Sutherland Shire Entertainment Centre – ESD Report

30 Eton St,
Sutherland NSW 2232

JN
Responsive Engineering

19010144

Revision History

REVISION	DATE	BY	CHECKED	COMMENTS
1	30/01/2020	BS	AD	Initial Issue

The recipient of the latest issue as noted above will be responsible for superseding/destroying all previous documents.

Contents

1. Executive Summary

JN Consulting has been engaged by to undertake the required Ecologically Sustainable Design (ESD) assessments and provide a sustainability report for the proposed alterations and additions to Sutherland Shire Entertainment Centre at 30 Eton St, Sutherland NSW 2232.

The principles of ecologically sustainable design will be an integral consideration throughout this development. This report summarises the energy efficiency provisions for the development which demonstrate commitment to environmental sustainability.

The sustainability targets for the development will be achieved in an integrated and staged approach through minimising the need for energy consumption (via passive measures) and then consumption optimisation (energy efficiency) and use of renewable resources where required.

The initiatives presented in this report demonstrate a wide range of measures which will result in high levels of environmental performance and also improvement of occupants' health, productivity, comfort and satisfaction.

Aiming at leading practice in energy and environmental targets, the project architect and building services design team will maximise energy efficiency in an integrated and staged approach:

Load Reduction (minimising the need for resource consumption e.g. energy, water and material)	Passive Design
	Building fabric improvements
	Maximise use of natural lighting
	Maximise use of Natural ventilation
Optimising energy and water consumption	High efficiency Heating, Ventilation and Air Conditioning
	High efficiency lighting
	High efficiency hot water systems
	High efficiency appliances
Use of renewable resources (renewable energy and rainwater harvesting)	Application of Solar Energy or Solar thermal systems where practical
	Rainwater harvesting

Benchmarking and compliance requirements:

The development will meet and outperform the following regulatory sustainability requirements:

- Standard Secretary's Environmental Assessment Requirements (SEARs) – ESD requirements
- NCC 2019 Section J (Energy Efficiency – outlined as part of the NCC Section J JV3 Report)

Sustainability targets beyond the minimum requirements

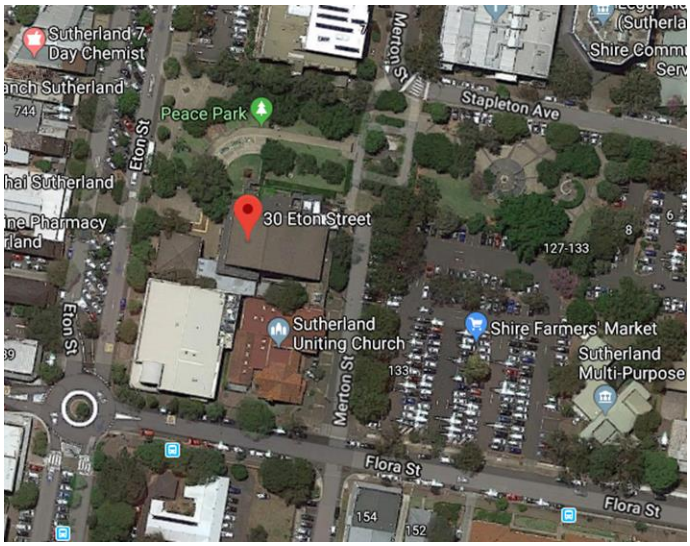
Although not seeking formal rating certification, where feasible, the design team will also consider the sustainable design principles based on the following sustainability tool.

- Green Star Design & As Built Tool – Green Building Council of Australian

2. INTRODUCTION

The design team recognise the importance of sustainable developments in terms of environmental preservation, occupants' health, safety and wellbeing, as well as in terms of greenhouse gases emissions reduction.

The project architect, consultants and contractors will strive to design and construct the building based on the Environmentally Sustainable Design (ESD) principles which exceed the minimum NCC Section J requirements.



Location – 30 Eton St, Sutherland NSW – Source: Google Map

The facade and floor plans are designed with the vision to give occupants the very best in terms of passive heating and passive cooling. This, when combined with other energy efficiency strategies (listed later in the report) will lead to low energy demands for the apartments and base building and therefore lower greenhouse gas emissions during the life of this development.

Natural lighting and natural ventilation will be utilised very effectively throughout the development. In addition to thermal comfort, energy and water efficiency, the proposed building design will provide sustainable and efficient operation to the occupants.

The proposed sustainable design initiatives will not only improve the building services life but are low-cost, low maintenance and reliable, especially when compared to often prohibitively complex and expensive retrofits. Furthermore, the passive design principles will facilitate a low-energy and cost-effective operation for the occupants.

The following are some of the design initiatives which will improve the environmental performance of the development and deliver long term energy efficiency during the life of the building.

- Optimising the size of the mechanical plant to ensure the plant is working at its peak efficiency and minimise the capital cost of the plant;
- Having high efficiency lighting and air conditioning equipment will reduce the energy consumption of the buildings;
- Variable Speed Drives (VSD) controls the speed of pumps, fans and other mechanical plant to ensure that they are only using as much power as it is needed;
- Commissioning of all services equipment to ensure their correct operation;
- A high-performance façade will limit the heat entering the buildings, reducing air conditioning system sizes and the energy use over the year;
- Emission reductions and material optimisation.
- Maximise use of non-toxic building materials
- Maximise use of materials that are recyclable
- Minimise Waste in Construction
- Minmise Waste in Operation
- Renewable Energy generation – Solar PV

3. Benchmarking

The development will meet and outperform the following regulatory sustainability requirements:

- Standard Secretary's Environmental Assessment Requirements (SEARs) – ESD requirements
- NCC 2019 Section J (Energy Efficiency – outlined as part of the NCC Section J JV3 Report)

Sustainability targets beyond the minimum requirements

Although not seeking formal rating certification, where feasible, the design team will also consider the sustainable design principles based on the following sustainability tool.

- Green Star Design & As Built Tool – Developed by Green Building Council of Australian

3.1 National Construction Code (NCC) Section J

Section J of the NCC sets regulations for energy efficiencies for all types of buildings with respect to the building's construction, design and activity.

The objective of the NCC Section J is to reduce the greenhouse gas emissions. Section J requires that a building, including its services, must have features to the degree necessary that facilitate the efficient use of energy.

The NCC offers two compliance methods that differ in complexity and flexibility. The two compliance methods are:

- Deemed-to-Satisfy (DTS) Compliance
- JV3 – Verification using a referenced building

The Deemed-to-Satisfy Provisions in Section J of the NCC 2019 include the following 8 components.

- Part J1 - Building Fabric – Minimum thermal performance constructions for roofs, ceilings, roof lights, walls, glazing and floors in the relevant climate zone.
- Part J2 - Blank in NCC 2019
- Part J5 - Air-Conditioning and – Provisions to reduce the loss of conditioned air and restrict unwanted infiltration to a building.
- Part J4 – Blank in NCC 2019
- Part J5 - Air-Conditioning and Ventilation Systems – Requirements to ensure these services are used and use energy in an efficient manner.
- Part J6 - Artificial Lighting and Power – Requirements for lighting and power to ensure energy is used efficiently within a building.
- Part J7 - Hot Water Supply – Restrictions for hot water supply design except for solar systems within climate zones 1, 2 and 3.
- Part J8 - Facilities for Energy Monitoring

The development will meet and outperform the NCC energy efficiency requirements of Part J.

3.2 Green Star

Green Star is an environmental rating tool developed by the Green Building Council of Australia (GBCA) that has a holistic approach over a wide range of issues that covers a range of sustainability impact areas. There are various Green Star tools developed to suit a range of different building types including:

- Design and As-Built
- Office Interiors
- Performance
- Communities

Green Star rating tools use Stars to rate performance:

- 4 Star Green Star Certified Rating (score 45-59) signifies 'Best Practice'
- 5 Star Green Star Certified Rating (score 60-74) signifies 'Australian Excellence'
- 6 Star Green Star Certified Rating (score 75-100) signifies 'World Leadership'

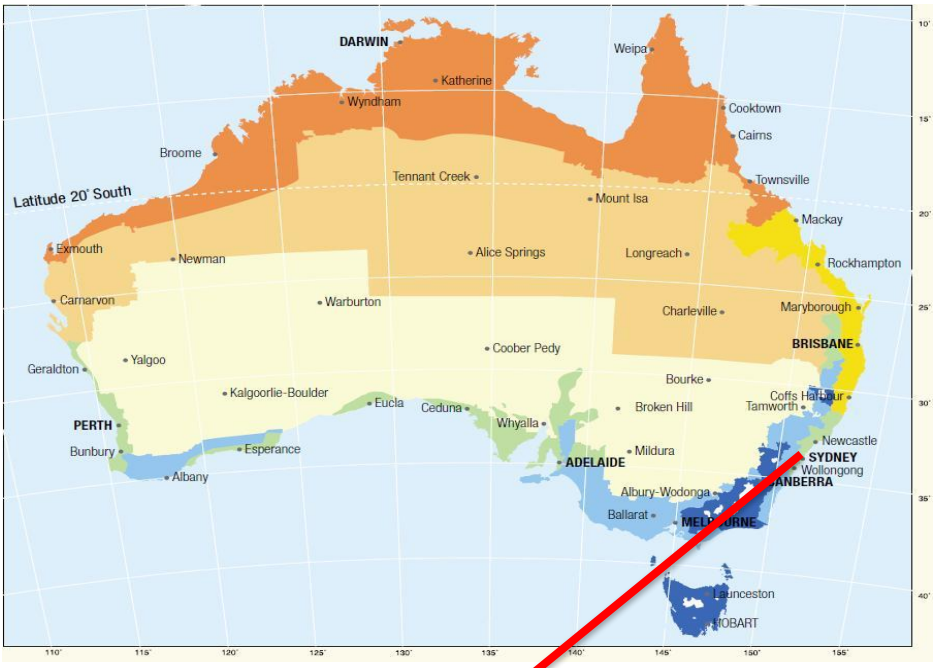
Green Star rating tools include eight separate environmental impact categories, which have different weighting attached to each category as seen in the table below:

- Management;
- Indoor Environment Quality;
- Energy;
- Transport;
- Water;
- Materials;
- Land Use and Ecology;
- Emissions, and
- Innovation

The development is not seeking a formal Green Star certification, however, where feasible, the design team will consider the sustainable design initiatives associated with Green Star.

4. Development Location

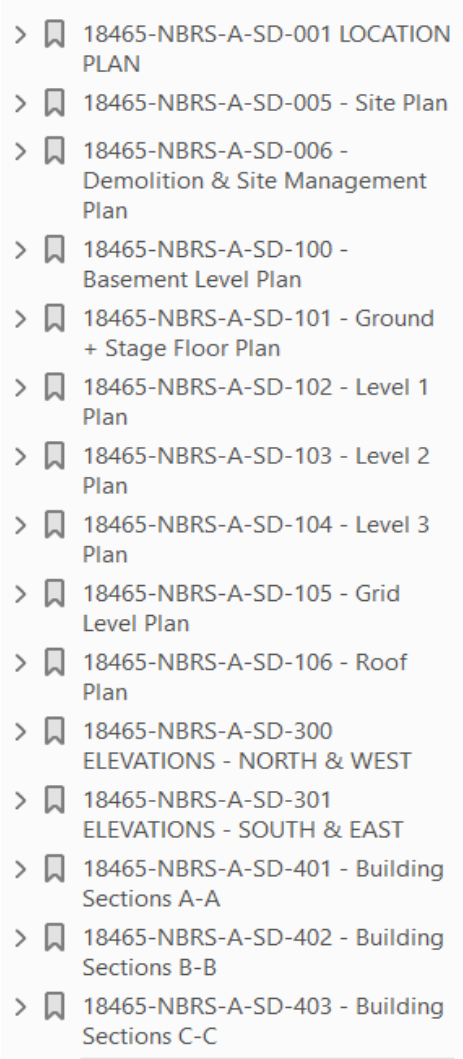
The development is located in Sutherland NSW which is within the NCC climate zone 5 (warm temperate). The main building classification for the building is Class 9b.



ZONE	DESCRIPTION
1	High humid summer, warm winter
2	Warm humid summer, mild winter
3	Hot dry summer, warm winter
4	Hot dry summer, cool winter
5	Warm temperate
6	Mild temperate
7	Cool temperate
8	Alpine

4.1 Information Used in Review

Our review is based on the following preliminary architectural drawings provided by NBRS Architecture.



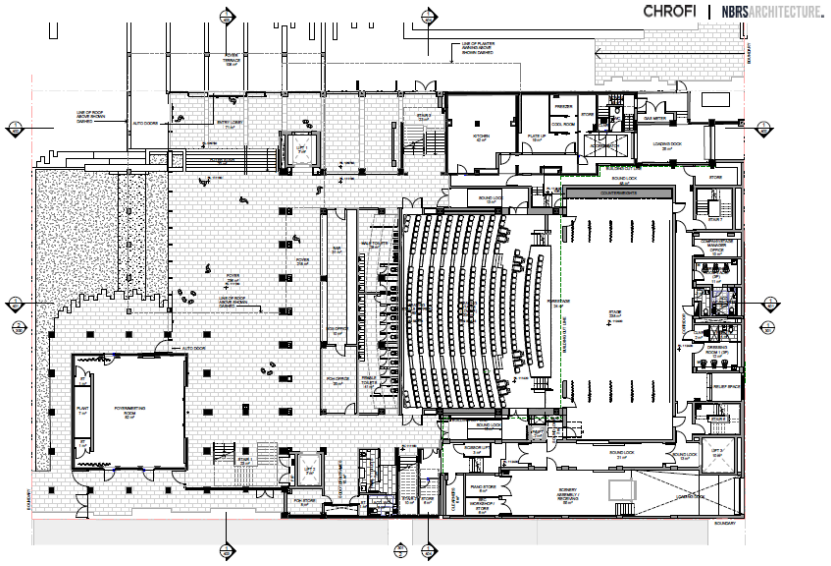
4.2 Architectural Drawings

Selected architectural plans and elevations for the proposed development are provided below.

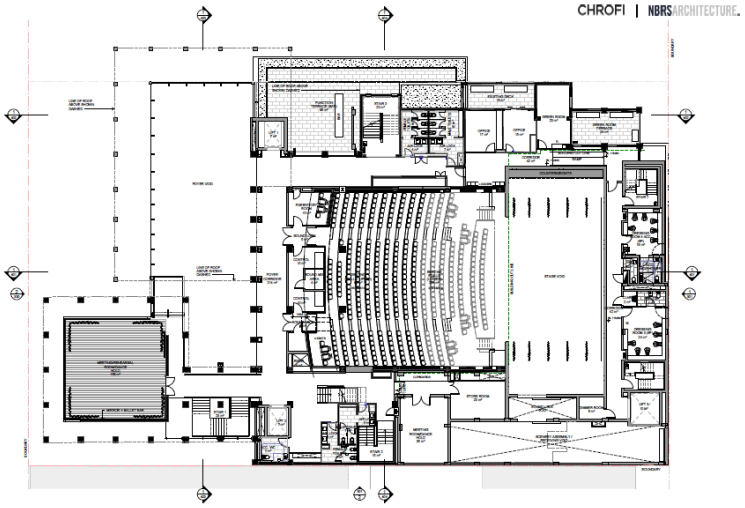
Site plan

Basement plan

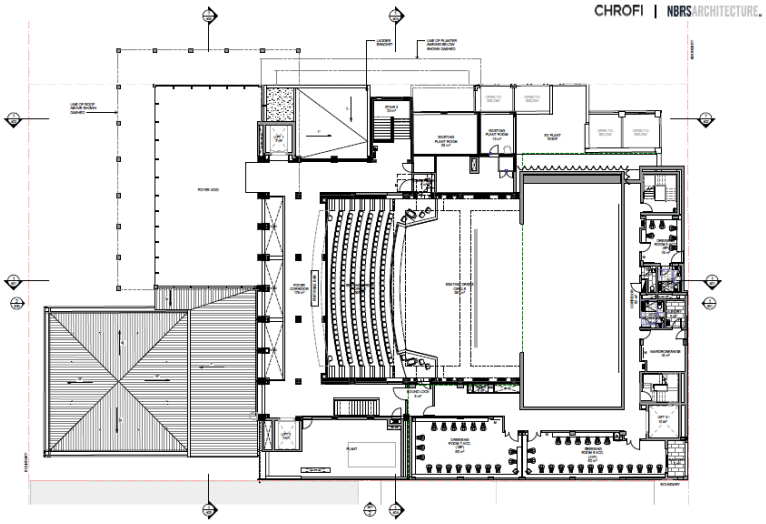
Ground – Floor plan:



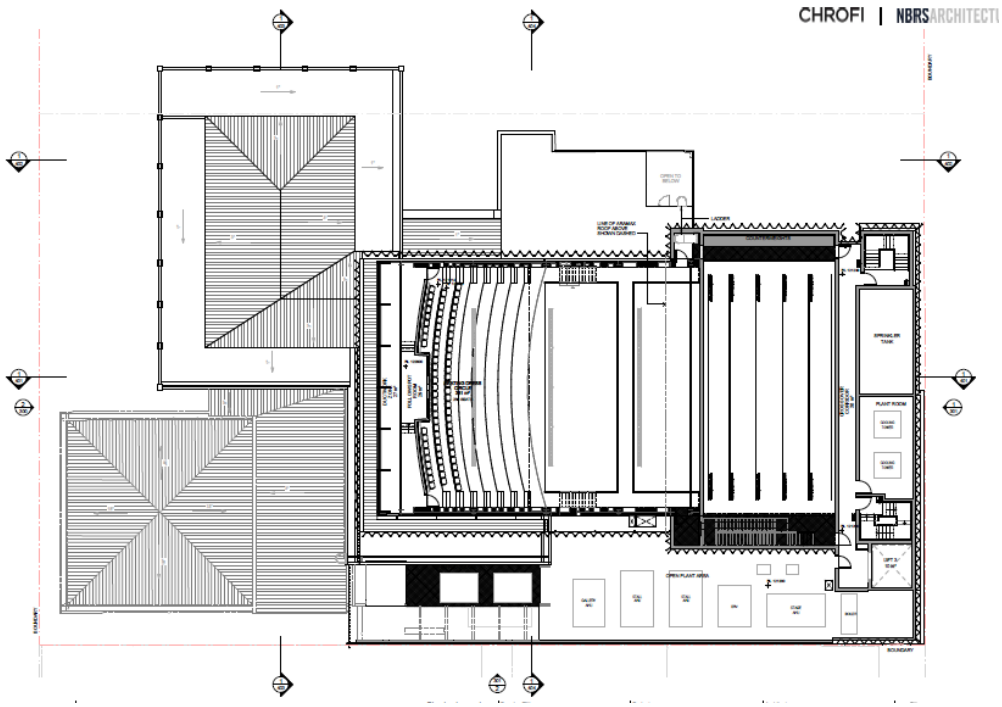
Level 1 - Floor plan:



Level 2 – Floor plan:

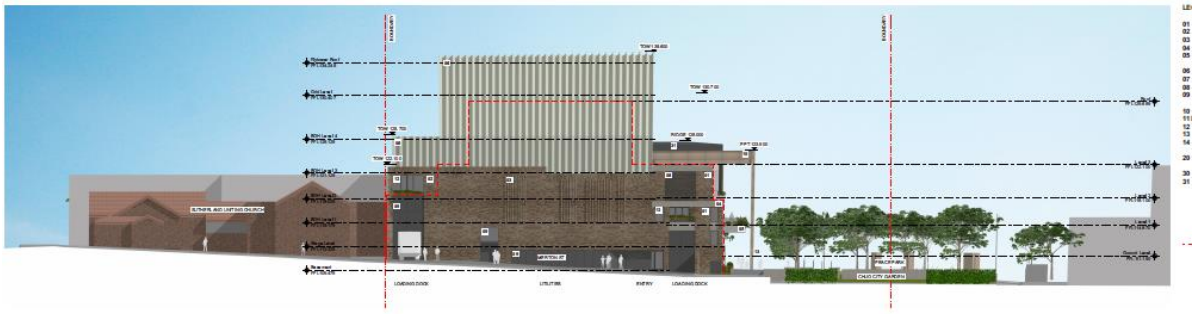


Level 3 – Floor plan:

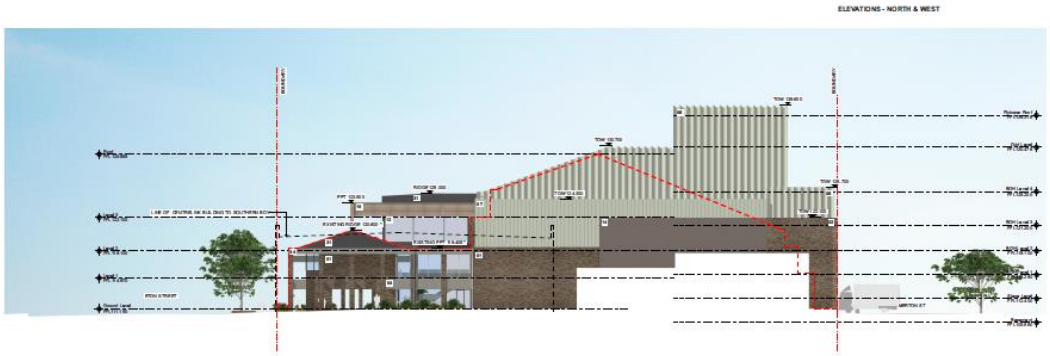


North & West Elevations:

East & South Elevations:

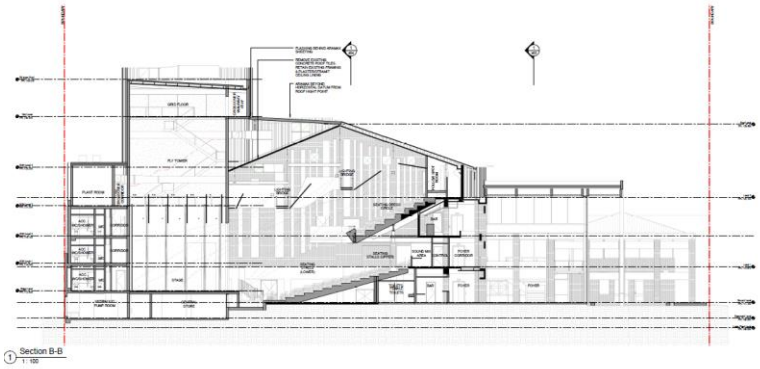


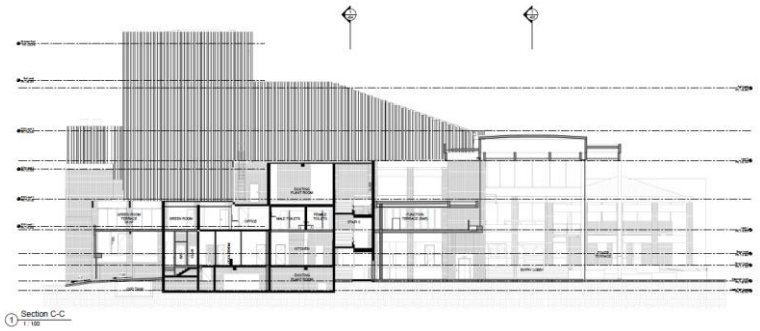
EAST ELEVATION

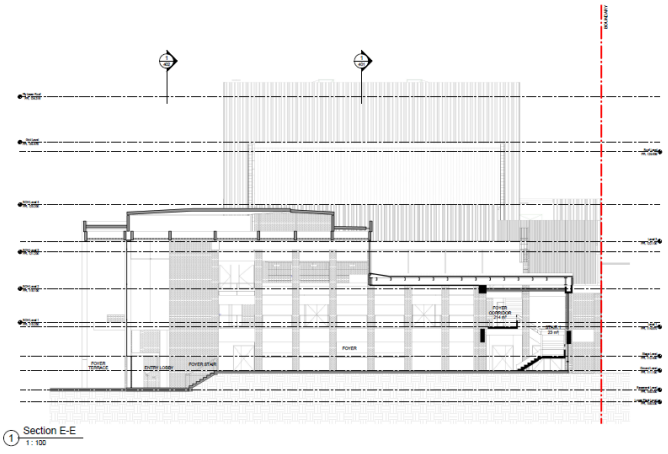


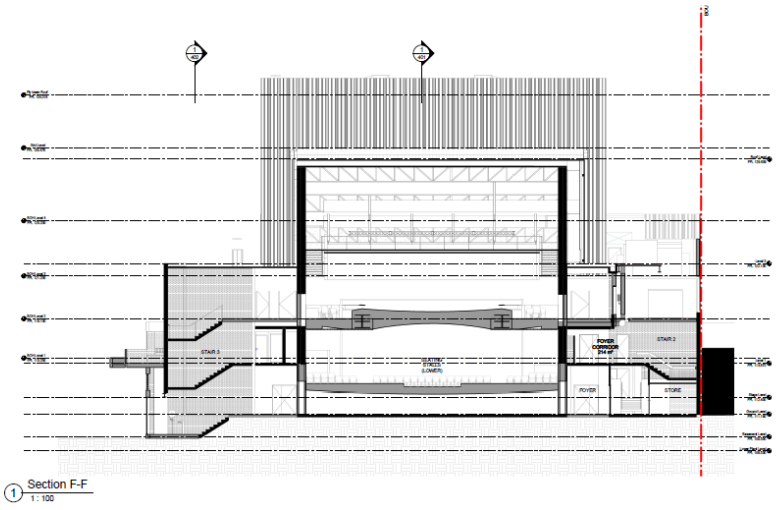
SOUTH ELEVATION

Sections:


Section B-B
1 : 100


Section C-C
1 : 100


Section E-E
1 : 100


Section F-F
1 : 100

5. ECOLOGICALLY SUSTAINABLE DESIGN (ESD) INITIATIVES

The principles of ecologically sustainable development are an integral consideration in design and construction of proposed development and also in assessing its benefits and impacts.

The design team will focus on a wide range of ESD strategies which will result in high levels of environmental performance and an increment on occupant's health, productivity, comfort and satisfaction.

5.1 Integrated Design Approach

The integrated design process is a process by which all of the design variables that affect one another are considered together and resolved in an optimal fashion. Often referred to as holistic design, this approach considers the development as a whole with the emphasis on integrating the different aspects of building's design.

5.2 Greenhouse gas emission reduction

Greenhouse gas emission reduction is achieved in a staged approach:

- First, reduction in overall energy consumption through demand reduction, passive design and energy efficiency, then;
- Reduction in electricity and gas utility consumption by utilising waste products, rainwater harvesting and renewable energy technologies (where feasible).

The integrated response to energy proposed for this project is summarised below:

1. Load Reduction and Passive Design
2. System Efficiency
3. Capture Waste
4. Renewable Energy (where feasible)

Energy consumption will be reduced through the efficient design of lighting, air-conditioning and ventilation systems, as well as energy efficient water heating and renewable energy technologies (where feasible). The development will consider Greenhouse gas emission reduction in design and operation through utilising energy conservation measures suitable for the development.

The following sections of the report outline the sustainability initiatives that will be considered and further developed by the design team during the detailed design stages.

5.3 Community

As presented in Section 1 community engagement and amenity will be a guiding concept for the ESD strategy. Specific initiatives to be investigated are detailed in this section.

5.3.1 Community Facilities

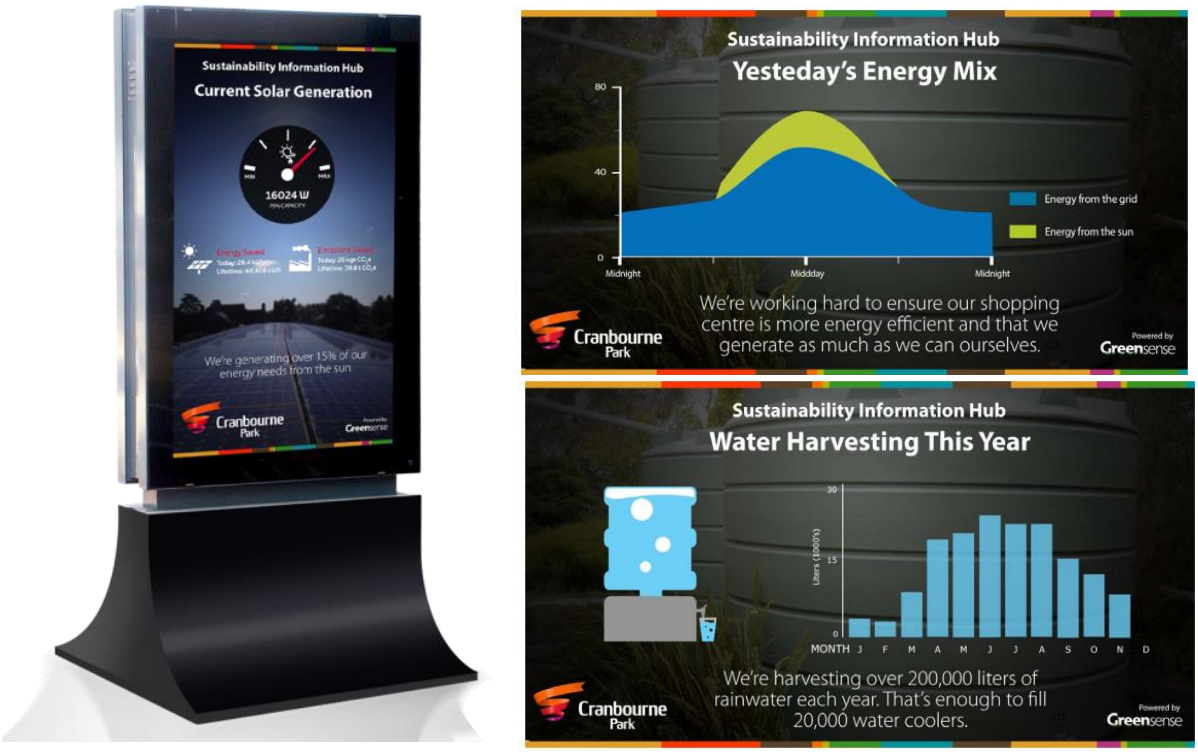
Facilities which attract and support members of the community could include:

- Provide free WiFi and areas suitable for study, reading and personal device use,
- Battery charging ports for mobile devices – connected to solar.
- Drinking water tap to refill water bottles.

5.3.2 Sustainability Displays

Real-time displays can be used to tell the story of center's ESD efforts in terms of energy savings, water savings, any renewable energy generation, waste reduction, and other initiatives. These can be simple, engaging and can help raise the profile of Entertainment Centre as an environmentally responsible centre and engage community interest in sustainability. The displays could also be used to introduce and explain any innovative ESD solutions.

Generally, displays can utilise existing screens (such as poster boards or kiosks) with the data capture, graphic design and dynamic displays managed by an external service provider to centre specifications on an annual subscription basis. An example for another facility is shown below.



Example in-centre information display.

Data Acquisition

Automated data is aquired via direct export from the existing Building Management System. In addition, local weather data will be acquired via the internet from the closest BoM weather station.

Data displays could include:

- Direct from existing meters and sensors
- Next day billing data from utility or meter data agent
- Manual data entry, e.g. of waste recycling rates or centre's environmental performance targets.

Data Processing

Greensense provides hosted data warehousing, processing and analytics. Data is stored and processed in real time and the resulting information is communicated to the information displays via the internet.

Data Presentation

Feedback on the environmental performance of the Centre will be provided to visitors via digital posterboards. These will be custom-designed incorporating the Centre's branding. The posterboards will display (e.g.):

- Solar PV system performance, including electricity generated and greenhouse gas emissions avoided
- Rainwater harvesting and re-use and total potable water saved
- Local weather conditions
- Energy use – tagreted vs. real time for each space
- Thermal comfort: targeted vs. real time / historical
- Status of equitpment e.g. in heating or cooling mode, or ventilation on or off.

5.4 Management

The initiatives under the management category promote the adoption of environmental principles from project inception, design and construction phases to the operation of the building and its systems.

This category aims to highlight the importance of a holistic and integrated approach to constructing a building with good environmental performance. The following measures are some of the initiatives targeted within the management category and are subject to further design development. These initiatives aim to reduce environmental impacts at construction and operational stages as well as to maximise building performance at commissioning.

5.4.1 Environmental Ratings and Involvement of a GSAP

Environmental rating schemes such as Green Star (Australia), LEED (US), Living Building Challenge (US) or BREEAM (UK) are used to create a marketable environmental credential based on achievement of a recognised benchmark. Ratings can be useful for marketing to centre visitors and for demonstrating ESD achievement for planning submissions.

Green Star is the most recognised rating scheme in Australia, with hundreds of certified buildings, mostly office buildings. The new Green Star – Design and As-Built chosen as an appropriate benchmark for the project.

Green Star includes a range of categories under which credits are available. Points are scored under each credit, and the total score is used to determine a final rating; 45-59 points for 4 Star, indicating Best Practice, 60-74 points for 5 Star, indicating Australian Excellence; and 75 or more points for 6 Star, indicating World Leadership. The categories are as follows:

- Management
- Indoor environment quality
- Energy
- Water
- Transport
- Materials
- Land use and ecology
- Emissions
- Innovation

It is recommended to involve a Green Star Accredited Professional (GSAP) as part of the design to prepare the necessary ESD guidelines. The ESD consultant from JN Consulting (author of this report) is a Green Star Accredited Professional.

5.4.2 Commissioning Clauses

Commissioning of building systems to a high standard, with independent oversight, will ensure that a quality process is followed and provide an outside review of the practicalities of the design. An extended building tuning period should be undertaken following defects liability period to ensure that systems are performing as intended, taking into account different seasonal variables, and that any need for recommissioning is identified and carried out.

To adopt commissioning and handover initiatives that ensure that all building services can operate to optimal design potential, such as:

- Where possible, comprehensive pre-commissioning, commissioning, and quality monitoring to be contractually required to be performed for all building services (BMS, mechanical, electrical and hydraulic).

5.4.3 Building Tuning

After handover, the building owner is expected to implement tuning of all building systems and undertake full re-commissioning 12 months after practical completion;

5.4.4 Building User's Guide

To produce a Building User's / Occupant's Guide, information management that enables building users / occupants to optimise the building's environmental performance during its operation;

5.4.5 Environmental Management Plan

The contractor is expected to adhere to a comprehensive Environmental Management Plan (EMP) for the works. Contractors are recommended to be ISO 14001:2004 certified. Environmental management plans and systems should be implemented to ensure that demolition and construction activities appropriately manage and mitigate environmental impacts.

5.4.6 Waste Management System

To encourage and facilitate effective waste management once the development is in operation, sufficient spatial provision will be made to allow for the effective separation of waste from recycling. Dedicated waste recycling rooms allow space for the separation and storage of recyclable waste during the building's operation, allowing for the following waste streams to be separated:

- Glass;
- Cardboard;
- Paper;
- Organics.
- Plastics,
- Metals.

Waste management solutions are varied and dependant on the extent of commitment of the end user. Recycling, reuse and composting are examples of waste management options.

5.4.7 Environmental Management and Maintenance

Effective environmental and waste management will be implemented throughout the demolition, construction and operational stages of this development.

The EMP shall include a Waste Management Plan, specifying recycling targets for demolition and construction waste. It is recommended that construction and demolition contracts stipulate a minimum 90% target for diversion of waste from landfill. This may be achieved through recycling or reuse.

- Identification of appropriate waste sub-contractors for recycling, costs of collection and timing of collection service;
- Participation in waste minimisation training for contractors and sub-contractors;
- Published waste minimisation plan to reduce site waste to landfill;

Provision of separate waste skips for cardboard, timber, metal, soft plastic, polystyrene, insulation, concrete, glass and bricks.

5.5 Indoor Environmental Quality (IEQ) Initiatives

Indoor Environmental Quality initiatives consider the wellbeing of occupants, addressing factors such as heating, ventilating and air conditioning (HVAC), lighting, indoor air quality and building attributes, all of which contribute to good indoor environmental quality.

The following measures are some of the initiatives targeted within the IEQ category for further consideration and development during detailed design.

- Improvement of outside air rate by providing at a rate greater than AS1668.2 requirements. Air-conditioning system will be installed with carbon dioxide monitoring and control to ensure sufficient outside is delivered to occupants.
- Optimisation of the air quality by improving air change effectiveness
- Maximisation of natural lighting level to the building occupants
- Minimisation of the contribution and levels of Volatile Organic Compounds (VOCs) via the use of low VOC paints, adhesives and sealants, carpets and flooring.
- All engineered wood products to be used in the development will have low formaldehyde emission.
- High efficiency lighting system with suitable luminance levels to avoid causing discomfort and strain for the occupants. All fluorescent luminaries are to be installed with high frequency ballasts to avoid discomfort caused by low frequency flicker.
- External Views: The design allows unobstructed external views for the majority of occupied spaces;
- Internal noise level at an appropriate level to ensure the occupants' satisfaction and wellbeing.

5.5.1 Thermal Comfort

Thermal comfort can be provided by passive and mechanical means. Passive design initiatives will be considered before the design of the mechanical systems to reduce operational energy costs, with potential reductions in the air conditioning size and ongoing maintenance.

Thermal comfort is a function of the following factors:

- Radiant temperature (45% of net comfort effect);
- Air temperature and humidity (35% of net comfort effect);
- Air movement, clothing and activity (20% of net comfort effect).

Passive heating and cooling design strategies which will improve occupant thermal comfort include:

- Roof insulation not only reduces heat gain and loss, but will also moderate radiant temperatures from the walls, floor and ceiling;
- Building facades with high performance glazing and window frames will have a combination of external shading and high-performance glass to reduce heat transfer and radiant temperatures in proximity to the windows.

Indoor areas will be designed to be protected from excessive summer solar radiation, reducing radiant heat loads on the space, but still providing enough daylight during appropriate times of the year to improve comfort levels.

The development is required to meet the minimum performance levels for the thermal comfort of the dwelling, expressed as energy required to heat and cool the dwelling (MJ/m2).

5.5.2 Effective Daylighting / Natural Lighting

Daylighting is the architectural and services design to allow maximum daylight penetration into a building whilst minimizing heat gain and thereby reducing indoor lighting loads.

The level of natural light in the building is primarily determined by the extent and type of glazing, and the depth of the building floor plate. Extent of glazing must be optimised to allow maximum daylight, views, and winter sun, while minimising uncomfortable glare and excessive solar heat gains in summer. Glazing should be selected with a high Visual Light Transmission to maximise daylight penetration.

Daylighting strategies will be considered to allow effective control of indoor lighting levels whilst minimising power consumption for the building. High level of architectural input regarding design, orientation and external shading will be considered to effectively maximise natural lighting for the building.

Daylighting strategies combined with dimmable lighting systems will allow high control of indoor lighting levels whilst minimising power consumption for the building.

5.5.3 Volatile Organic Compounds (VOC) & Formaldehyde Minimisation

To ensure long term comfort of occupants, all due care will be taken to minimise VOC and formaldehydes used within the building. Maintaining VOC limits below the recommended levels will assist in reducing any potential detrimental impacts on occupant health arising from products which may emit volatile pollutants.

VOC's are commonly found in carpets, paints, adhesives and sealants uses in construction and extensive exposure to VOC's can cause Sick Building Syndrome effects (eye, nose and skin irritation, headaches lethargy etc.).

Formaldehydes are found within composite wood products and extensive exposure can cause irritation to eyes, nose and throat, lead to skin ailments and respiratory system ailments such as asthma.

Where possible, contamination of indoor air by common indoor pollutants will be minimised in this development by careful material selection, including:

- Use of low-VOC and water-based paints rather than oil-based paints, stains or sealants, reducing indoor air contamination and consequent side-effects including sick-building syndrome and respiratory problems;
- Selection of low-VOC carpets and adhesives;
- Selection of low formaldehyde composite wood products, avoiding the carcinogenic effects of formaldehyde off-gassing.

5.6 Energy Conservation Initiatives

It is essential to ensure the building is designed and built to minimise energy consumption and reduce or eliminate greenhouse gas emission to the atmosphere. Energy performance is considered by the design team as a crucial issue.

The energy conservation initiatives aim to reduce the overall energy consumption for the project directly contributing to greenhouse gas emissions and energy production capacity.

Greenhouse reductions are achieved in a staged approach:

- Reduction in overall energy consumption through demand reduction and energy efficiency.

- Reduction in electricity and gas utility consumption by utilising waste products and renewable energy technologies.

Several strategies will be assessed and put in place to minimise energy consumption.

The integrated energy strategies being considered for the development include:

Load reduction	Passive Design
	Mixed mode AC systems
	Maximise use of natural lighting
	Energy efficient equipment
	Water efficiency in hot water systems
Building Services System Efficiency	High Efficiency in Heating, ventilation and Air Conditioning
	High efficiency LED
	High efficiency hydraulic services
	High efficiency appliances
Renewable Energy	Solar PV (if deemed feasible by the design team)

5.6.1 Passive Design

The development will utilise passive design to minimise the amount of air-conditioning required and therefore significantly reduce the building's energy consumption and greenhouse performance. A building's form, fabric and orientation will have the biggest influence on its thermal comfort and environmental performance. The following factors will be considered in the detailed stages of the design:

- Orientation
- Shading
- Structure
- Insulation
- Glazing

5.6.2 Building Envelope

The building envelope will be designed to reduce heating and cooling requirements through passive design principles. The role of the building envelope is to block solar gains from penetrating the building fabric in summer while optimising daylight and minimising glare. The glazing performance and shading configuration for each orientation will be optimised to ensure that thermal comfort is achieved and solar gains are adequate for the efficient operation of the mechanical system.

Insulation

The building envelope will be treated with the required levels of thermal insulation to reduce heat gains in hot days and to minimise heat losses in cold days through conduction. This will have significant impact on reducing energy consumption.

Insulation reduces the heat transfer between the internal and external conditions. Adequate insulation will be allowed for the ceilings, floors and walls to reduce the heating and cooling load of the building and to reduce the ongoing operational costs. This has a twofold saving through a smaller mechanical system capacity along with operating energy consumption reduction.

All insulations installed are required to meet NCC and AS/NZ 4859.1 and the builder is required to ensure compliance, during construction.

The thermal insulation requirements will be compliant with the minimum NCC Section J requirements.

Glazing and Window Framing

Adequate performance glass will be provided to reduce excessive heat gains in hot conditions, increasing periods when natural ventilation will be able to restore thermal comfort, and therefore reducing the frequency of air conditioning use.

The following glazing parameters will be considered:

- U-Value: a measure of how much heat is passed through the glass.
- Solar Heat Gain Coefficient (SHGC)
- Visible Light Transmission (VLT): the percentage of visible light transmitted by the glass.

Where possible, the glazing will have a low SHGC to avoid heat gains in the summer, and a low U-value to reduce losses in the winter through the glass. The performance of the proposed glazing systems (glass and frame) are required to comply with NFRC100-2001 conditions and using the tested AFRC values.

Consideration will be given to incorporating effective shading features into the design to avoid the necessity for low shading coefficients in the glass, which usually also decrease the visible light transmission (VLT) of the glass. To maximise the natural daylight within the building, VLT should be as high as possible.

Glazing properties will be specified in conjunction with the shading arrangement on each orientation to control solar loads imposed on the mechanical systems, ensuring thermal comfort, optimising daylight penetration and preventing glare. This strategy will effectively minimise direct solar loads whilst maximising daylight penetration and access to views.

To reduce heat losses in cold days, especially at night, the use of blinds will limit the contact between the internal air and the glass, therefore reducing heat losses by conduction.

The glazing performance requirements shall comply with the minimum NCC Section J requirements.

5.6.3 Energy Efficient Systems and Services

The mechanical and electrical systems for the building will be developed to minimise the need for plant equipment and will be designed to be responsive to the immediate climatic conditions.

Energy consumption will be reduced through the efficient design of lighting, air-conditioning, hot water and ventilation systems. The following energy efficiency initiatives will be further investigated and where feasible incorporated in the building services design.

Efficient Artificial Lighting

Lighting efficiency is important in maintaining low energy consumption for reuse projects. Lighting consumption for a facility such as this could account between 15-25% of the estimated energy use of the facility.

High efficiency lighting and effective control initiatives such as daylight and movement sensors will be considered to reduce artificial lighting energy consumption and allow maximum advantage to be taken of natural lighting.

Lighting power density is required to meet AS1680 and NCC requirements. Energy efficiency for the internal lighting throughout the building is required to be in accordance with NCC energy efficiency requirements and the following.

- High quality LED lighting where applicable;
- Lighting control system based on smart zoning, occupancy profiles and operational hours, dimming controls and timers.

Photoelectric (PE) / Photodiode sensors or similar controls to detect when external lighting should switch on and off to reduce the energy consumption associated with external lighting where possible.

No external lighting is to be installed such that any direct light beam results into the night sky either generated from within the site. The path of any direct light's angle of incidence that is directed to the sky must be obstructed by a non-transparent surface and the lighting design and is to comply with AS4282 'Control of the Obtrusive Effects of Outdoor Lighting.

Efficient Heating, Ventilation & Air-Conditioning (HVAC)

Heating and cooling of the building accounts for a large portion of the building's energy use throughout the year. Selection of highly efficient HVAC equipment with high performance levels not only minimises energy consumption, but also reduces operational energy costs.

The design of the mechanical services will be to industry Best Practise Standards. An emphasis will be placed on providing low energy Heating Ventilation Air Conditioning (HVAC) systems and strategies. To ensure the energy efficient performance of HVAC systems specified and installed mechanical plant will be of high quality and supplied by leading industry manufacturers.

The energy efficiency of HVAC system is required to meet the minimum requirements of the National Construction Code (NCC), Green Star provisions where feasible and relevant Australian Standards including but not limited to AS1668.1, AS1668.2, AS 1682 and AS3666.

The following energy initiatives will be further considered in the detailed design phase:

- High efficiency chilled water air conditioning plant (with high COP) will be utilized combined with ERV technology to maxmise energy efficiency.
- The air conditioning strategy is optimized to reduce energy consumption and maximize efficiency. For example, by moderating the amount of fresh air relative to the number of people in the space, through the use of CO2 detectors. The system will be zoned to increase the flexibility in the use of different spaces and reduce overall consumption.
- Variable speed drives will be provided to fans and pumps where feasible.
- Full outside air cycle will be provided to all air handling systems.

- Building commissioning and building tuning to be undertaken to ensure that the building systems function as required to achieve energy efficiency design targets.

All refrigerant plant will be specified such that the refrigerant type has Zero Ozone Depletion Potential (ODP).

When outside conditions are not favourable for the natural ventilation mode of operation, the mechanical system shall deliver thermal comfort when spaces are occupied.

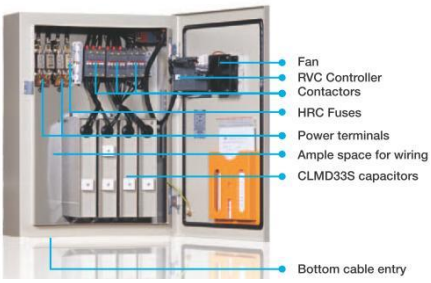
Manually operable windows will allow bedrooms and living rooms to be naturally ventilated when external temperature conditions are favourable. During periods when external temperature conditions prevent the opening of windows or during hot nights when acoustic issues will limit the opening of windows, a dedicated reverse cycle heat pump refrigerant

Common area ventilation systems are to include variable speed modes where appropriate and are to be linked to light switches where feasible to limit the extent of operation and improve energy efficiency of these areas.

Power Factor Correction

To reduce maximum kVA demand on the electricity grid and lower the demand charges, power factor correction units will be provided at the main switch board(s) in accordance with the NSW Installation and Service Rules.

The power factor correction units proposed will improve the power to a factor of 0.98 or higher.



Monitoring & reporting

To enable effective monitoring and tracking of energy and water consumption, sub-metering will be considered for systems with major energy use, to help identify areas of inefficiency with potential for improvement.

Metering is to be provided throughout the building and central services for all major building plant and equipment. An effective monitoring system is to be provided to monitor energy and water consumption throughout the building as required.

Ongoing reporting may allow the manager of the facility to set goals for energy consumption reductions and attributed energy costs to particular uses. By monitoring energy, losses and wastage can be identified, therefore improving the overall performance of the building in operation. This initiative is subject to further design development and review.

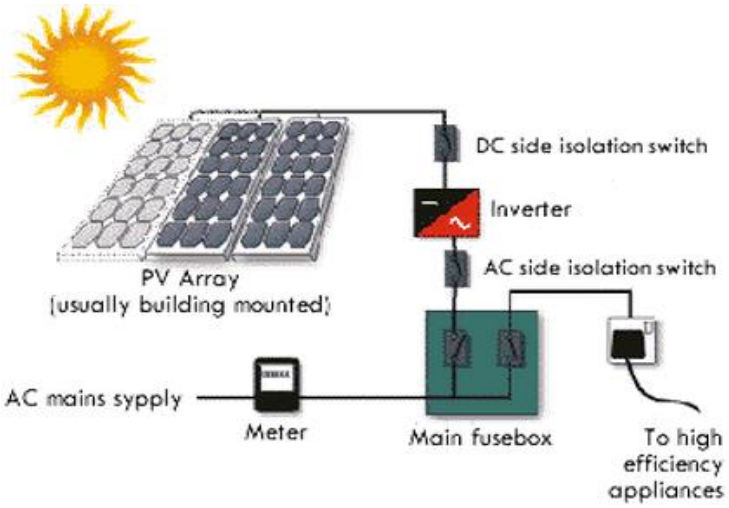
Hot Water Systems

Hhigh effieicny gas hot water systems will be used to provide the Domestic Hot Water demands for the faclity.

5.6.4 Renewable Energy – Solar Photovoltaic (PV) System

Photovoltaic (solar PV) is a common and widely accepted technology to generate electricity onsite. The generated electricity can be harnessed and used to power any number of devices. It is proposed that the PV panels are mounted on the roof where they will be out of sight and produce the optimum energy output.

PV modules have a very long lifetime with many manufacturers guaranteeing an output of at least 80% of manufactured capacity for 20 years. Another benefit of PV is that it can be installed in various system sizes and the modular design of the systems allows retro-fitting of additional panels if required in the future.



There are generally three types of solar panels available: mono-crystalline (proposed for this development), poly-crystalline and amorphous. Each of these have their advantages and disadvantages and efficiencies range from 6% for amorphous to 19% for mono-crystalline.

A 100 kW PV system may be considered for the development. The exact sizing, configuration and final design will be completed during the design stage.

The expected renewable energy generation by the system is approx. 142.3 MWh per annum.

Solar PV - System Components

The Photovoltaic (PV) system may consist of the following main components or of equal capacity.

Total nominal power:	**100 kW**
Approx. roof space requirements:	**800 m²**
Estimated Capital Costs (without battery):	**$110,000 (Exc GST) after rebates**
Estimated Payback Period:	**< 5 yrs**

Components	Brand, Model & Quantity
PV Inverter	SMA – Quantity: (4-5) x 20kW
PV Panels	LG - Neon 330 – capacity: 330W - Quantity: 302 Approx.
Battery storage	Tesla Powerpack or other similar systems Quantity: depending on the requirements and final design
PV mounting frame and system balance	Sunlock or equivalent, as required.

The exact sizing, configuration and final design will be completed during the design stage. Please refer to Appendices A, B, C, D & E for technical data sheets of the proposed PV panels (LG), the grid-connected inverter (SMA), solar mounting systems and energy storage options (Tesla).

Solar PV - Projected energy generation based on a 100 kW system

Sutherland Shire Entertainment Centre - 100 kW Grid-Connected Solar PV

Geographical Site	**Sydney**		**Country**	**Australia**
Situation	Latitude	33.5°S	Longitude	151.1°E
Time defined as	Solar Time		Altitude	42 m
Collector Plane Orientation	Tilt	34°	Azimuth	0°

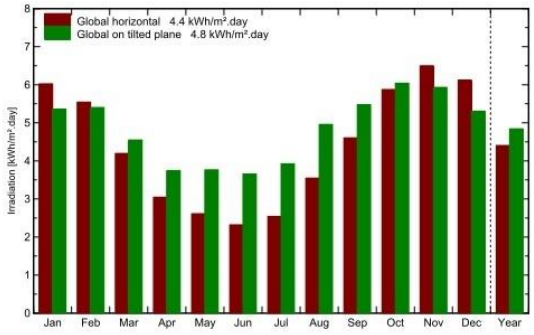
PV-field installation main features

Module type	Standard
Technology	Polycrystalline cells
Mounting method	Facade or tilt roof
Back ventilation properties	Ventilated

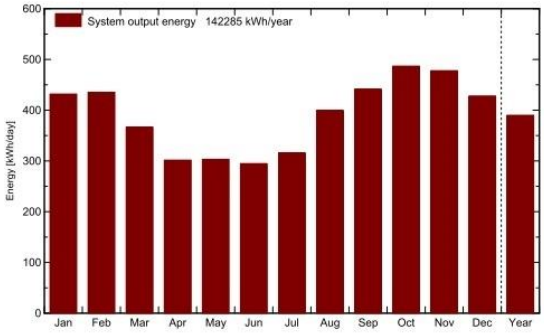
System characteristics and pre-sizing evaluation

PV-field nominal power (STC)	Pnom	100 kWp		
Collector area	Acoll	952 m²		
Annual energy yield	Eyear	142 MWh	Specific yield	1423 kWh/kWp

Meteo and incident energy



System output



	Gl. horiz. kWh/m².day	Coll. Plane kWh/m².day	System output kWh/day	System output kWh
Jan.	6.02	5.36	431.6	13380
Feb.	5.54	5.40	435.1	12182
Mar.	4.20	4.55	366.4	11359
Apr.	3.05	3.74	301.5	9045
May	2.61	3.76	303.2	9398
June	2.32	3.66	294.5	8836
July	2.54	3.93	316.1	9800
Aug.	3.55	4.96	399.4	12380
Sep.	4.61	5.48	441.2	13235
Oct.	5.87	6.04	486.7	15087
Nov.	6.50	5.93	477.7	14330
Dec.	6.12	5.31	427.6	13254
Year	4.40	4.84	389.8	142285

5.7 Transport sustainability measures

The use of transport (both private and commercial) is a major contributor to environmental pollution and the excessive consumption of natural resources. The following sustainable transport principles are recommended.

- Improve amenity for active transport users (pedestrians and cyclists), with attention paid to the needs of specific user groups likely to have a greater reliance on active transport such as youths, centre employees, and nearby community groups.
- Promote nearby cyclist facilities to enhance the uptake of cyclists to the site.
- Integrate transport initiatives into community engagement and communication strategies.

Given the site location of the development, the occupants will be able to take advantage of local public transport networks and available facilities around the site such as retail shops.

The following measures are some of the initiatives recommended to reduce dependence on motorised vehicles, encouraging walking, cycling and the use of mass public transport.

- **Cyclist facilities:** provision of bicycle racks; where possible adequately sized and fully equipped secure cyclist facilities with change room and showers are to be provided to promote the use of cycling.
- **Public Transport:** The building is close to public transport with a number of bus routes served; building occupants are encouraged to use mass transport to travel to work.
- **Trip Reduction:** The development is located adjacent to a number of local amenities, reducing the need for trips;
- **Fuel efficient vehicles:** encouraging the use of more fuel-efficient vehicles by providing adequate parking spaces at prime parking spot solely dedicated for use by small cars, car-pool participants or other alternative fuel vehicles.

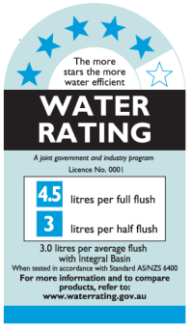
5.8 Water Conservation and Management Initiatives

The water conservation category aims to reduce the overall water potable consumption and provide effective mechanisms for recycling of water uses on site.

The approach to water efficiency for the development will focus on reducing water demand through conservation measures and water reuse systems. Water conservation strategies proposed for this project include:

- Reducing the potable water consumed within the development through demand management.
- Substituting mains water required to meet this demand by utilising alternative sources such as rainwater.

5.8.1 Demand Management



Strategies to minimise consumption include water-efficient fittings and fixtures, water-efficient appliances and low-water use air-conditioning and irrigation systems. In order to reduce the overall water consumption for this development, the following initiatives will be considered.

All water fixtures to be installed to the building are to be water efficient and where possible outperform the minimum requirements. The following criteria are provided as a guide and subject to further design development.

Water Fixtures	Hand wash basins – 6 Star WELS;
	Kitchen taps (where provided) – 6 Star WELS;
	Showerheads (where provided) – 3 Star WELS or higher;
	Toilets – 4 Star WELS or higher;
Appliances	Dishwashers (where provided) – 4 Star WELS or higher
Air Conditioning	Minimise use of water-cooled systems
Landscape Irrigation (where applicable)	Native and water efficient species
	Sub-surface irrigation
	Rainwater usage for landscape

5.8.2 Landscape Selection

The use of native, drought-resistant planting will be considered to reduce water consumption used in irrigation. Sub-soil irrigation systems should be considered where non-native species are selected.

5.8.3 Rainwater collection and recycling

In order to reduce the impacts of stormwater runoff from the site, the following stormwater management strategies will be considered:

- Rainwater capture from rooftops for reuse in building reducing stormwater runoff as well as mains potable water use.
- The use of permeable surfaces to be considered where suitable, allowing stormwater to seep directly into the earth and reducing stormwater flows off-site.

Collecting rainwater from roof runoff is a common way to recycle water. In addition to saving potable water, it allows preparation for times of low rainfall, so landscapes will be maintained throughout the year. It also reduces loads on storm water systems because roof runoff is not

flushed into the drains. Rainwater will be collected from roof runoff and piped to storage tanks and will be used on site.

Ultra-violet (UV) treatment is the disinfection process of passing water by a special light source. Immersed in the water in a protective transparent sleeve, the special light source emits UV waves that can inactivate harmful microorganisms. This method of treatment is growing in popularity because it does not require the addition of chemicals.

Harvested water will be considered to supplement non-potable water uses such as common area landscape irrigation.

This strategy will assist to significantly reduce the potable water consumption for the facility.

5.8.4 Water consumption monitoring and reporting

Where practical, it is recommended that all major water uses within the building to be provided with water meters. This includes central services, rainwater tanks, irrigation systems, potable water, non-potable water sources.

Water monitoring will assist to identify abnormal usage patterns usually associated with leaks, helping to reduce the considerable water lost in this way. In addition, it would also allow to measure and verify the impact of any water efficiency measures implemented in the facilities.

5.9 Materials

This category aims to reduce the consumption of natural resources and encourage the reuse of materials. The various environmental and human health impacts arising from building materials are reduced when special attention is given to the selection of ecologically preferable materials.

To minimise the environmental impact of the development, preference will be given to environmentally responsible materials during the selection process, according to the following principles:

- Avoidance of ecologically sensitive products (such as scarce minerals and old-growth forest)
- Selection of materials with a low embodied energy and high recycled content;
- Low toxicity material selection;
- Low impact on the indoor environment;
- Durability, flexibility and recyclability;
- Emissions in manufacture and composition, including greenhouse gases and ozone depleting substances;
- Waste reduction
- Provisions for appropriate recycling storage space that facilitates recycling

The targeted initiatives will reduce embodied energy and environmental impacts caused by the whole life cycle of building materials.

5.9.1 Reuse and Conservation of materials

Where possible reuse the building material to conserve embodied energy and water. By conserving the building fabric or structure the waste volumes are significantly reduced for the development.

5.9.2 New Materials

Material specifications for the project will consider elements of sustainability that relate to the following factors of durability, embodied energies, renewable sources content, ease of manufacturing, ability to be recycled / reused / reconditioned, maintenance, local availability, VOC content, emission production, affordability and toxicity.

Where feasible the materials specified for this project are to consider the above environmental measures through a comparison between different product types and manufacturers where possible. The design team is to adopt this approach in assessing suppliers and products for the development.

Interiors finishes will consider the concentration of Volatile Organic Compounds with products for adhesives, paints, carpets and floor sealants. The design team will work with suppliers and contractors to identify opportunities to reduce the level of VOC's within products and finishes.

5.9.3 Materials with Ozone Depletion Potential

Selection of insulation will be targeted to minimise Ozone Depletion Potential (ODP).

5.9.4 Operational Waste Minimisation

To encourage and facilitate effective waste management once the facility is in operation, sufficient spatial provision will be made to allow for the effective separation of waste from recycling. Dedicated waste recycling rooms allow space for the separation and storage of

recyclable waste during the building's operation, allowing for the following waste streams to be separated:

- Glass;
- Cardboard;
- Paper;
- Organics.
- Plastics,
- Metals.

Waste management solutions are varied and dependant on the extent of commitment of the end user. Recycling, reuse and composting are examples of waste management options.

The following waste streams have currently been identified:

- Office waste
- Paper and cardboard
- Plastics
- PET bottles and containers, cans and glass
- Compostable material
- Grease and fats
- Cigarette butts
- Light tubes
- Toxic or hazardous materials
- Foam
- Cleaning products and other substances going down drains
- Composting of organic waste from the restaurant, for re-use within the Greenhouse.

5.9.5 Timber

Where possible, timber will be supplied from sustainable sources including Forestry Stewardship Council (FCS) certified plantation timbers and recycled products. No timber (either solid or veneer form) will be sourced from rainforests or old-growth forests.

5.9.6 PVC Minimisation

PVC is being phased out in the European Union, as there is widespread evidence to its harmful environmental impact, particularly during disposal or fire. PVC is used in almost all electrical and data cabling and for drainage pipework. Alternatives to PVC products will be used where feasible:

- HDPE and polypropylene pipe work instead of PVC pipe for water supply and drainage systems;
- Linoleum and other natural products instead of vinyl floor coverings;
- Composite materials for electrical cabling.

5.10 Land Use and Ecology

This initiative refers to improvements through Reuse of Land or Change of Ecological Value. The site has been previously built on, and is not a Greenfield. The new development will aim to enhance permeable area and vegetation improving the ecological value of the site.

5.11 Emissions

In addition to the reduction in greenhouse emissions as a result of lower on-site energy usage, emissions to land, air and water will be minimised. The following measures are some of the initiatives targeted within the emissions category:

- Where available, thermal insulation products should be selected which have a low Ozone Depletion Potential in their manufacture and composition, reducing the impacts of insulation on the atmosphere;
- Where feasible, refrigerants will have an Ozone Depletion Potential of zero; and integrated refrigerant leak detection will ensure early identification of leaks;
- Estimated wastewater discharge to sewer will be significantly reduced relative to a standard building through the implementation of water efficiency measures;
- Watercourse Pollution: Design that minimises stormwater run-off to and the pollution of the natural watercourses.
- Light Pollution: No light beam will be directed upwards or outside the building. External lighting will be in accordance with AS 4282-1997. This will assist to minimise interference and disturbance to neighbouring properties and wildlife.

6. Climate Change Adaptation

6.1 NARCliM Climate Change Projections

The information provided in this section of the report follows the climate change projections based on the NSW and ACT Regional Climate Modelling (NARCliM) project. NARCliM is a multi-agency research partnership between the NSW and ACT governments and the Climate Change Research Centre at the University of NSW. NSW Government funding comes from the Office of Environment and Heritage (OEH), Sydney Catchment Authority, Sydney Water, Hunter Water, NSW Office of Water, Transport for NSW, and the Department of Primary Industries.

Climate change projections are presented for the near future (2030) and far future (2070), compared to the baseline climate (1990–2009). The projections are based on simulations from a suite of twelve climate models run to provide detailed future climate information for NSW and the ACT.

The climate change projections are made for the following 5 parameters:

1. Temperature extremes
2. Hot days
3. Cold nights
4. Rainfall
5. Fire weather

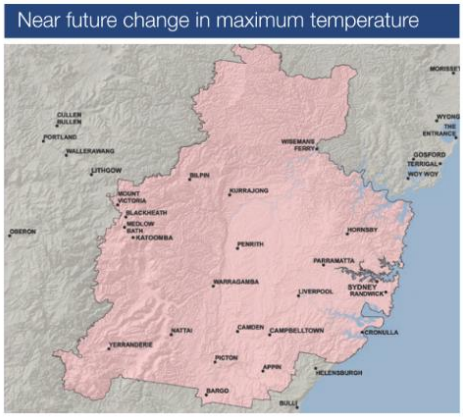
Reference: https://climatechange.environment.nsw.gov.au/

NSW Office of Environment and Heritage (OEH)

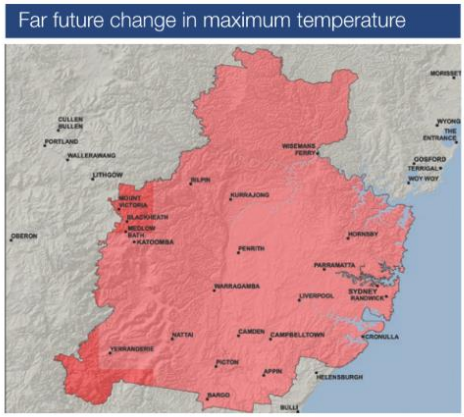
6.1.1 Temperature

Sutherland Shire is expected to experience an increase in all temperature variables (average, maximum and minimum) for the near future and the far future

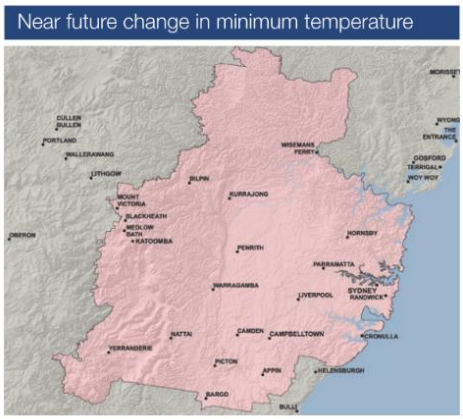
- Maximum temperatures are projected to increase by 0.7°C in the near future and up to 1.9°C in the far future. Spring will experience the greatest change in maximum temperatures, increasing by up to 2.2°C in the far future. Increased maximum temperatures are known to impact human health through heat stress and increasing the number of heatwave events.
- Minimum temperatures are projected to increase by 0.6°C in the near future up to 2°C in the far future. Increased overnight temperatures (minimum temperatures) can have a considerable effect on human health.



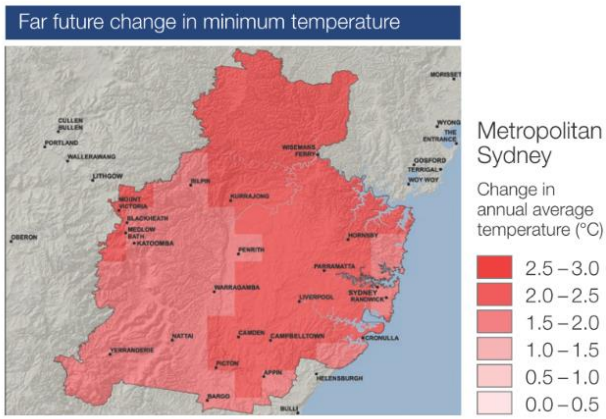
Near future (2020–2039) change in annual average maximum temperature, compared to the baseline period (1990–2009).



Far future (2060–2079) change in annual average maximum temperature, compared to the baseline period (1990–2009).



Near future (2020–2039) change in annual average minimum temperature, compared to the baseline period (1990–2009).

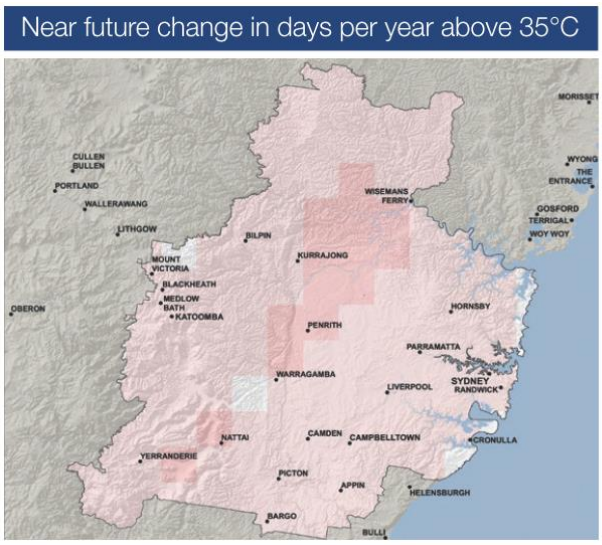


Far future (2060–2079) change in annual average minimum temperature, compared to the baseline period (1990–2009).

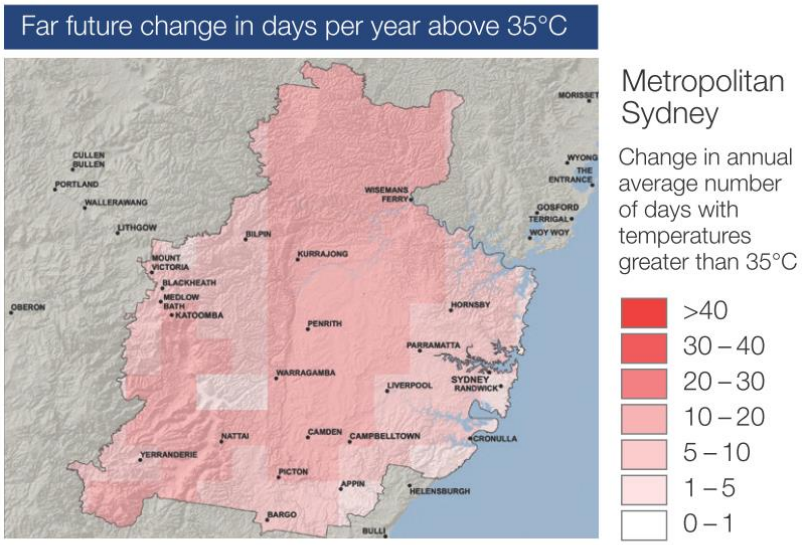
6.1.2 Hot days (days per year above 35°C)

Currently Sutherland Shire experiences fewer than 10 days above 35°C each year due to its proximity to the coast. Seasonal changes are likely to have considerable impacts on bushfire danger, infrastructure development and native species diversity.

- The facility is expected to experience more hot days in the near future and in the far future.
- These increases in hot days are projected to occur mainly in spring and summer although in the far future hot days are also extending into autumn.



Near future (2020–2039) projected changes in the number of days per year with maximum temperatures above 35°C.



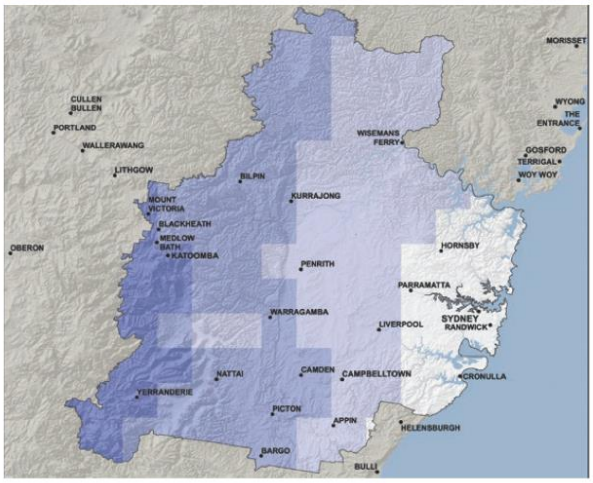
Far future (2060–2079) projected changes in the number of days per year with maximum temperatures above 35°C.

6.1.3 Cold nights (days per year below 2°C)

Most of the emphasis on changes in temperatures from climate change has been on hot days and maximum temperatures, but changes in cold nights are equally important in the maintenance of our natural ecosystems and agricultural/horticultural industries. For example, some common temperate fruit species require sufficiently cold winters to produce flower buds.

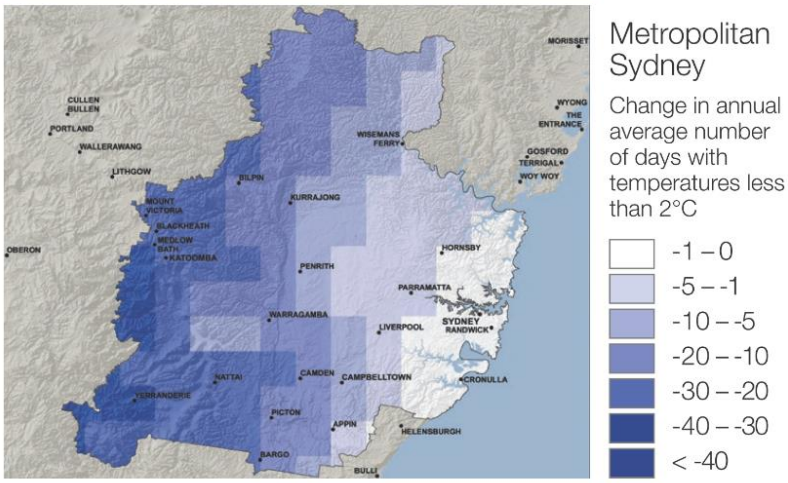
- The greatest decreases are projected to occur in the south-west and in the Blue Mountains, with decreases of up to 20 nights by 2030 and more than 40 fewer cold nights by 2070.
- NARCliM projections suggest that Sutherland Shire will not see a considerable decrease in cold nights (see the white areas in the map).

Near future change in number of cold nights (below 2°C) per year



Near future (2020–2039) projected changes in the number of nights per year with minimum temperatures below 2°C, compared to the baseline period (1990–2009).

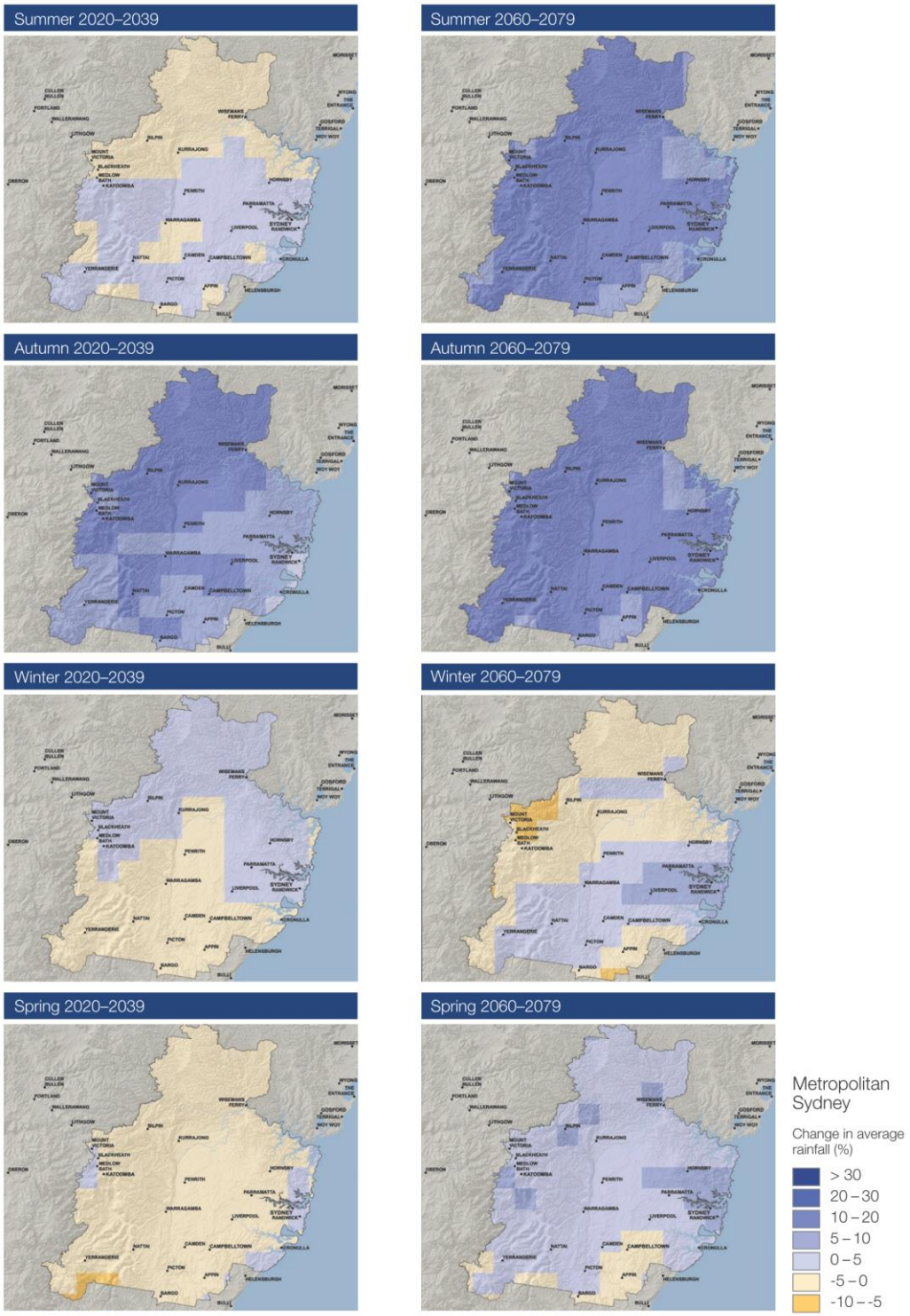
Far future change in number of cold nights (below 2°C) per year



Far future (2060–2079) projected changes in the number of nights per year with minimum temperatures below 2°C, compared to the baseline period (1990–2009).

6.1.4 Rainfall

Changes in rainfall patterns have the potential for widespread impacts. Seasonal shifts can often impact native species' reproductive cycles as well as impacting agricultural productivity, for example crops that are reliant on winter rains for peak growth. The majority of models (8 out of 12) agree that autumn rainfall will increase in the near future and the far future (7 out of 12). Rainfall is projected to increase in autumn.



Near future (2020–2039) projected changes in average rainfall by season.

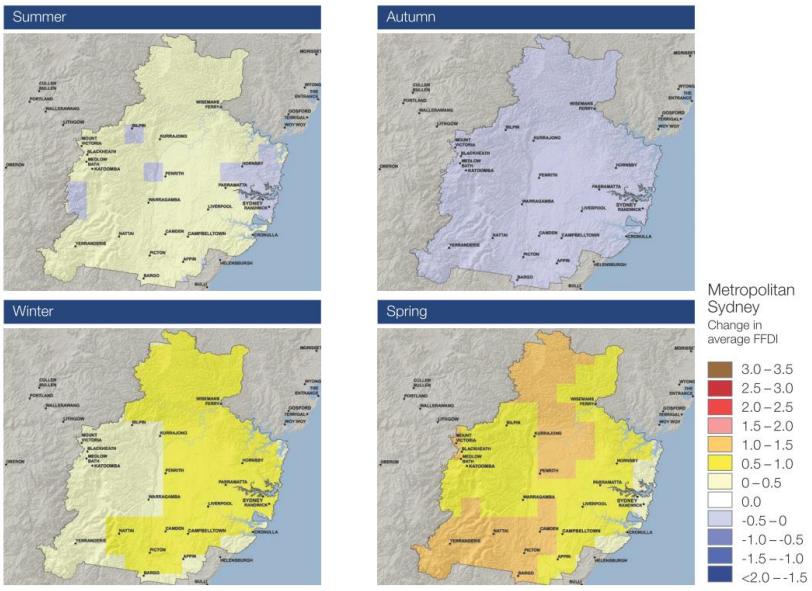
Far future (2060–2079) projected changes in average rainfall by season.

6.1.5 Fire weather

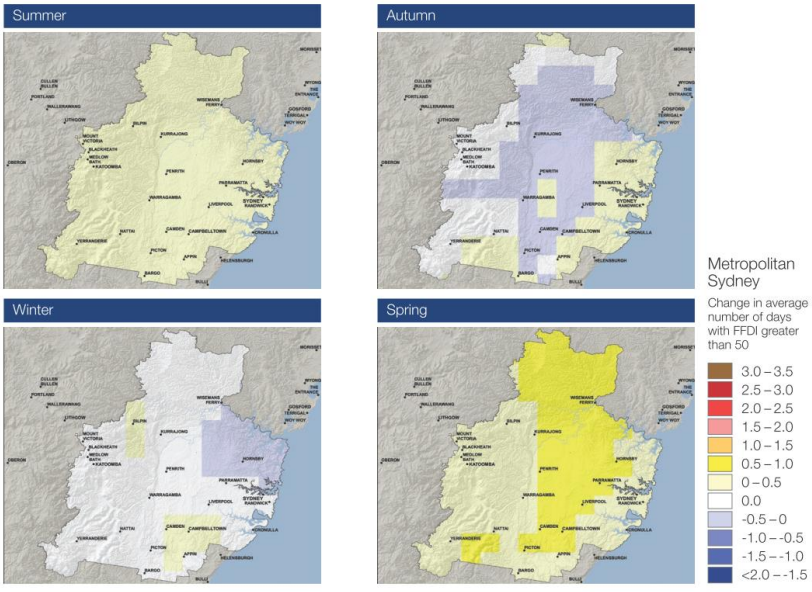
The Bureau of Meteorology issues Fire Weather Warnings when the FFDI (Forest Fire Danger Index) is forecast to be over 50. High FFDI values are also considered by the Rural Fire Service when declaring a Total Fire Ban.

Projected regional climate changes

- Metropolitan Sydney is expected to experience an increase in average and severe fire weather in the near future and the far future.
- The increases are projected mainly in summer and spring in the far future. These changes are projected in prescribed burning periods (spring) and the peak fire risk season (summer).
- The majority of models (7 out of 12) project an increase of severe fire weather in spring in the near future, with a greater confidence in the increase in the far future.



Far future (2060–2079) projected changes in average daily FFDI, compared to the baseline period (1990–2009).



Far future (2060–2079) projected changes in average annual number of days with a FFDI greater than 50, compared to the baseline period (1990–2009).

6.2 Climate Change Adaptation Plan

The climate change adaptation plan (CCAP) follows the ISO31000 Risk Management Process.

The plan involves three key steps to develop risks and mitigation strategies collaboratively with key project stakeholders.

1. Review of the development and context
2. Risk analysis
3. Mitigation Strategies

6.2.1 Risk Assessment Framework

To assess risks systematically, a likelihood scale was used to determine how likely a risk was to occur, followed by consequence assessment. The first stage of the assessment is to define the likelihood of a given risk. The likelihood level can be described as the frequency or probability for a risk to occur.

Risk likelihood matrix:

Likelihood	**Almost Certain** expected in most circumstances
	Likely will probably occur in most circumstances
	Possible might occur at some time
	Unlikely could occur at some time
	Rare may occur, only in exceptional circumstances

Example Consequence Scale and Success Criteria (AGO 2007):

	Public Safety	Local Economy and Growth	Community and Lifestyle	Environment and Sustainability	Financial /Time Program/Budgets
Catastrophic	Large numbers of serious injuries or loss of life	Precinct decline leading to widespread business failure	The area is considered very unattractive, moribund and unable to support its community	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage	Loss or increased cost of 50% or greater of annual budget.
Major	Isolated instances of serious injuries or loss of lives	Precinct stagnation such that businesses are unable to thrive	Severe and widespread decline in services and quality of life within the community	Severe loss of environmental amenity and a danger of continuing environmental damage	Loss or increased cost of 25%-50% of annual budget.
Moderate	Small numbers of injuries	Significant general reduction in precinct economic performance	General applicable decline in services	Isolated but significant instances of environmental damage that might be reversed with intensive efforts	Loss or increased cost of 10%-25% of annual budget

Minor	Serious near misses or minor injuries	Isolated areas in precinct decline	Isolated but noticeable examples of decline in services	Minor instances of environmental damage that could be reversed	Loss or increased cost of 5% to 10% of annual budget
Insignificant	Appearance of a threat but no actual harm	Minor shortfall to forecast growth	There would be minor areas in which the region was unable to maintain its current services	No environmental damage	Loss or increased cost of less than 5% of annual budget

Risk likelihood and consequence were then combined using the risk assessment matrix in Table below, leading to the systematic development of a risk rating used to prioritise risk management strategies.

Example Risk matrix:

Show	**Matrix Score**				
Risk Rating Number + Name	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	**Medium**	**High**	**High**	**Critical**	**Critical**
Likely	**Medium**	**Medium**	**High**	**Critical**	**Critical**
Possible	**Low**	**Medium**	**Medium**	**High**	**Critical**
Unlikely	**Low**	**Low**	**Medium**	**Medium**	**High**
Rare	**Low**	**Low**	**Low**	**Medium**	**High**

Risk management strategies aim to reduce risk levels by reducing either likelihood or consequence of the risk, or both. The objective is to develop cost-effective options for treating/controlling each identified risk and minimise its impact to the project.

Show	**Matrix Score**				
Risk Rating Number + Name	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	**Medium**	**High**	**High**	**Critical**	**Critical**
Likely	**Medium**	**Medium**	**High**	**Critical**	**Critical**
Possible	**Low**	**Medium**	**Medium**	**High**	**Critical**
Unlikely	**Low**	**Low**	**Medium**	**Medium**	**High**
Rare	**Low**	**Low**	**Low**	**Medium**	**High**

6.2.2 Risk Assessment outcomes

Climate variable	Risk Statement	Likelihood	Consequence	Level of Risk	Adaptation actions	Residual Likelihood	Residual Consequence	Residual level of Risk
Increase in hot days	Accelerated structural material fatigue and degradation of facades leading to increased maintenance and repair costs	Rare	Catastrophic	**High**	Select materials which have a higher temperature tolerance if required. Review material datasheets for in-service temperature range and allow for increase in peak temperatures.	Rare	Moderate	**Low**
Increase in hot days	Brownouts/ Blackouts leading to failure of medical equipment	Possible	Major	**High**	Ensure that existing plans to add to backup generation based on demand is followed through. Consider use of Solar Energy with Battery Energy Storage Systems (BESS).	Possible	Minor	**Medium**
Increased rainfall variability	Parapet roof retains water due to blockage in syphonic drainage system leading to structural failure.	Possible	Major	**High**	Check the design includes overflow outlets in parapet. Add to design if required.	Rare	Major	**Medium**
Increased rainfall variability	Parapet roof retains water due to insufficient capacity in the syphonic drainage system leading to structural failure.	Possible	Major	**High**	Overflow systems in place in the form of overflow slots. The capacity of these can be increased if required to allow for increased rainfall intensity.	Rare	Major	**Medium**

Climate variable	Risk Statement	Likelihood	Consequence	Level of Risk	Adaptation actions	Residual Likelihood	Residual Consequence	Residual level of Risk
Increased rainfall variability	Onsite Water Detention Tank (OSD) cannot deal with increased flows leading to overflow and flooding of basement.	Possible	Major	**High**	If necessary, overflow system to be provided. Hydraulic engineers to check if systems can manage the increased flows and implement further measures if required.	Rare	Major	**Medium**
Increased rainfall variability	Overland flow of water leads to pooling around sub-station, switch room and generator room, causing electrical failure and power outage.	Possible	Catastrophic	**Critical**	Primary storm water drainage system to be designed to cater for a minimum of a 100-year storm. System to also have full backup of either piped overflow or overland flow designed to a higher storm intensity. Also, ensure that generator can provide backup to critical services in the event of a flood and introduce operational management plan to include measures to account for residual risk. Consider other feasible mitigation measure as required.	Rare	Major	**Medium**
Increased intensity of storm events	Any mechanical plant on the roof are damaged by extreme hail event leading to failure of ventilation system.	Possible	Major	**High**	Consider options for protecting the mechanical plant in design. Implement if required.	Rare	Major	**Medium**

Climate variable	Risk Statement	Likelihood	Consequence	Level of Risk	Adaptation actions	Residual Likelihood	Residual Consequence	Residual level of Risk
Increased intensity of storm events	Severe hail blocking roof drains causing increased water ingress into building envelope and potential structural impacts, leading to increased maintenance costs	Possible	Major	**High**	Screen outlets with hail guards. Planned overflow slots should allow rain to overflow for all but the most severe hail events.	Rare	Major	**Medium**
Increased intensity of storm events	Airborne debris causing damage to exterior building elements and increased maintenance costs.	Possible	Major	**High**	Check wind load thresholds in engineering for façade and glazing. If required, adopt heat treated glazing for greater impact strength.	Rare	Major	**Medium**
Increased intensity of storm events	Wind driven rain penetrates podium level and retail spaces creating slip hazards for public circulation spaces.	Likely	Moderate	**High**	Consider in design and highlight risk for building managers. Include wet weather management plan in facilities management contract.	Rare	Moderate	**Low**
Increased fire weather	Smoke ingress into facility via HVAC system causing increased employee and patient health risks	Almost certain	Major	**Critical**	Evacuation plan to be developed by FM company, including use of link to the hospital for particularly vulnerable patients. Consider use of non-latching outside air smoke detectors to shut down outside air systems in the event of a bushfire situation.	Almost certain	Insignificant	**Medium**

6.2.3 Recommendations

Many of the potential risks to the building are already addressed by existing design features of the building or are being explored as an immediate consequence of this process. All those identified through the workshop and subsequent discussions as requiring additional action are set out in table below, along with responsibility for those actions.

This information should be added to the overall project risk register, with actions implemented and recorded, and subsequently reported in the Green Star documentation.

Summary of adaptation actions required to achieve revised risk rating:

Risk Statement	Initial Risk	Residual Risk	Action requiring implementation	Design / Operations	Proposed Responsibility
Brownouts/Black outs leading to failure of medical equipment.	High	Medium	Backup generator in place. Overall generator capacity can be increased to deal with the loads. Solar PV with Battery Energy Storage System (BESS).	Design and operations	Electrical Engineer
Accelerated structural material fatigue and degradation of façades, leading to increased maintenance and repair costs	High	Low	Review material datasheets for in-service temperature range and allow for a nominal tolerance on peak temperatures based on today's values. Select materials which have a higher temperature tolerance if required.	Design	Façades Engineer, Structural Engineer
Water restrictions during prolonged droughts leading to inability to deliver core services.	High	Low	Develop a Drought Management Plan. Water restrictions would likely be signposted well in advance. Consider alternative water supply.	Operations	Facilities Manager
Parapet roof retains water due to blockage in symphonic drainage system leading to structural failure.	High	Medium	Check the design includes overflow outlets in parapet. Add to design if required.	Design	Hydraulic Engineer
Parapet roof retains water due to insufficient capacity in the symphonic drainage system leading to structural failure.	High	Medium	Check whether capacity of overflow slots and drainage system is sufficient to allow for increased rainfall intensity. Increase either/both if required.	Design	Hydraulic Engineer, Architect

Onsite Water Detention Tank (OSD) cannot deal with increased flows leading to overflow and flooding of basement.	High	Medium	Ensure secondary overflow system provided and check if systems can manage increased flows. Implement further measures if required.	Design	Civil Engineer
Overland flow of water leads to pooling around sub-station, switch room and backup generator room, causing electrical failure and power outage.	Critical	Medium	Primary storm water drainage system to be designed to cater for a minimum of a 100- year storm. System to also have full backup of either piped overflow or overland flow designed to a higher storm intensity. Ensure generator will provide backup to critical services in the event of a flood and develop operational management plan to include measures to account for residual flood risk. Consider other feasible mitigation measures as required.	Design	Hydraulic Engineer, Architect, Electrical Engineer
Any mechanical plant on the roof are damaged by extreme hail event leading to failure of ventilation system.	High	Medium	Consider options for protecting the mechanical plant in design. Implement if required.	Design	Mechanical Engineer

7. Disclaimer

This report is prepared using the information described above and inputs from other consultants. Whilst JN Consulting has endeavoured to ensure the information used is accurate, no responsibility or liability to any third party is accepted for any loss or damage arising out of the use of this report by any third party. Any third party wishing to act upon any material contained in this report should first contact JN Consulting for detailed advice which will take into account that party's particular requirements.

Computer performance assessment provides an estimate of building performance. This estimate is based on a necessarily simplified and idealised version of the building that does not and cannot fully represent all the intricacies of the building once built. As a result, simulation results only represent an interpretation of the potential performance of the building. No guarantee or warrantee of building performance in practice can be based on simulation results alone. JN Consulting and its employees and agents shall not be liable for any loss arising because of, any person using or relying on the Report and whether caused by reason or error, negligent act or omission in the report. The draft assessment has been prepared indicatively and using the limited architectural and building services design with the view to conduct a detailed assessment once the design is further developed.

Performance of the completed building may be significantly affected by the quality of construction; the quality of commissioning, ongoing management of the building, and the way the building is operated, monitored and maintained.

APPENDIX A - TECHNICAL DATASHEETS FOR SAMPLE PV PANELS (330 W)

LG
Life's Good

The High Performer

LG NeON®2

LG325/330N1C-A5

UP TO 19.3% MODULE EFFICIENCY

EUPD RESEARCH TOP BRAND PV MODULES AUSTRALIA 2017
EUPD RESEARCH TOP BRAND PV MODULES AUSTRALIA 2016
inter solar award 2013 WINNER
inter solar award 2015 WINNER

THE NeON® 2 - THE PANEL OF THE FUTURE AVAILABLE TODAY

The LG NeON® 2 has seen many improvements, from longer warranties and higher efficiency to stronger frames and better wind loading. This panel is ideal for homes seeking a visually pleasing solar panel and for roofs where space is tight or where future system expansions are considered e.g. to incorporate battery storage or electric car charging.

The LG NeON® modules with their double sided cells and CELLO technology absorb light from the front and the back of the cell. This technology sets a new standard for innovation and was recognised with the 2015 Photovoltaic Innovation Award at the Intersolar Industry Event in Germany. LG also won the 2016 Intersolar award for our new NeON BiFacial range.

Great Visual Appearance

LG NeON® 2 panels have been designed with appearance in mind. Their black cells, black frames and thinner wire busbars give an aesthetically pleasing uniform black appearance. Your home deserves the LG NeON® 2.

12 Years Product Warranty (Parts & Labour)

The LG product warranty is 2 years longer than many competitors standard 10 years and covers 12 years. The Warranty is provided by LG Electronics Australia and New Zealand. The warranty includes replacement labour and transport.

More Power per Square Metre

LG NeON® 2's 330W are a similar physical size to many conventional 260W panels. This means with the LG NeON® 2 330W you get 27% more electricity per square metre than a 260W panel. So you can install more kW of solar on your roof with the LG NeON® 2.

Improved 25 Year Performance Warranty

The initial degradation of the module has been improved from -3% to -2%, in the 1st year and the annual rate of degradation has fallen from -0.7%/year to -0.55%/ year thereafter. This brings an 84.8% warranted output after 25 years, compared to 80.2% for many standard panels.

Panels made in Korea

www.lgenergy.com.au

LG325N1C-A5 | LG330N1C-A5

LG NeON® 2

ABOUT LG ELECTRONICS

LG Electronics embarked on a solar energy research programme in 1985, using our vast experience in semi-conductors, chemistry and electronics. LG Solar modules are now available in 32 countries. In 2013, 2015 and 2016 the LG NeON® range won the acclaimed Intersolar Award in Germany, which demonstrates LG Solar's lead in innovation and commitment to the renewable energy industry.

With over 200 lesser known brand panels selling in Australia, LG solar panels offer a peace of mind solution, as they are backed by an established global brand.

KEY FEATURES

Proven Field Performance

LG has been involved in a number of comparison tests of the LG panels against many other brand panels. LG NeON® models are consistently among the best performing in these tests.

Low LID

The N-type doping of the NeON® cells results in extremely low Light Induced Degradation (LID) when compared with the standard P-type cells. This means more electricity generation over the life of the panel, as the panel degrades less.

LG Corrosion Resistance Certification

LG NeON® 2 panels can be installed confidently right up to the coastline. The panels have received certification for Salt Mist Corrosion to maximum severity 6 and Ammonia Resistance.

Extensive Testing Programme

LG solar panels are tested between 2 to 4 times the International Standards at our in-house testing laboratories, ensuring a very robust and longer lasting solar module.

Strict Quality Control Reliable for the Future

The quality control of LG world-class solar production is monitored and improved using Six Sigma techniques via 500+ monitoring points to effectively maintain and improve our uncompromising quality.

Cyclone Wind Load Resistance

LG modules have a strong double walled frame. When it comes to wind forces (rear load) many competitor modules are certified to 2400 Pascals. LG modules are certified to more than double - 5400 Pascals, which provides at least double the strength and durability to a standard module.

Multi Anti-reflective Coatings Increase Output

LG is using an anti-reflective coating on the panels glass as well as on the cell surface to ensure more light is absorbed in the panel and not reflected. More absorbed light means more electricity generation.

Positive Tolerance (0/+3%)

If you buy a 330 Watt panel then the flash test of this panel will show somewhere between 330W and 340W. Some competitor panels have -/+ tolerance, so you could get a flash test result below the rated Watt, meaning you pay for Watts you never get.

Improved High Temperature Performance

Solar panels slowly lose ability to generate power as they get hotter. LG NeON® 2, has an improved temperature co-efficient to standard modules, which means in hot weather LG NeON® 2 panels will deliver higher output.

Anti PID Technology for Yield Security

PID (Potential Induced Degradation) affects the long term ability of panels to produce high level electricity output. LG panels have anti PID technology and have been successfully tested by leading third party laboratories regarding PID resistance.

"CELLO" Technology Increases Power

"CELLO" Multi wire busbar cell technology lowers electrical resistance and increases panel efficiency, giving more power per panel and provides a more uniform look to the panel.

Fully Automated Production in South Korea

All LG solar panels are manufactured in a custom designed and fully automated production line by LG in Gumi, South Korea ensuring extremely low tolerances. This means great quality and build consistency between panels.

LG NeON® 2

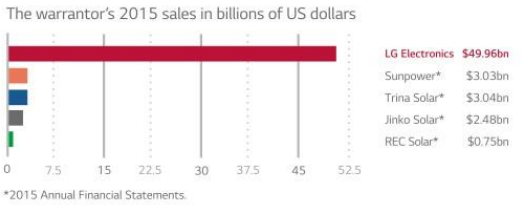
LG NeON® 2 – ENHANCED. MORE EFFICIENT. ADVANCED.

LG NeON® 2 solar modules now offer even more output. Featuring a classy design and with a total of 60 cells, it can withstand a load of 6,000 pascals. LG has lengthened its product warranty from 10 to 12 years and has improved its linear performance guarantee to 84.8 % of nominal output after 25 years. The LG NeON® 2 is an excellent choice for high performing long lasting solar systems.

LOCAL WARRANTY, GLOBAL STRENGTH

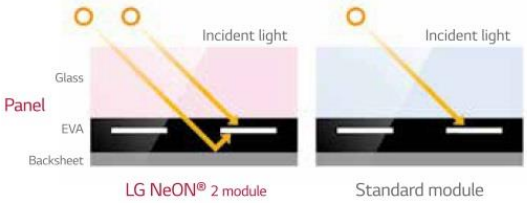
LG Solar is part of LG Electronics Inc., a global and financially strong company, with over 50 years of experience in technology.

Good to know: LG Electronics Australia Pty Ltd is the warrantor in Australia and NZ for your solar modules. So LG support, via offices in every Australian mainland state and NZ and through our 70 strong, Australia wide dealer network, is only a phone call away.



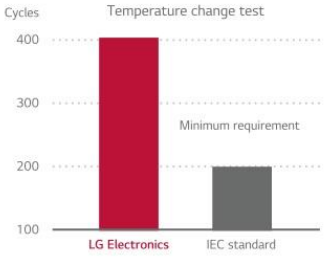
HIGHER OUTPUT, HIGHER YIELD

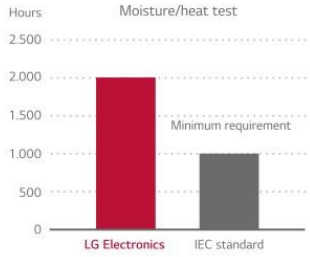
The NeON® Cell produces energy from both the front and the back of the cell. This innovative approach allows the absorption of light from the back of the cell which raises the panel's efficiency and power output. Standard panels only absorb light from the front.



EXCELLENT QUALITY, INDEPENDENTLY TESTED

You can rely on LG. We test our products with at least double the intensity specified in the IEC standard. (International Quality Solar Standard).

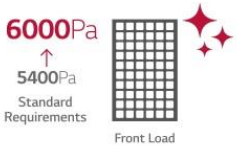


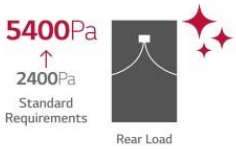


Our panel range have won a string of International Awards.

POWERFUL DESIGN, GUARANTEED ROBUST

With reinforced frame design, the LG NeON 2 can endure a front load of 6000 Pa which is the equivalent of 1048 kg over the size of the module. The rear load/wind load of the module is 5400 Pa which is more than twice the wind load resistance of standard modules (2400 Pa).





Longer Product Warranty

10yrs +2yrs

LG offers a two year longer product warranty for parts and labour than many competitors. 10 years to an impressive 12 years.

LG325N1C-A5 | LG330N1C-A5

LG NeON® 2

Mechanical Properties

Cells	6 x 10
Cell Vendor	LG
Cell Type	Monocrystalline / N-type
Cell Dimensions	161.7 x 161.7 mm
# of Busbar	12 (Multi Wire Busbar)
Dimensions (L x W x H)	1686 x 1016 x 40 mm
Front Load	6000 Pa
Rear Load	5400 Pa
Weight	18.0 kg
Connector Type	Genuine MC4, IP68 (Male: PV-KST4) (Female: PV-KBT4)
Junction Box	IP68 with 3 bypass diodes
Length of Cables	2 x 1000 mm
Front cover	High transmission tempered glass
Frame	Anodised aluminum with protective black coating

Certifications and Warranty

Certifications	ISO 9001
	IEC 61215, IEC 61730-1/-2, UL1703
	IEC 61701(Salt Mist Corrosion Test)
	IEC 62716 (Ammonia Test)
Module Fire Rating	Class C
Product Warranty	12 Years
Output Warranty of Pmax (Measurement Tolerance ± 3%)	Linear Warranty[1]

[1] 1) 1st year 98%, 2) After 1st year 0.55%p annual degradation, 3) 84.8% for 25 years

Temperature Characteristics

NOCT	45 ± 3 °C
Pmax	-0.37 %/°C
Voc	-0.27 %/°C
Isc	0.03 %/°C

Electrical Properties (STC[2])

Module Type	325 W	330 W
Maximum Power Pmax (W)	325	330
MPP Voltage Vmpp (V)	33.3	33.7
MPP Current Impp (A)	9.77	9.80
Open Circuit Voltage Voc (V)	40.8	40.9
Short Circuit Current Isc (A)	10.41	10.45
Module Efficiency (%)	19.0	19.3
Operating Temperature (°C)	-40 ~ +90	
Maximum System Voltage (V)	1000	
Maximum Series Fuse Rating (A)	20	
Power Tolerance (%)	0 ~ +3	

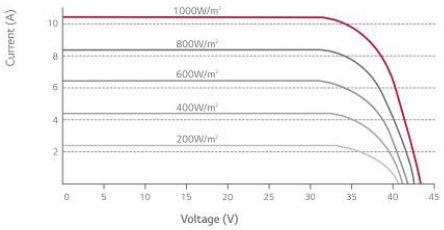
[2] STC (Standard Test Condition): Irradiance 1000 W/m², Module Temperature 25 °C, AM 1.5.
The nameplate power output is measured and determined by LG Electronics at its sole and absolute discretion.

Electrical Properties (NOCT[3])

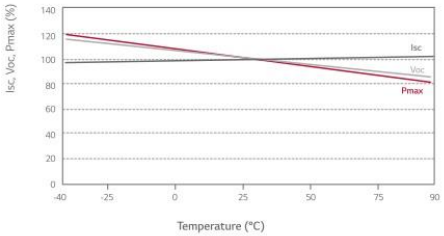
Module Type	325 W	330 W
Maximum Power Pmax (W)	240	243
MPP Voltage Vmpp (V)	30.8	31.2
MPP Current Impp (A)	7.78	7.81
Open Circuit Voltage Voc (V)	38.0	38.1
Short Circuit Current Isc (A)	8.38	8.41

[3] NOCT (Nominal Operating Cell Temperature): Irradiance 800 W/m², ambient temperature 20 °C, wind speed 1 m/s

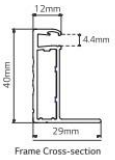
Current – Voltage characteristics at various irradiance levels

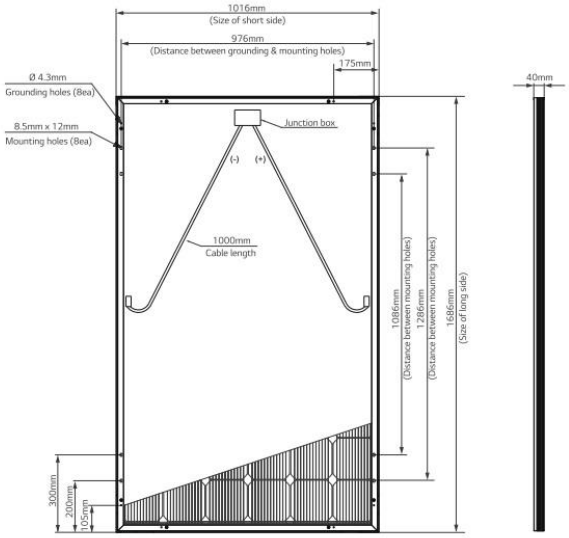


Current – Voltage characteristics at various cell temperatures



Dimensions (mm)





LG Life's Good

LG Electronics Australia Pty Ltd
Solar Business Group
2 Wonderland Drive, Eastern Creek, NSW 2766
Ph: (02) 88054038
E-Mail: solar.sales@lge.com.au
Web:lgenergy.com.au

LG Electronics Inc.
Solar Business Division
Twin Building, Western Tower, 11F,
128, Yeoui-daero, Yeongdeungpo-gu,
Seoul, 07336, Korea
www.lg.com/global/business

Product specifications are subject to change without prior notice.
Date: 04/2017

APPENDIX B - TECHNICAL DATASHEETS FOR SAMPLE PV INVERTERS

SUNNY TRIPOWER
15000TL / 20000TL / 25000TL

Efficient
- Maximum efficiency of 98.4%

Safe
- DC surge arrester (SPD type II) can be integrated

Flexible
- DC input voltage of up to 1000 V
- Multistring capability for optimum system design
- Optional display

Innovative
- Cutting-edge grid management functions with Integrated Plant Control
- Reactive power available 24/7 (Q on Demand 24/7)

SUNNY TRIPOWER
15000TL / 20000TL / 25000TL

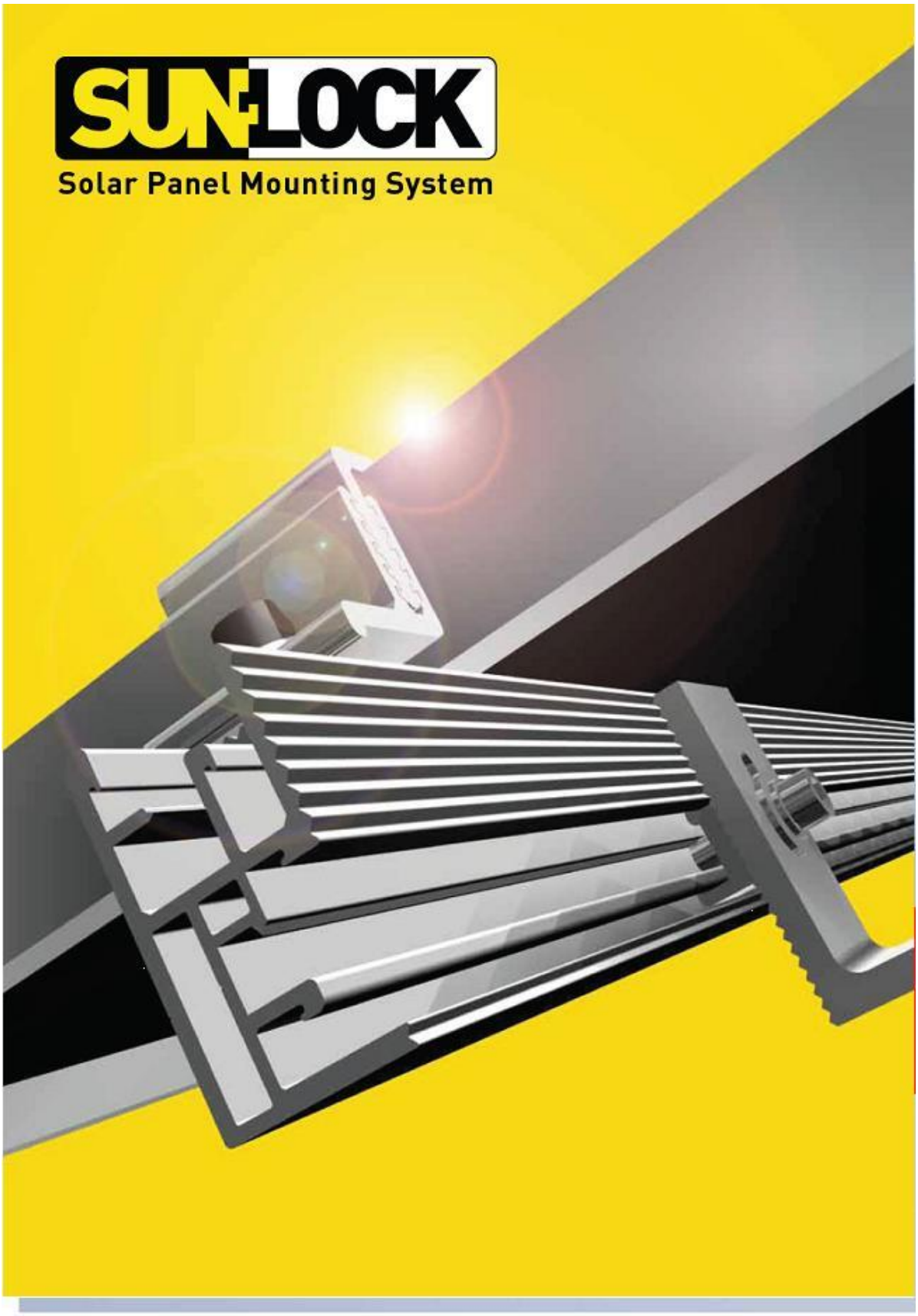
The versatile specialist for large-scale commercial plants and solar power plants

The Sunny Tripower is the ideal inverter for large-scale commercial and industrial plants. Not only does it deliver extraordinary high yields with an efficiency of 98.4%, but it also offers enormous design flexibility and compatibility with many PV modules thanks to its multistring capabilities and wide input voltage range.
The future is now: the Sunny Tripower comes with cutting-edge grid management functions such as Integrated Plant Control, which allows the inverter to regulate reactive power at the point of common coupling. Separate controllers are no longer needed, lowering system costs. Another new feature—reactive power provision on demand (Q on Demand 24/7).

SUNNY TRIPOWER
15000TL / 20000TL / 25000TL

Technical Data	Sunny Tripower 15000TL
Input (DC)	
Max. DC power (at cos φ = 1) / DC rated power	15330 W / 15330 W
Max. input voltage	1000 V
MPP voltage range / rated input voltage	240 V to 800 V / 600 V
Min. input voltage / start input voltage	150 V / 188 V
Max. input current input A / input B	33 A / 33 A
Number of independent MPP inputs / strings per MPP input	2 / A:3; B:3
Output (AC)	
Rated power (at 230 V, 50 Hz)	15000 W
Max. AC apparent power	15000 VA
AC nominal voltage	3 / N / PE; 220 V / 380 V 3 / N / PE; 230 V / 400 V 3 / N / PE; 240 V / 415 V
AC voltage range	180 V to 280 V
AC grid frequency / range	50 Hz / 44 Hz to 55 Hz 60 Hz / 54 Hz to 65 Hz
Rated power frequency / rated grid voltage	50 Hz / 230 V
Max. output current / Rated output current	29 A / 21.7 A
Power factor at rated power / Adjustable displacement power factor	1 / 0 overexcited to 0 underexcited
THD	≤ 3%
Feed-in phases / connection phases	3 / 3
Efficiency	
Max. efficiency / European Efficiency	98.4% / 98.0%
Protective devices	
DC-side disconnection device	●
Ground fault monitoring / grid monitoring	● / ●
DC surge arrester (Type II) can be integrated	○
DC reverse polarity protection / AC short-circuit current capability / galvanically isolated	● / ● / –
All-pole sensitive residual-current monitoring unit	●
Protection class (according to IEC 62109-1) / overvoltage category (according to IEC 62109-1)	I / AC: III; DC: II
General data	
Dimensions (W / H / D)	661 / 682 / 264 mm (26.0 / 26.9 / 10.4 inch)
Weight	61 kg (134.48 lb)
Operating temperature range	–25 °C to +60 °C (–13 °F to +140 °F)
Noise emission (typical)	51 dB(A)
Self-consumption (at night)	1 W
Topology / cooling concept	Transformerless / Opticool
Degree of protection (as per IEC 60529)	IP65
Climatic category (according to IEC 60721-3-4)	4K4H
Maximum permissible value for relative humidity (non-condensing)	100%
Features / function / Accessories	
DC connection / AC connection	SUNCLIX / spring-cage terminal
Display	○
Interface: RS485, Speedwire/Webconnect	○ / ●
Data interface: SMA Modbus / SunSpec Modbus	● / ●
Multifunction relay / Power Control Module	○ / ○
OptiTrack Global Peak / Integrated Plant Control / Q on Demand 24/7	● / ● / ●
Off-Grid capable / SMA Fuel Save Controller compatible	● / ●
Guarantee: 5 / 10 / 15 / 20 years	● / ○ / ○ / ○
Planned certificates and permits * Does not apply to all national appendices of EN 50438	ANRE 30, AS 4777, BDEW 2008, C10/11:2012, CE, CEI 0-16, CEI 0-21, EN 50438:2013*, G59/3, IEC 60068-2-x, IEC 61727, IEC 62109-1/2, IEC 62116, NBR 16149, NEN EN 50438, NRS 097-2-1, PPC, RD 1699/413, RD 661/2007, Res. n°7:2013, SI4777, TOR D4, TR 3.2.2, UTE C15-712-1, VDE 0126-1-1, VDE-AR-N 4105, VFR 2014
Type designation	STP 15000TL-30

APPENDIX C - TECHNICAL DATASHEET FOR SAMPLE MOUNTING SYSTEM



Solar panel installation made simple

SUNLOCK

Sunlock is an Australian designed and manufactured solar panel mounting system. Utilising custom built aluminium extrusions and components, the Sunlock system's design streamlines construction and improves frame strength to greatly simplify solar panel installation.

Sunlock's significantly higher strength-to-weight ratio allows more efficient use and greater spans. Its highly versatile design offers adjustability and expandability to suit any size job.

Sunlock is backed by a 10 year warranty and is fully compliant with the Australian/New Zealand standard on wind actions AS/NZS1170.2, making it suitable for a wide variety of building types and climatic zones.

Design Features

» Aluminium 6106T6 extrusion made from 100% recycled material.

» Building height up to 200m

» Roof slope range 10° to 65 °

» Static load capacity up to 1800N

» Optional tilt legs for greater solar efficiency

» Corrosion resistant, providing low maintenance and extended product life cycle.

» Can be used to secure a vast array of solar panel thicknesses.

» Easy to install with adjustable locking devices.

» Installation site: residential, commercial, remote area and marine applications.

» Complies with Australian/New Zealand Standard on wind actions, AS/NZS 1172.2:2002

Technical Specifications

Material	Extruded Aluminium 6106T6	
Tensile strength	Ultimate	235 MPa
	Yield	210 MPa
Installation site	Australia / NZ	
Roof types	steel, tile and slate	
Modules thickness	35 to 50mm	
Module arrangement	portrait or landscape	
Roof slope	3° to 65°	
Building height	Up to 200m	
Mounting structure	timber or steel substructure	

Ultimate Wind Load Capacity

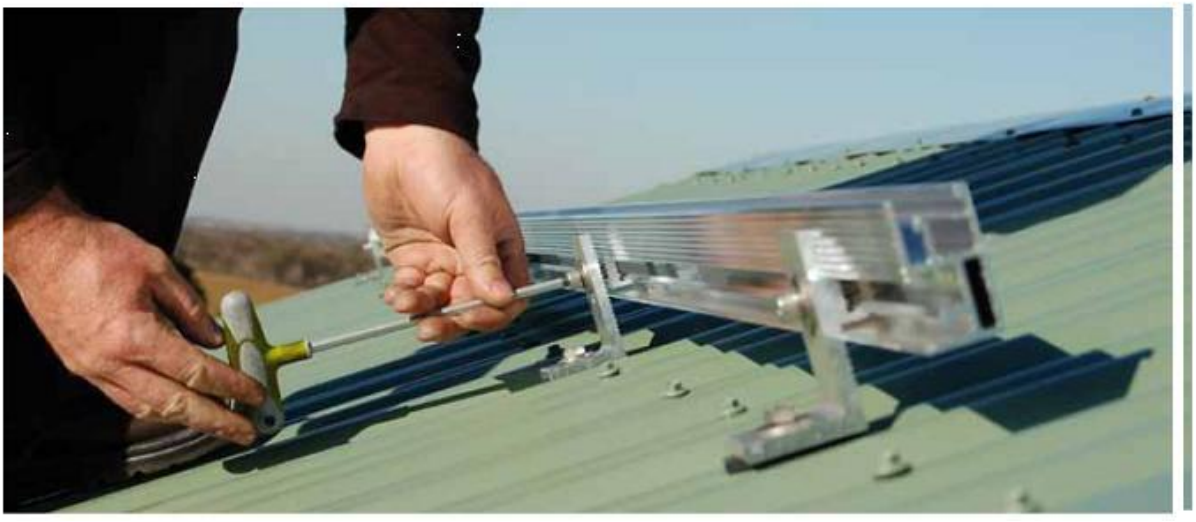
Structural design analysis confirms the following ultimate wind loads supported by Sunlock framing.

Fixing centres	Ult Wind Load - KPa | kg/m²	
mm	600mm Sunlock Rail Spacing	750mm Sunlock Rail Spacing
650	22.9 | 2335	18.37 |1873
850	13.4 | 1366	10.7 | 1091
1000	9.7 | 989	7.7 | 785
1200	6.8 | 693	5.4 | 550

Maximum Serviceable Wind Loading

The table below descibes the maxium serviceable wind loading that Sunlock rails can support in reference to a maxium deflection of span/200 (Span/200 is considered the maximum acceptable deflection limit for Sunlock rails supporting solar panels).

Fixing centres	Max Deflection - mm	Max Service Wind Load - Kpa | kg/m²	
mm	L/200	600mm Sunlock Rail Spacing	750mm Sunlock Rail Spacing
650	3.5	15.3 | 1560	12.2 | 1244
850	4.25	8.9 | 907	7.1 | 723
1000	5	6.4 | 652	5.1 | 520
1200	6	4.4 | 448	3.5 | 356



Longevity

Corrosion resistant, providing low maintenance and extended product life cycle.

Efficiency

Sunlock's significantly higher strength to weight ratio allows for more efficient use and greater spans.

Flexibility

Using adjustable clamps the Sunlock system can be used to secure a vast array of solar panel thicknesses.

Advantage

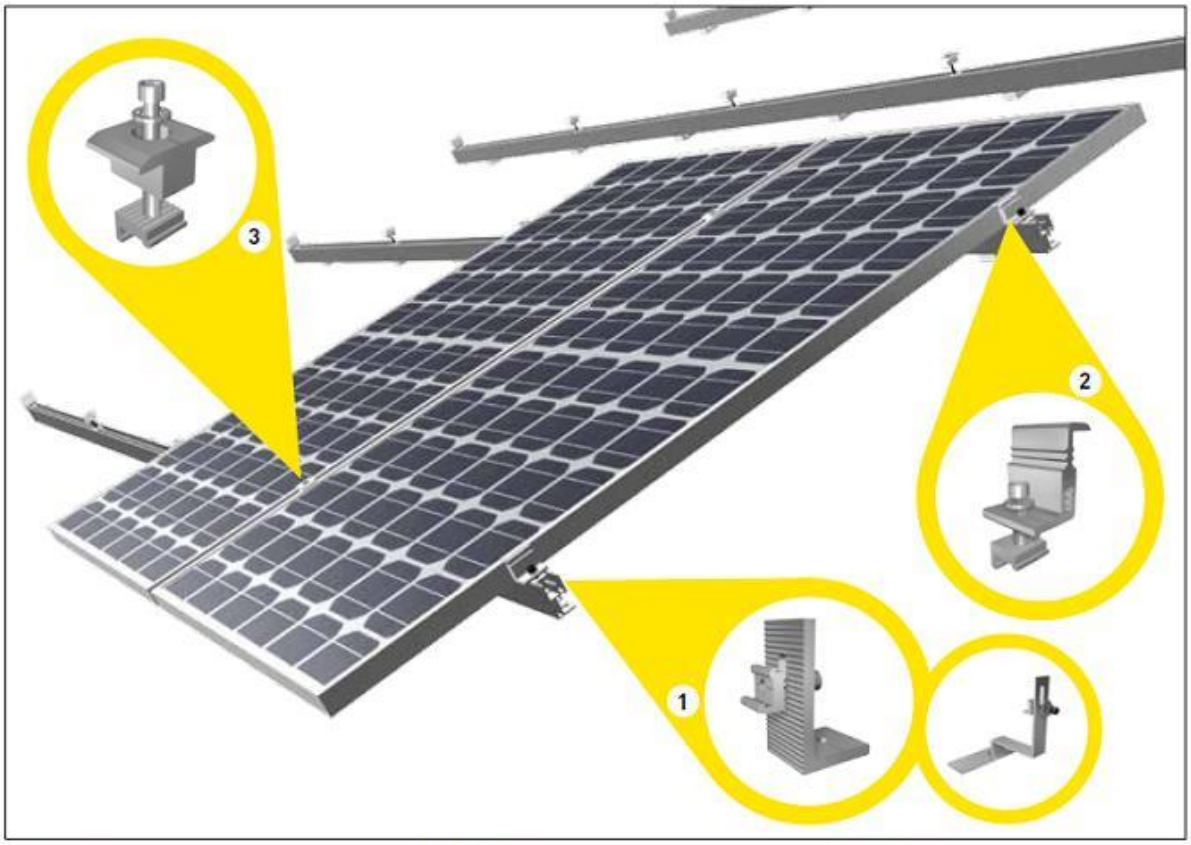
Modular design allows trouble free installation and expandability.

Expandability

Sunlock rail joiner can be used to extend the solar frame to any length required.

Quality and Safety

Complies with Australian/New Zealand Standard on wind actions, AS/NZS 1172.2:2002



1 Roof mounts
Roof mounts are used to secure the solar framing to the roof and are suitable for steel or tile roofed buildings

2 End clamp
Adjustable end clamps are used to secure solar modules of varying thicknesses.

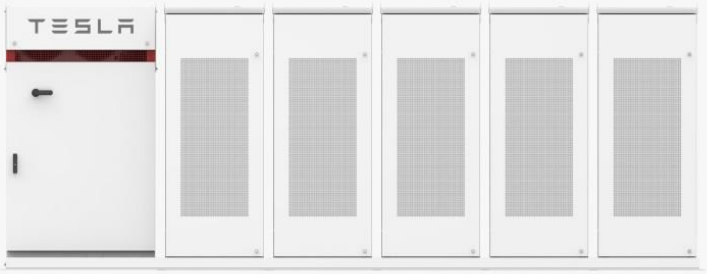
3 Middle clamp
Adjustable middle clamps are used to easily secure modules together in the array.

APPENDIX D - TECHNICAL DATASHEET FOR TESLA POWERPACK (ENERGY STORAGE OPTION)

POWERPACK

Tesla has been building integrated battery systems in cars for over 10 years. The same degree of expertise, quality control and technological innovation has informed our process of developing high-performance energy storage systems.

The Powerpack system scales to the space, power and energy requirements of any site from 210 kWh to 100 MWh+.



Powerpack System Includes an Inverter and DC Battery Packs

FULLY INTEGRATED SYSTEM

A complete energy storage system including DC batteries, bi-directional inverter, and a Powerpack controller with intelligent software. This turnkey system is designed to maximize savings and prolong battery life.

OPTIMIZATION SOFTWARE

Powerpack systems have the most advanced battery technology and dispatch optimization software to quickly learn and predict a facility's energy patterns. Tesla's proprietary storage dispatch software can charge and discharge autonomously to maximize customer value.

ENHANCED SYSTEM SAFETY

Powerpack's battery architecture consists of a low voltage battery with a DC/DC converter for added electrical isolation and safety. It also has an integrated liquid cooling / heating system for thermal safety and enhanced performance and reliability.

APPLICATIONS

PEAK SHAVING
Discharge at times of peak demand to reduce expensive demand charges

EMERGENCY BACKUP
Powers a facility when the grid goes down

CAPACITY FIRMING
Smooth out the intermittency of renewables by storing and dispatching when needed

LOAD SHIFTING
Shift energy consumption from one point in time to another

MICROGRID
Build a localized grid that can disconnect from the main power grid

TRANSMISSION & DISTRIBUTION SUPPORT
Supply power at a distributed location to defer the need to upgrade aging infrastructure

DEMAND RESPONSE
Discharge or charge in response to signals from a demand response administrator

ANCILLARY SERVICES
Provide service to the grid in response to signals sent

TESLA

TESLA.COM/ENERGY

POWERPACK SPECIFICATIONS
4hr System

- 1 Powerpack includes 16 battery pods
- Each pod has an isolated DC/DC inverter and thermal control system
- Sensors to monitor cell-level performance in real-time
- Standard configuration:
  i. 4 hour discharge duration

ELECTRICAL

AC Voltage	380-480VAC 3-phase
Nominal Frequency	50 & 60 Hz
Continuous Discharge Duration	4 hours
AC Energy available per Powerpack[1]	210 kWh
Inverter Sizes	Scalable from 50kW - 653kW
Roundtrip[1] System Efficiency	89%

[1]Net energy delivered at 25°C (77°F) including thermal control.

REGULATORY

Lithium-Ion Cells	NRTL listed to UL 1642
System	NRTL listed to UL 1973, 9540, 1741 IEEE 1547 Compliant to grid codes and safety standards of all major markets. Full list provided upon request.

MECHANICAL AND MOUNTING

Enclosure	IP67 (Pod) NEMA 3R / IP35 (Powerpack) NEMA 4 / IP66 (Inverter)
System Area Requirements	50kW / 210kWh: 95ft² / 8.9m² 100kW / 420kWh: 127ft² / 11.8m² 250kW / 1050kWh: 221ft² / 20.5m² 500kW / 2100kWh: 377ft² / 35m²
Powerpack Unit Dimensions	L: 51.5" (1308mm) W: 32.4" (822mm) H: 86" (2185mm)
Weight	2160 kg / 4765 lbs
Inverter Dimensions	L: 39.9" (1014mm) W: 49.4" (1254mm) H: 86.3" (2192mm)
Weight	Up to 1200 kg / 2645 lbs
Operating Ambient Temperature	-22°F to 122°F / -30°C to 50°C

COMMUNICATIONS

Protocol	Modbus TCP DNP3 Rest API

TESLA

TESLA.COM/ENERGY

Tesla's software for behind the meter Powerpack applications, called Opticaster, is designed to maximize economic benefit for customers. Opticaster now operates in more than 100 commercial and industrial stationary energy storage systems, resulting in tens of thousands of hours of field experience in a vast range of grid-connected and off-grid applications. With each of Tesla's 120,000+ electric vehicles operating its proprietary battery system software, Tesla's experience in this realm is unparalleled.

The robust data set accumulated through Tesla's field experience informs the development and continuous improvement of Tesla's global fleet of vehicles and energy storage systems. Tesla's software logic for behind the meter energy storage applications is a culmination of this vast experience and is the focus of this paper.

Opticaster is an integral component of Powerpack system. At every stage of project maturity, Opticaster is used to optimize Powerpack system size to achieve maximum financial returns for customers. During operation, it forecasts and optimizes the dispatch of stored electricity to reduce electricity bills and perform grid services.

This paper illustrates the applications Tesla's Opticaster performs, and explores three layers of functionality that define its operation: forecasting, optimization, and real-time control.

SYSTEM SIZING

System modeling enables customers to evaluate the benefits of adding a Powerpack system. Based on a simple set of customer data, such as utility rate structures and historical load data, Opticaster leverages its core optimization and forecast abilities to perform detailed simulations, which determine an optimal system size and application set for any customer. Figure 1 illustrates commonly modeled functions and applications:

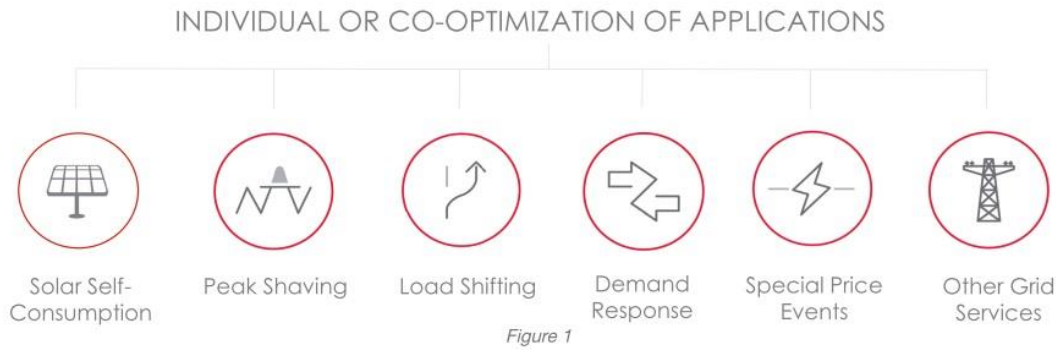


Figure 1

To ensure the greatest probability for customer savings and revenue, Tesla simulates multiple scenarios for each customer. Each scenario provides a probability for economic benefit by testing multiple customer load behaviors against an array of Powerpack sizes and applications.

APPLICATIONS

Commercial electricity bills are usually comprised of demand charges and energy charges. Opticaster automatically optimizes both weighted by their respective costs.

Demand charges typically make up the greatest portion of commercial electricity bills, and can be reduced by discharging an on-site Powerpack system during the customer's period of peak demand. Through peak shaving / demand charge management, Opticaster automatically forecasts customers' site peak and discharges Powerpack batteries to reduce demand charges.

To reduce energy charges, Opticaster charges Powerpacks when the site demand or utility energy prices are low, then dispatches electricity to the customer when prices are high. Figure 2 demonstrates a combination of peak shaving and energy load shifting in an application called **tariff optimization.**

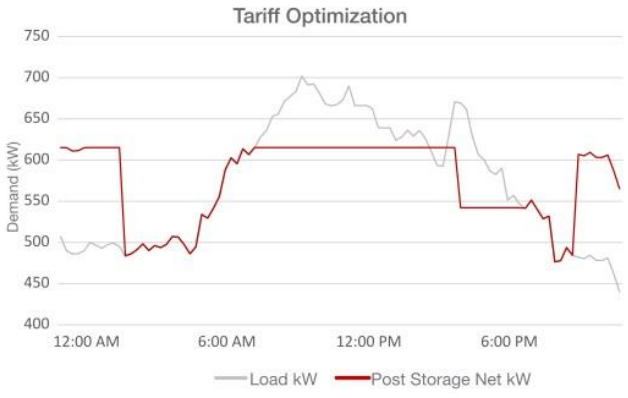


Figure 2

Commercial customers may also use solar panels to offset the electricity their site consumes from the local grid. For these customers, an on-site Powerpack system stores the solar electricity generated during the day for use during peak demand times through an application called **solar self-consumption.**

In solar self-consumption, Opticaster maintains system parameters to ensure optimal performance: maximum solar export power, percentage of battery to charge from solar, maximum and minimum site power level, utility interconnection rules, and other requirements that qualify the customer for government incentives. This flexible approach maximizes economic benefit for customers.

Figure 3 shows an example of Opticaster commanding Powerpacks to charge from solar during the day, then discharge to shave the customer's evening peak.

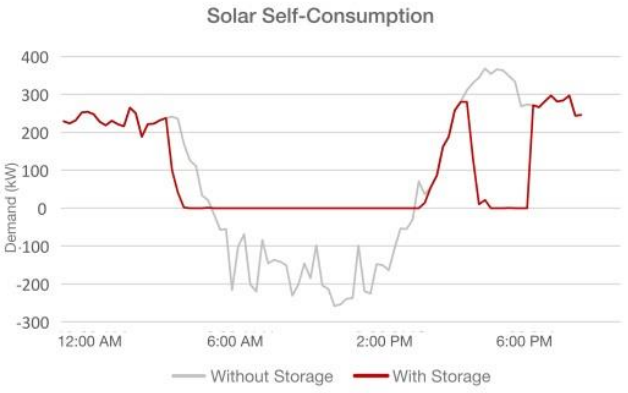


Figure 3

To secure multiple revenue streams for customers, Opticaster also supports **demand response (DR)** and other special price events such as critical peak pricing in PG&E and TUoS in the U.K.. Figure 4 shows an example of a DR event, during which the algorithm commands the Powerpack system to precisely meet the DR commitment of 50 kW below the baseline.

Figure 4

Through a combination of peak shaving and load shifting applications, customers reduce demand charges and energy charges on-site. By also participating in a DR program, customers add a layer of revenue that increases financial returns. Figure 5 depicts a customer co-optimizating all applications, which includes tariff optimization where Powerpacks charge during the night and discharge to keep the maximum peak below 410 kW at all time, and demand response where Powerpacks discharge to reduce the load well below the demand response baseline.

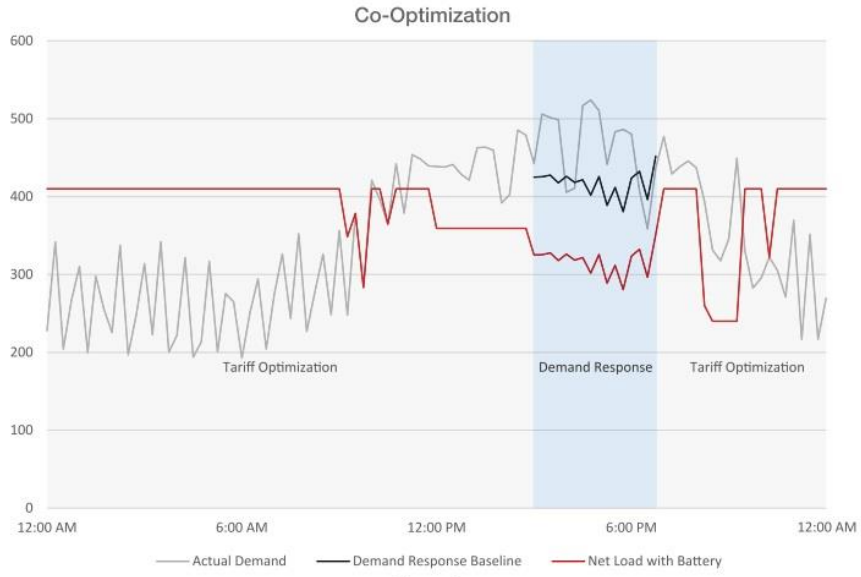


Figure 5

OPERATION

Opticaster's operation takes three major steps: demand forecast, optimization, and real-time operation.

Accurately forecasting customer demand is critical to overall system performance. To produce a customer demand forecast, Opticaster considers a robust set of variables including load profiles, solar profiles, holiday schedules, and temperature data. In addition, on-site electric and solar meters feed data into the system's data set to update the demand forecast continuously.

Continuous updates of demand forecast occur every couple of minutes. As shown in Figure 6, the forecast of the peak load gets increasingly accurate as it moves forward in time. The data retrieved between each new forecast become new input for the optimization model explained next.

Figure 6

Based on the forecasted demand, utility rate structure, and battery state, Opticaster's optimization module autonomously develops a charge/discharge schedule that maximizes customer savings while satisfying other non-monetary requirements. These schedules are updated with the same frequency as demand forecasts.

Then the real-time operation module translates the charge/discharge schedules to the instantaneous power commands that control Powerpacks. It monitors the real-time demand from the site and ensures that optimal charge/discharge schedules are satisfied.

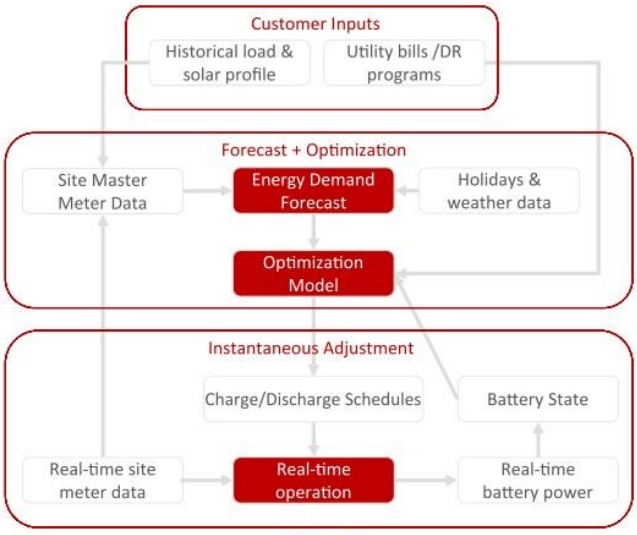


Figure 7

Every new version of Opticaster is benchmarked against Tesla's performance at existing sites to ensure constant improvement. Opticaster's combination of forecasting, optimization, and real-time controls makes it the most capable software solution on the market for managing advanced energy storage applications. Scalable to the power and energy requirements of any site, Powerpack systems provide a complete solution for a breadth of commercial and utility applications. To determine if energy storage is right for your site, please email powerpack@tesla.com.

APPENDIX E - TECHNICAL DATASHEET FOR TESLA POWERPACK INVERTER (STORAGE OPTION)

TESLA **POWERPACK INVERTER**

May 12, 2017 *CONFIDENTIAL INFORMATION - SHARED UNDER NDA ONLY* Rev. 1.2

SPECIFICATIONS

Mechanical Specifications

Width	1254 mm (49.4 in)
Depth	1014 mm (39.9 in)
Height	2140 mm (84.3 in)
Weight	1200 kg (2645 lbs) max

***NOTE**: Dimensions do not include removable mounting feet and lifting flanges, which add 136mm (5.4in) to the overall width and 50mm (2in) to the height of the inverter.*

***NOTE**: Weight changes depending on number of installed power stages.*

Power Specifications

The inverter is configurable to a nominal output voltage of 400 VAC or 480 VAC. The specs below are split for each default voltage value. Each inverter contains up to 10 inverter modules, or "Powerstages".

Grid-Connected (Utility-Interactive) Mode

Default Voltage	**400 VAC**	**480 VAC**
Rated Output Power (for 10 Powerstages)	500 kVA	625 kVA
Future Rated Output Power (for 10 Powerstages, available Aug. 2017)	540 kVA	650 kVA
Overload Capability	120% of rated power (10 sec max)	120% of rated power (10 sec max)
Input Voltage Range	880-950 VDC	
Output Voltage Range	360-528 VAC (380-480 VAC grid)	
Nominal Frequency (configurable)	50 or 60 Hz	
Frequency Range	40-70 Hz	
Input Current	720 A	
Phases	3	
System configuration	4-wire, Wye grounded	
Max Output Current	800 A (80A per Powerstage)	
Peak Efficiency	> 98.9%	
Full Load Efficiency	98.5%	
CEC Weighted Efficiency	98.84%	
Power Factor at Full Load	> 99%	
Adjustable Power Factor (Controller Feature)	-1 to +1	
Total Current Harmonic Distortion (THD)	< 1.2%	
Power Regulation Accuracy	< 2%	
Overvoltage Category	Category IV up to 3000 m	

Supplemental Specifications for Grid-Forming (Islanding) Mode

Total Voltage Harmonic Distortion (THD)	< 8% (Individual Harmonic: Max 6%)
Imbalanced Phase Load Power Output	100%

The inverter may be de-rated by changing software parameters to meet specific site restrictions and requirements.

Environmental Specifications

Operating Temperature	-30ºC to 50ºC (-22ºF to 122ºF)
Storage Temperature	-40ºC to 60ºC (-40ºF to 140ºF)
Humidity	Up to 100% condensing
Maximum Altitude	3000 m (9840 ft) above sea level
Noise	< 70 dBA at 1 meter
Ingress Rating	IP66, NEMA 4
Impact Rating	IK09
Seismic Rating	High seismic level, 1.0g ZPA, 2% damping per IEEE 693-2005 (pending)

Product Configurations

Each inverter is configured by Tesla with one of the following:

- 1 to 10 Powerstages
- Four DC fuse variants: 5, 10, 15, or 20 pre-installed DC fuses (corresponding to the number of DC Powerpack Units installed with each inverter)

Note: Inverter configurations are at Tesla's discretion.

Table 1 describes the inverter configurations possible with the corresponding power values.

Table 1: Inverter Configurations

Number of Powerstages	kVA Nameplate at 480V as of Q4 2016	kVA Nameplate at 400V as of Q4 2016	*kVA Nameplate at 480V Aug 2017*	*kVA Nameplate at 400V Aug 2017*	Max Continuous Current (A)
1	62.5	50	65	54	80
2	125	100	130	108	160
3	187.5	150	195	162	240
4	250	200	260	216	320
5	312.5	250	325	270	400
6	375	300	390	324	480
7	437.5	350	455	378	560
8	500	400	520	432	640
9	562.5	450	585	486	720
10	625	500	650	540	800

FEATURES

Voltage Ride-Through

The inverter has five voltage and time setpoints for low voltage ride-through, configurable to the following ranges (measured as line to neutral):

Table 2: Inverter LVRT Settings

Parameter	Voltage Range	Default Values for 480V (in EU)	Time (sec)	Notes
LVRT Point 5	0-415.5 V	124.65	0-30	0.1 sec resolution
LVRT Point 4	0-415.5 V	166.2	0-30	0.1 sec resolution
LVRT Point 3	0-415.5 V	243.76	0-30	0.1 sec resolution
LVRT Point 2	0-415.5 V	243.76	0-30	0.1 sec resolution
LVRT Point 1	0-415.5 V	243.76	0-30	0.1 sec resolution

The inverter has four high voltage ride-through setpoints, with one instantaneous trip voltage setting, configurable to the following ranges (measured as line to neutral):

Table 3: Inverter HVRT Settings

Parameter	Voltage Range	Default Values for 480V (in EU)	Time (sec)	Notes
HVRT Point 3	0-415.5 V	332.4	0-30	0.1 sec resolution
HVRT Point 2	0-415.5 V	332.4	0-30	0.1 sec resolution
HVRT Point 1	0-415.5 V	304.7	0-30	0.1 sec resolution
HVRT max trip	0-415.5 V	346.25	N/A	

The above tables represent the max parameter values that the user can input. However, 480 VAC nominal systems are limited to a maximum HVRT of 120%, and 400 VAC nominal systems are limited to a maximum HVRT of 145%.

The inverter ships with the following pre-defined settings:

Table 4: Interconnection System Default Settings for Abnormal Voltages

Voltage Range (% of base voltage)	Clearing Time (s)
$V < 45$	0.16
$45 \leq V < 60$	1
$60 \leq V < 88$	2
$110 < V < 120$	1
$V \geq 120$	0.16

Frequency Ride-Through

The inverter has three under-frequency (UF) and three over-frequency (OF) trip points and times, as well as one under-frequency instantaneous trip point and one over-frequency instantaneous trip point. These parameters are configurable to the following ranges:

Table 5: Inverter Frequency Trip Points

Trip Point	Frequency Range	Time (sec)	Notes
Instantaneous UF Trip	40Hz-70Hz	N/A	0.1Hz resolution
UF Trip Time 3	40Hz-70Hz	0-600	0.1Hz and 0.01 second resolution
UF Trip Time 2	40Hz-70Hz	0-600	0.1Hz and 0.01 second resolution
UF Trip Time 1	40Hz-70Hz	0-600	0.1Hz and 0.01 second resolution
OF Trip Time 1	40Hz-70Hz	0-600	0.1Hz and 0.01 second resolution
OF Trip Time 2	40Hz-70Hz	0-600	0.1Hz and 0.01 second resolution
OF Trip Time 3	40Hz-70Hz	0-600	0.1Hz and 0.01 second resolution
Instantaneous OF Trip	40Hz-70Hz	N/A	0.1Hz resolution

The following FQRT settings are pre-programmed in the inverter to comply with IEEE 1547 requirements:

Table 6: Inverter FQRT Default Settings

Function	Frequency (Hz)	Clearing Time (s)
UF1	< 57	0.16
UF2	< 59.5	2
OF1	> 60.5	2
OF2	> 62	0.16

Anti-Islanding Features

The Powerpack Inverter includes these anti-islanding features:

- Reconnection delay timer
- Active anti-islanding: Sandia Frequency Shift implemented on all systems
- Passive anti-islanding: Configurable Rate of Change of Frequency (ROCOF) preferences

The reconnection delay timer is configurable with the following settings:

Table 7: Reconnection Delay Timer Default Settings

Feature Name	Effect	Setting Range	Default
Reconnect Time Delay	The amount of time the inverter waits before reconnection, after the grid returns within the frequency and voltage windows defined above	0-1,000 sec	300 sec
Reconnect Min. Voltage	The minimum voltage at which the inverter interprets the grid is within tolerable conditions	0-415.5 V	240.99 V
Reconnect Max. Voltage	The maximum voltage at which the inverter interprets the grid is within tolerable conditions	0-415.5 V	293.62 V
Reconnect Min. Frequency	The minimum frequency at which the inverter interprets the grid is within tolerable conditions	40-70 Hz	59.3 Hz
Reconnect Max. Frequency	The maximum frequency at which the inverter interprets the grid is within tolerable conditions	40-70 Hz	60.5 Hz

ROCOF is configurable with the following settings:

Table 8: ROCOF Settings

Feature Name	Effect	Setting Range	Default
ROCOF Enable	Turns ROCOF on or off	n/a	Off
ROCOF Fault Limit	Sets the rate of change required for a trip	0.1-100.0 Hz/sec	1 Hz/sec
ROCOF Time Delay	Sets how long the rate of change has to be present for the inverter to trip	0-1 seconds	1 second

Certifications (Pending)

The Powerpack Inverter is certified to, and meets the requirements for, the following codes, standards, and regulations:

- UL1741
- IEEE 1547.1 (EMI: Complies with immunity requirements)
- FCC Part 15 Sub B Class A
- CSA 22.2 #107.1
- EN 62109-1, EN 62109-2
- IEC 61000-6-2, IEC 61000-6-4
- NERSA Version 2.8
- G59
- VDE-AR-N 4105 & VDE-V0 124-100
- CEI 0-21
- AS/NZS 4777.2:2015
- NBR 16149 & NBR 16150
- NBR IEC 62116
- RD 1699 / UNE 206007-1

Dimensions

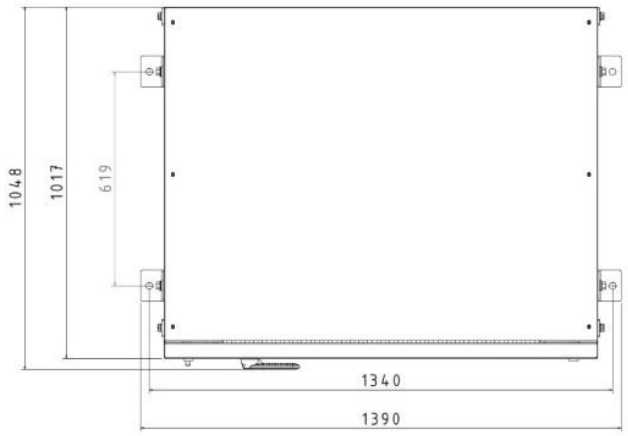


Figure 1: Inverter Top View (in mm)

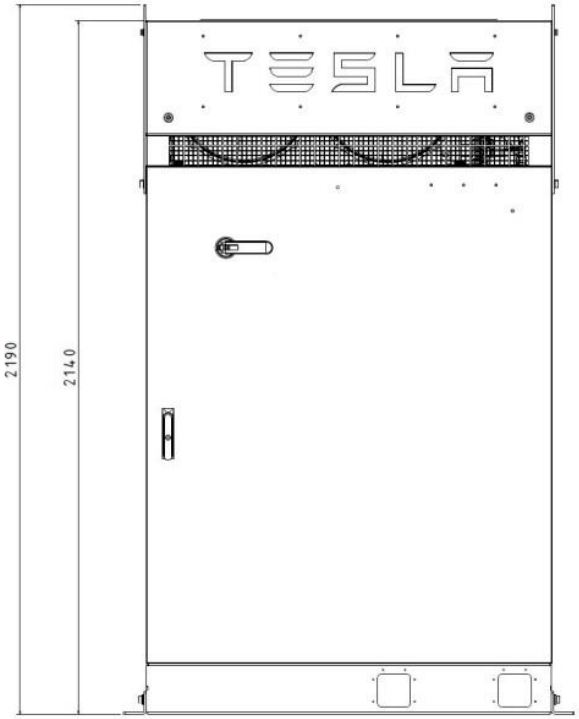


Figure 2: Inverter Front View (in mm)