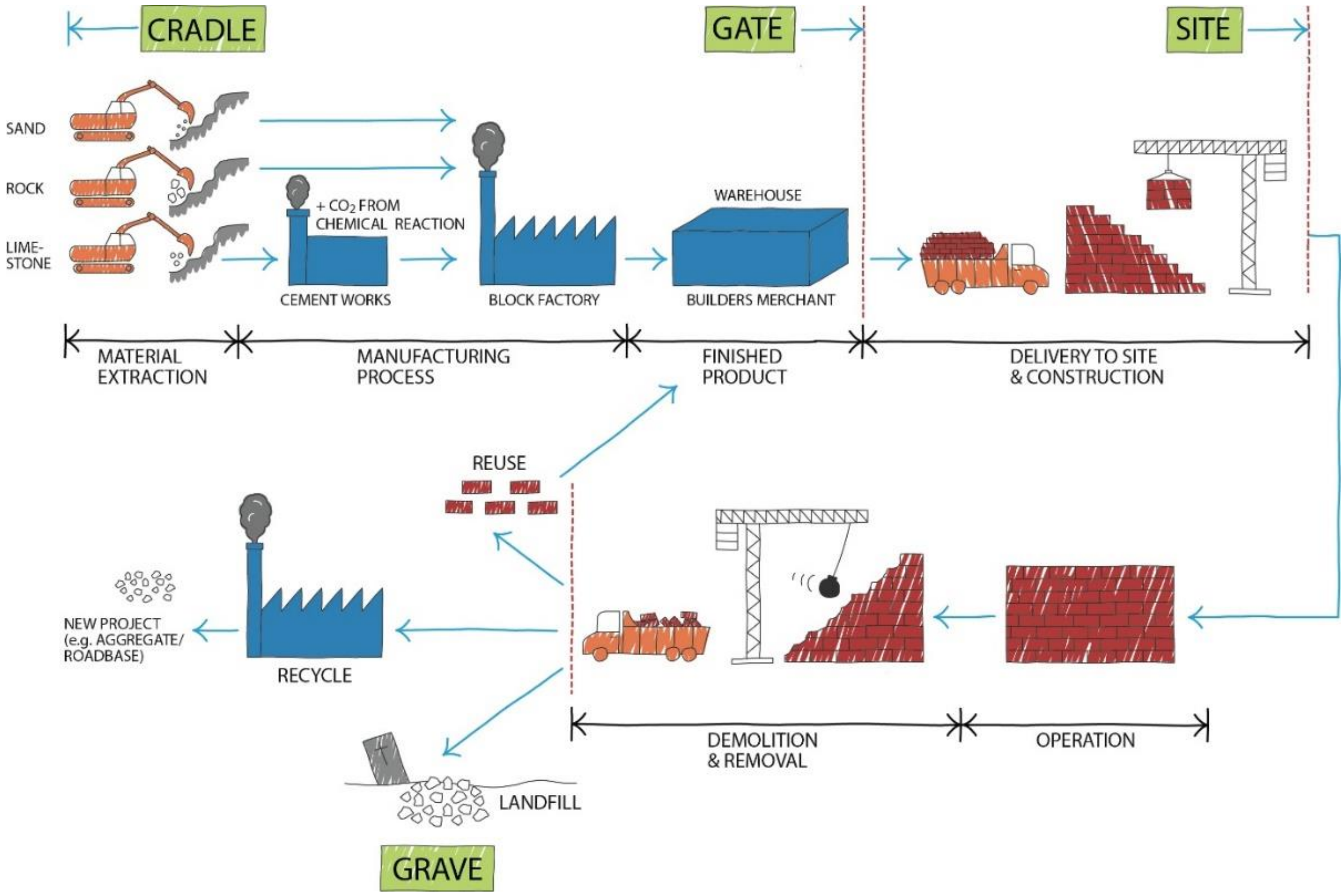


Figure 29 Stages in the lifecycle of a concrete block (Source: What Colour is Your Building?, David Clark, 2013)

[1] Embodied carbon in Australia's buildings, GBCA and thinkstep anz, 2021
[2] What Colour is Your Building?, David Clark, RIBA Publishing, 2013

International standard EN 15978 defines how to calculate the life cycle of buildings and products in more detail. For the product stage (cradle-to-gate) there are 3 modules A1 to A3 covering raw materials, transport and manufacturing. The GHG emissions for A1-A3 are available in various embodied carbon databases for generic products and in independently certified Environmental Product Declarations prepared by manufacturers for specific products.

The new BASIX materials index

In October 2023, the NSW Sustainable Buildings State Environmental Planning Policy (SEPP) came into effect. This requires all residential development to quantify the embodied greenhouse gas (GHG) emissions of materials used in construction of buildings. This is the Cradle-to-Gate (module A1-A3) emissions stage.

A new materials index module has been included in BASIX to estimate the embodied emissions. This captures information and enables decision making that is aligned to the development application (DA) stage of development. To simplify the assessment at DA stage, it is based on generic materials and typical construction forms selected by the user for the following components:

- Floors
- Walls
- Roof / Ceiling
- Windows

These components typically account for over 75% of the total materials emissions during construction. The emissions associated with transport of materials to site and construction activities (including energy use and waste) are not calculated. The module may be expanded in the future to include other components such as foundations, doors, internal walls, floor finishes, fit-out, joinery, building services and landscaping.

Modelling of typical dwelling typologies using the BASIX materials index methodology was undertaken in 2021 and the results for 2 types shown below[3].

[3] BASIX Materials Index Final Report', UTS Institute for Sustainable Futures and Kinesis, 2021

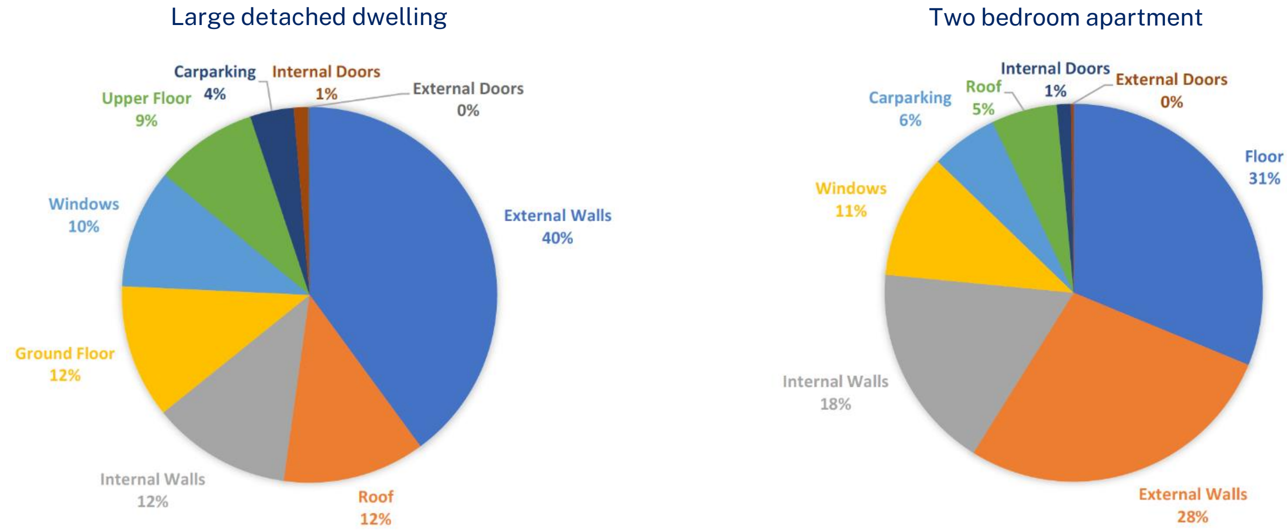


Figure 30 Breakdown of embodied emissions by building components of a large detached dwelling and a two-bedroom apartment unit

Embodied emissions methodology in BASIX

The calculation of embodied emissions (ECO_2) of a material is relatively simple:

ECO_2 = Quantity of material x GHG emission factor for the material

The calculation for a building is to repeat this for every material used and add the results together. This is not dissimilar to preparing a cost estimate from a bill of quantities with GHG factors replacing the cost rates.

GHG emission factors

Most embodied emissions calculations utilise GHG emission factors contained in industry databases. These collate data from many sources to give industry average estimates for different materials, typically with an accuracy of ±30%. This is because the production of many materials involves global supply chains. Even within Australia, the embodied emissions of a product manufactured using 100% renewable electricity in an energy efficient factory will be different to a similar product manufactured in an inefficient factory using fossil fuel energy.

More specific embodied emission factors can be obtained from Environmental Product Declarations (EPDs). These are prepared for a specific product based on a detailed Life Cycle Assessment to ISO 14025 and independently certified.

At the DA stage most products have not been selected (e.g. concrete supply from a specific supplier). BASIX uses the Environmental Performance in Construction (EPiC) database for typical materials. This database was prepared by the University of Melbourne with the support of the Australian Government. It is widely used in Australia and is recognised by NABERS and the Green Building Council of Australia.

Future versions of BASIX may allow users to enter values from EPDs when these become more widely available.

Influencing the supply chain

Designing for low carbon buildings is only one step in reducing the embodied emissions of a building. Ultimately the building has to be constructed from products and materials procured from suppliers – timber, concrete, reinforcement, steel, bricks, blocks, tiles, plasterboard, floor finishes, heating and cooling systems, pipework, electrical cabling, etc.

Every product has a carbon footprint but they are not all the same size. A way to reduce embodied emissions in buildings is to procure low carbon materials and products from suppliers who have third party verification of their low carbon credentials with EPDs or other certifications. Markets respond to demand, so the more customers preference businesses committed to reducing the carbon footprint of products, the faster the transition will occur.

What you design and what you buy are both fundamental to delivering low carbon buildings.

Material quantities in components

There are very few components of a building that comprise a single material. For example, a concrete slab-on-ground comprises concrete, reinforcing mesh and a waterproof membrane. To simplify the data entry, BASIX contains a library of construction types for which the embodied emissions have already been calculated and converted into $kgCO_2$ per m^2. These are based on assumed material quantities, types of materials and the GHG emission factors from the database.

Depending on the component type, some or all of the following options are available to build up the construction of floors, walls, windows and roofs:

- Construction type – e.g. suspended concrete slab, brick veneer wall
- Framing type – e.g. no frame, timber, steel
- Insultation type – e.g. rockwool batts, polyurethane, foil
- Low emission concrete – % of cement replacement

The area of each construction type is either taken from other inputs used elsewhere (e.g. from the DIY thermal comfort inputs for houses) or is entered into BASIX in the materials index module. Where data is not gathered, BASIX makes default assumptions.

In houses, the embodied emissions of doors are also calculated based on the floor area, number of bedrooms and typical door construction. In Class 2 buildings, the concrete volume for columns and core/lift shaft walls is entered instead of attempting to estimating this from floor areas as this will vary considerably depending on the form of the building.

The calculation is performed for every component including multiple types of each and these are then added together to give the total.

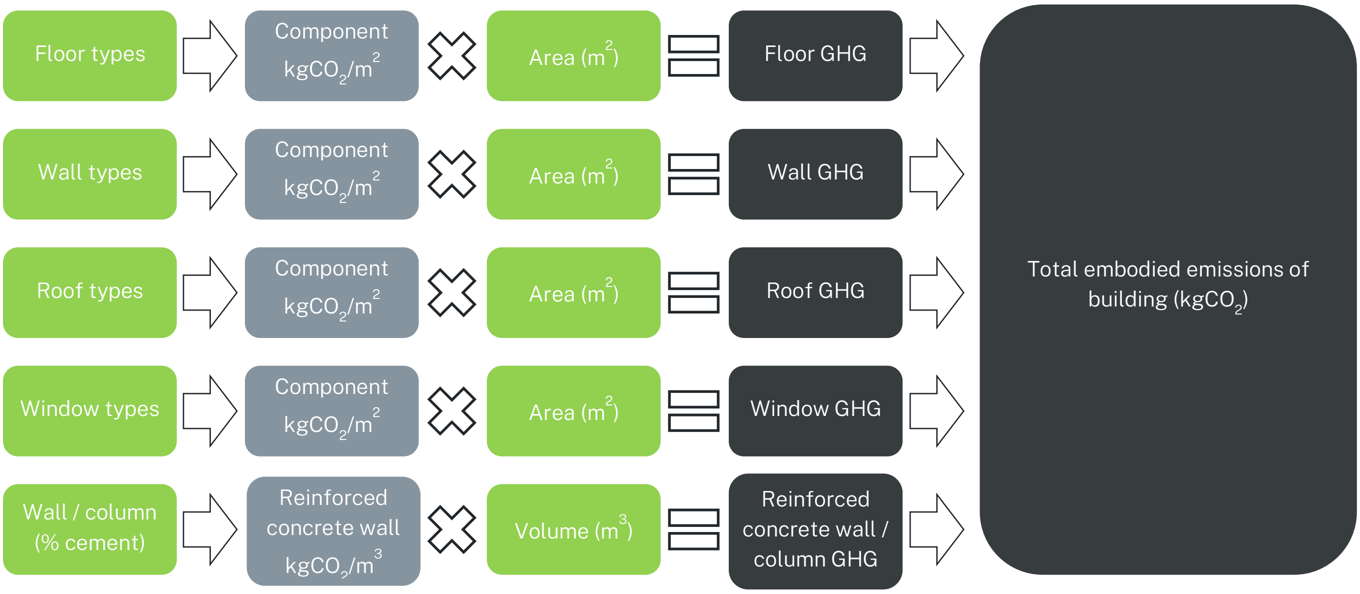


Figure 31 Key components to calculate total embodied emissions of buildings in the BASIX materials module

Example calculation for a construction type

To illustrate how BASIX calculates the embodied emissions for different construction types consider a concrete slab-on-ground where the user has selected 30% cement replacement in the concrete mix. BASIX makes fixed assumptions for the concrete grade, reinforcement type and membrane. An average concrete depth of 125mm is assumed including the edge beam and thickenings under internal walls.

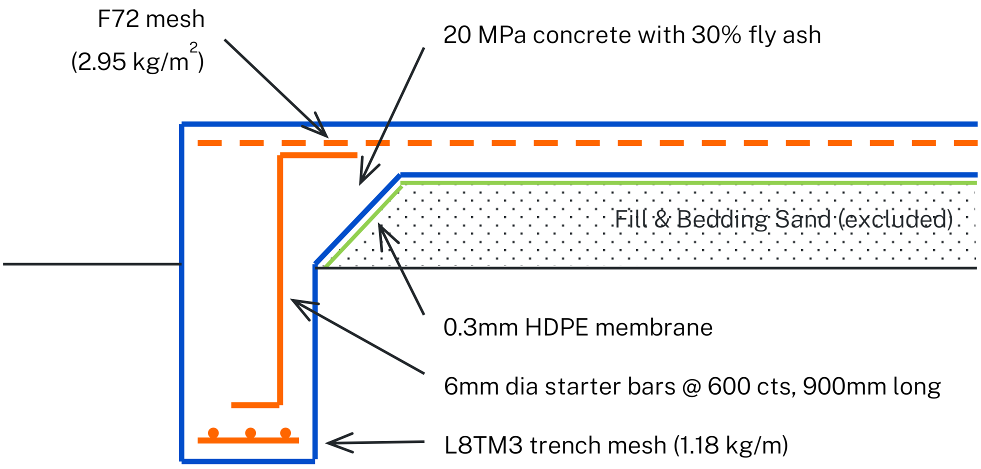


Figure 32 Cross section of a concrete slab-on-ground construction

To calculate the trench mesh and starter/trimmer bars per m^2 of floor slab, a 21m by 12m floor slab ($252m^2$) is assumed. Allow 8.5% for laps and trimming bars in reinforcement mesh. The calculation is summarised in the table:

Table 11 Calculation of the embodied emissions of a concrete slab on ground construction

	Concrete	Slab Mesh	Trench Mesh	Starters & Trimmers	Membrane
Quantity per m^2 of slab	0.125 m^3	3.20 kg	0.32 kg *	0.18 kg **	0.282 kg ***
Material type in EPiC database	Concrete 20MPa + 30% fly ash	Cold rolled steel	Cold rolled steel	Cold rolled steel	HDPE film
GHG factor	251 $kgCO_2/m^3$	2.90 $kgCO_2/kg$	2.90 $kgCO_2/kg$	2.90 $kgCO_2/kg$	6.4 $kgCO_2/kg$
GHG ($kgCO_2$ per m^2)	**31.4**	**9.3**	**0.92**	**0.52**	**1.8**
BASIX value	**43.9 $kgCO_2$ per m^2 of ground floor slab**				

* *1.18kg/m x (21m x 2 + 12m x 2) / 252m² = 0.32kg/m²*

** *0.9m x (21m x 2 + 12m x 2) / 0.8m = 20m x 0.22 kg/m = 4.4kg / 252m² = 0.09 kg/m²*
(assume same again for trimmer bars = 0.09 + 0.09 = 0.18 kg/m²)

*** *0.0003m x 940kg/m³ = 0.282 kg/m²*

Embodied emissions benchmark

The new BASIX materials index will calculate and report on the embodied emissions of a home. The index is based on $kgCO_2$ per person not floor area. This is because smaller homes require less materials than large homes. A home for 2 people that is twice as big as it needs to be is not a good use of resources. More building often means more land to be built on and less space for nature. This also aligns with the benchmarks for energy and water in BASIX.

National average benchmarks of 10,400 $kgCO_2$ per person for houses and 8,800 $kgCO_2$ per person for units have been established to calculate a score to assist in putting the results of the embodied emissions calculations into context.

Initially there will be no target on embodied emissions of building materials in BASIX. This will be developed in the future as data from BASIX embodied emissions assessments is collated and analysed.

Future development

Reducing embodied emissions in the construction of houses and apartment buildings, through design and procurement decisions, will help NSW meet the zero carbon goals. The BASIX material index will evolve over time to help drive this change.

Future development may include:

- expanding the components to include foundations, doors, internal walls, floor finishes, fit-out joinery, building services and landscaping
- allowing Environmental Product Declaration values to be used where these products are specified at DA and installed during construction
- calculating GHG emissions due to delivery of materials to site and construction activities
- assessing the full life cycle impact of building materials (in use and end of life) including consideration of durability, recyclability ad other key circular economy principles.

Reducing embodied emissions

Design

To reduce embodied emissions in design, consider the following:

- Maximise reuse of existing buildings or components of buildings (structure, envelope, finishes, services) to reduce the amount of materials required and to minimise demolition waste.
- Design to optimise use of space – bigger isn't always better and will increase both the materials needed for construction and the energy needed to heat and cool.
- Select low carbon construction typologies with timber structures typically being amongst the lowest carbon solutions.
- Design to standard material dimensions (typically in factors of 300mm) to reduce material offcuts which can end up as waste.
- Every building uses concrete somewhere in its construction so specify low carbon mixes. In high rise apartment buildings, reinforced concrete can account for over 60% of the total embodied emissions split roughly 50/50 between concrete and reinforcement steel.

Portland Cement production is responsible for between 4% to 7% of global GHG emissions. To reduce the amount of cement required to build dwellings avoid over specifying the concrete strength grade (higher grades need more cement per m3) and use cement replacement such as fly ash, granulated blast furnace slag and geopolymers. BASIX allows users to select the percentage of cement replacement but not the strength grade (which is assumed as 20 MPa for houses).

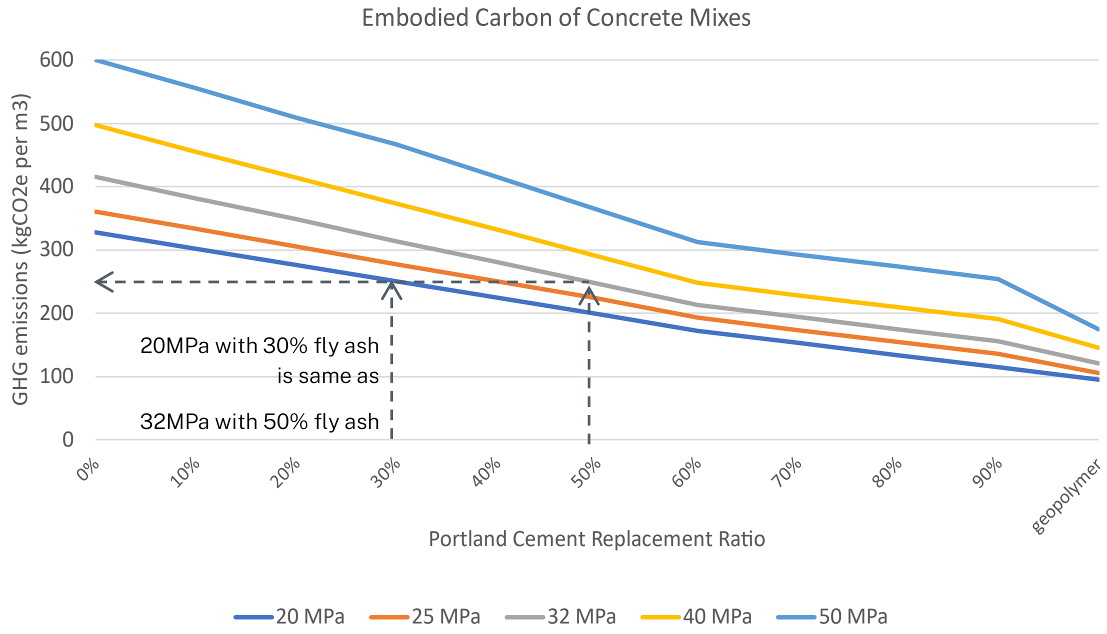


Figure 33 Embodied carbon of concrete mixes (data extrapolated from EPiC database 2019)

Procurement

When choosing which materials and products to purchase consider:

- Is a reused or recycled product available instead of buying new?
- Does the product have an Environmental Product Declaration (EPD) or other third-party environmental certification to confirm its low carbon credentials?
- Does the manufacturer's website provide details of how they reduce, or are intending to reduce, the GHG emissions associated with their product? Is it credible or greenwash?

Volume home builders and apartment developers can exert more influence on the supply chain than individual home builders – so use that leverage to help the manufacturers transition to low carbon products faster by creating demand and competitive advantage.

Delivery and construction activities

This is not covered in the BASIX Materials Index but typically represents between 10% and 15% of the total embodied emissions during construction. Opportunities to reduce embodied emissions include:

- selecting local suppliers to reduce delivery distances.
- minimising use of diesel generators and equipment where possible by switching to electric.
- using biodiesel to reduce GHG emissions due to fossil fuels.
- procuring 100% renewable electricity during construction.
- asking suppliers to take back packaging to reduce waste.

- reducing the generation of waste through design.
- setting a waste diverted from landfill target of 90% and ask the contractor to provide a waste report confirming compliance.

Life cycle considerations

Embodied emissions should not be considered in isolation of operational GHG emissions and durability. For example, a concrete ground slab will have a higher initial embodied emissions than a suspended timber floor. However, it should last longer, require less maintenance, and if its thermal mass properties are utilised in the house design, it can reduce heating and cooling energy consumption and improve thermal comfort. The timber floor may provide a better solution depending on the climate and application – but only if the timber was sourced from sustainable plantations.

The optimum solution is typically the one that delivers the biggest overall cost, carbon and environmental benefit over the expected life of the building.

Appendices

Average thermal loads for energy testing

This section provides an overview of how to use the average thermal caps to quickly test Class 2 building energy options during concept design stage without having to enter every apartment individually. This saves time as the design of these will inevitably change as part of the design process prior to DA submission.

Understanding the thermal caps

NatHERS star bands

From the NatHERS website download the star bands database. Sydney CBD is in Zone 17. The caps in 2023 for 7 star upwards are shown in the table below. This is for the total of heating and cooling loads combined.

Table 12 NatHERS star bands of 6 stars and above in Sydney CBD

Stars	6	6.5	7	7.5	8	8.5	9	9.5	10
MJ/m^2	39	35	30	26	22	18	14	10	7

For Class 2 apartment buildings greater than 5 storeys, BASIX uses the 7 star value (30 MJ/m^2) to set the total cap (heating + cooling) for the average of the whole building, and the 6 star value (39 MJ/m^2) for the total cap for each individual unit.

For Class 2 apartment buildings 5 storeys or lower there is no cap on the total for individual units, but the average of 7 stars for the whole building must still be met. For houses the 7 star cap applies.

BASIX heating and cooling caps

BASIX has set separate caps for heating and cooling. For low to mid rise apartments the caps for the whole building average are the same as for individual units. For 6 storeys and higher there are separate caps for the average and the individual units. Caps for a 6 storey Sydney CBD building are shown in the table below.

Table 13 BASIX heating and cooling caps for a 6-storey building in Sydney CBD

	Heating Cap	Cooling Cap	Total Cap		Sum of caps
Average for whole building	28.0	18.6	**30**		46.6
Individual units	36.9	20.4	**39**		57.3

As can be seen, the sum of the heating and cooling caps is more than the total cap. All six caps must not be exceeded to pass BASIX.

Understanding what the BASIX caps are and how they relate to NatHERS star bands can be used in the concept design stage to test energy performance options for the building without having to undertake NatHERS ratings of the whole building while the design is still evolving and changing.

Estimating the average heating and cooling loads for energy testing

The heating and cooling caps in BASIX vary by climate zone, as does their proportion to the sum of both. For example, in Sydney CBD heating (28.0 MJ/m^2) is 60% of the sum of both heating and cooling (46.6 MJ/m^2) but this can range from 18% in Byron to 82% in Orange.

Assuming the heating and cooling caps are representative of heating and cooling energy demands in these climates, the ratio heating and cooling caps can be used to estimate the average heating and cooling loads to enter in BASIX for testing of the total building energy consumption.

Using the Sydney CBD 6 storey apartment building example the thermal loads to enter in BASIX for a 7-star NatHERS star rating can be calculated as follows:

Heating load = 30 MJ/m^2 x 60% = 18 MJ/m^2

Cooling load = 12 MJ/m^2 x 40% = 12 MJ/m^2

The same process can be used to test the energy savings due to increasing the thermal performance of the building envelope by achieving higher NatHERS ratings.

Table 14 Heating and cooling loads with different NatHERS star ratings for energy testing

NatHERS star rating	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**
Heating (MJ/m^2)	18.0	15.6	13.2	10.8	8.4	6.0	4.2
Cooling (MJ/m^2)	12.0	10.4	8.8	7.2	5.6	4.0	2.8
Total (MJ/m^2)	**30**	**26**	**22**	**18**	**14**	**10**	**7**

It is important to note that this is only used to allow BASIX to estimate the total heating and cooling energy consumption of the building based on the system type and efficiency selected.

It is not used to confirm the thermal performance design of the building. This needs to be done through sample testing in NABERS of typical and extreme apartments to identify design solutions to meet the heating, cooling and total thermal caps in BASIX.

Benchmarks and factors used in BASIX

Energy benchmark

The greenhouse gas (GHG) emission factor is the emission (expressed as kilograms of carbon dioxide equivalent ($kgCO_2$-e)) generated and transmitted from each unit of energy to households. GHG was used as a proxy to allow grid electricity and natural gas consumption to be combined into a single unit for energy benchmarking purposes. This is a common approach taken by many rating tools including NABERS.

The table below shows how energy consumption data and GHG factors were used to calculate the BASIX Energy benchmark in 2003.

Table 15 Assumptions and calculations behind the BASIX energy benchmark

Item	Value	Source of data

Total population of NSW (Dec 2002)	6,660,377	ABS 3218.0
Population that are off the electrical grid (Dec 2002)	10,000	The NSW Department of Energy, Utilities and Sustainability (DEUS)
Population for BASIX benchmark	**6,650,377**	
Annual residential on-grid electricity consumption in 2002/03 (GWh/year)	19,747	DEUS Electricity Network Performance Report 2002/03
Electricity GHG factor ($kgCO_2/kWh$)	1.012	
Annual GHG emissions ($MtCO_2$)	19,983	
Electricity GHG benchmark ($kgCO_2$/person.year)	**3,005**	(91% of benchmark)
Annual residential reticulated gas consumption in 2002/03 (GJ/year)	26,523,420	IPART for 2002/03
Gas GHG factor ($kgCO_2/MJ$)	0.0719	
Annual GHG emissions ($MtCO_2$)	1,907	
Gas GHG benchmark ($kgCO_2$/person.year)	**287**	(9% of benchmark)
BASIX Energy Benchmark ($kgCO_2$/person.year)	**3,292**	

Water benchmark

The water consumption benchmark is based on Sydney water estimates for the average NSW daily per capita water use (L/(person.day)) from both the internal and external areas of each type of dwelling in 2002/03. The estimated value of the benchmark is 247.5 L/(person.day).

Greenhouse gas energy factors for 2023

The NSW electricity grid is rapidly decarbonising due to renewable energy generation while natural gas GHG factors remains the same. The GHG factors in BASIX are:

Gas = 0.0663 $kgCO_2$-e per MJ (0.24 $kgCO_2$-e per kWh) – unchanged from previous version of BASIX

Electricity = 0.67 $kgCO_2$-e per kWh – based on the estimated 10-year average GHG factor for the NSW electricity grid from 2022 to 2031.

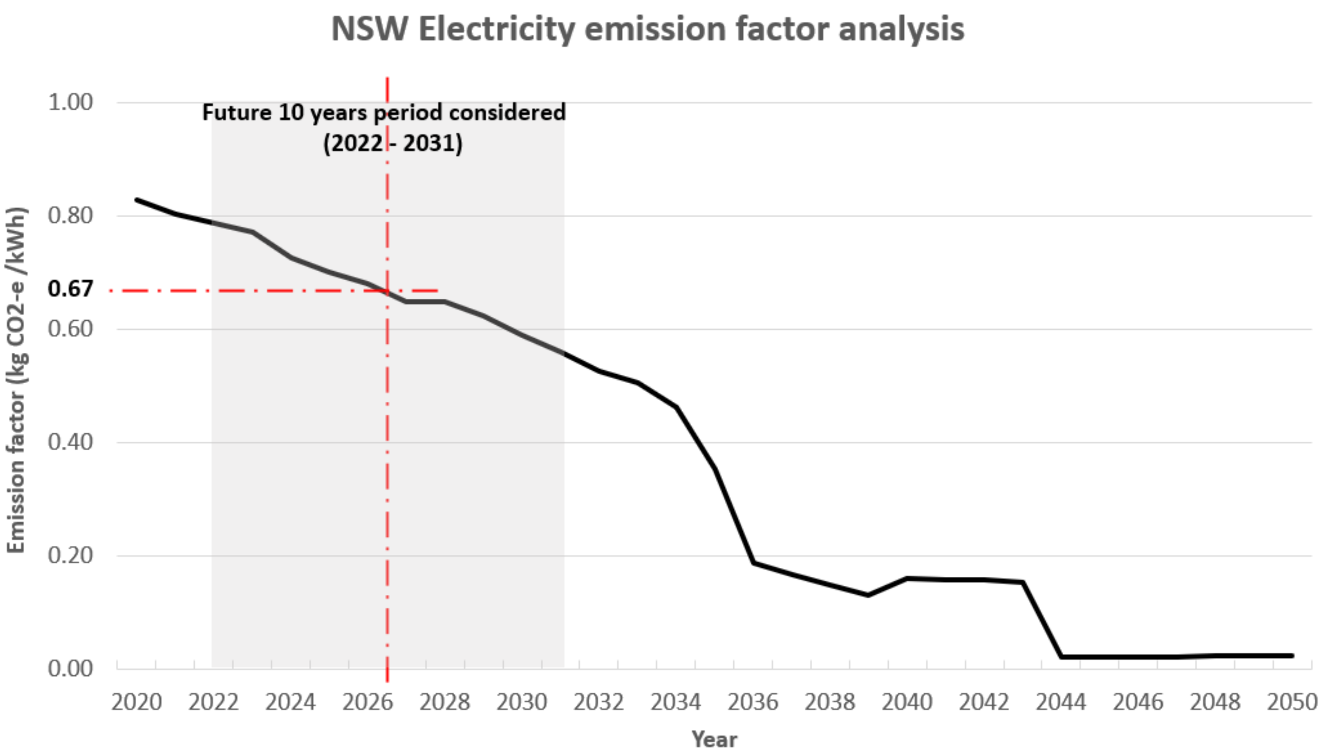


Figure 34 Greenhouse gas emission factor of grid electricity in BASIX

(Source: https://www.planningportal.nsw.gov.au/BASIX-standards)

Dwelling occupancy methodology

From October 2023 BASIX uses a new method of estimating the number of occupants (N_{Occ}) to align with the NCC 2022 NatHERS whole-of-home calculation as follows:

$$N_{Occ} = 1.525 \times \ln A_D - 4.533$$

where:

A_D represents the total floor area excluding garage,

N_{Occ} is bounded between 1 and 6 inclusive and varies with A_D as shown in the graph below

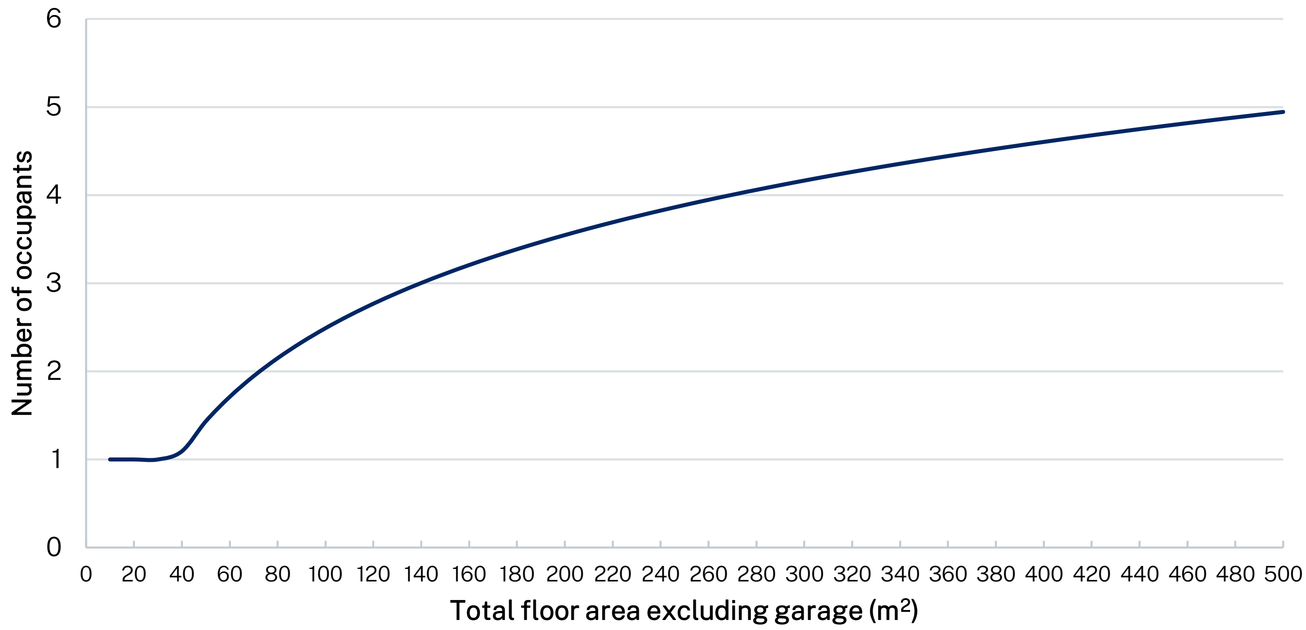


Figure 35 Estimated number of occupants based on total floor area

Key changes to BASIX in 2023

Several changes were introduced in the updated version of BASIX released on 1 October 2023. These are summarised in the table below.

Table 16 A summary of the key changes to BASIX in 2023

Use	Key changes
House areas	▪ Standards will vary with total floor area. This is to account for energy consumption and the number of people that live at a property. For example, A small house with a floor area of 100m^2 will have different standards to a large house with floor area of 250m^2.
High rise	▪ Two separate standards are proposed for high rise apartment buildings to account for the energy consumption of shared services specified in high-rise buildings: 6 – 20 storeys and 21 storeys and higher.
Lighting	▪ LED is now the default for dwellings.
Appliances	▪ Default efficiencies updated ▪ Fridges and washing machines removed as options to improve the score (because BASIX is about dwelling design not appliances that may be replaced within 30 minutes) ▪ Dishwashers and dryers are retained as these are typically installed in the purchase of a new dwelling

Central systems (Class 2 and 3 buildings only)	▪ New lift calculation methodology to include lift banks serving different floors and express zones ▪ Tempered air supply option added for lift lobbies and corridors ▪ Heat pump options increased
Heating and cooling systems	▪ Ceiling fans have been removed as their benefit in reducing cooling loads is now assessed directly in NatHERS. ▪ The day/night zoning option for air conditioning in Class 2 units has been removed. This previously reduced calculated heating and cooling energy in a unit by 20%.
Photovoltaic systems in dwellings	▪ These are calculated using NatHERS Whole-of-Home algorithms and allow orientation and inclination (slope) to be entered.
Materials index	▪ A new module to estimate the GHG emissions due to materials used in the construction and comparison to a benchmark. No regulatory target is set.

NSW Department of Planning and Environment

4 Parramatta Square
12 Darcy Street Parramatta NSW 2150

Locked Bag 5022
Parramatta NSW 2124

Office hours:
Monday to Friday
9.00 am — 5.00 pm

www.dpie.nsw.gov.au