Ausgrid Climate Impact Assessment 2022

A report on the future impacts of climate change

Empowering communities for a resilient
affordable and net-zero future.

Ausgrid

Contents

Executive Summary

Australians are experiencing more extreme weather events as global temperatures increase.

Within the Ausgrid network area, our customers have generally experienced the benefits of a highly resilient and secure electricity system. However, over the past decade we have seen the number of escalating extreme weather events causing damage to our network and increasing the risk to the communities we serve. A warming climate will result in more intense extreme weather events which will result in further wide area, prolonged outages for customers.

> *The cost of natural hazard events in Australia has more than doubled since the 1970s and totalled $35 billion over the past decade[1].*

The frequency and magnitude of these events are increasing due to climate change and will affect future generations more profoundly. It is estimated that the total financial cost of natural hazards across all sectors will average $73-94 billion per year by 2060 without significant investment in resilience and risk mitigation[2].

Ausgrid's current network performance is susceptible to the impacts of extreme weather events. These events cause damage to our electrical assets and our historical data tells us that although only 27% of the events on our network are weather related, they account for 66% of out of the minutes experienced by customers and result in wide area and long duration outages.

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[1] https://www.climatecouncil.org.au/resources/hitting-home-compounding-costs-climate-inaction

[2] Australian Business Roundtable for Disaster Resilience & Safer Communities 2021

It is important that as an essential service provider and given the increasing drive for electrification, Ausgrid looks at resilience and how to best promote the long-term interests of consumers.

To manage this increasing risk and maintain the quality of life for our customers there is a need to understand the risk climate change presents to our network and operations, how it will impact current and future customers, and what we can do about it. We have heard from our stakeholders, including customers, employees, shareholders, and partners that we need to respond to a changing climate.

First of its kind in Australia – analysis of climate impact on electricity distribution

Ausgrid has undertaken, the first of its kind in Australia, an analysis of future climate change impacts on an electricity distribution business. Using Ausgrid asset data and external climate data sets (See **Appendix A**), we used the modelling to determine the climate change impact on our customers and our business.

Projected climate risk change

We first modelled future climate emissions scenarios (low, medium, and high) and the related risk of different types of extreme weather events in Ausgrid's network area.

Under a medium emissions scenario there is a 26% increase in extreme weather events on our network by 2050[3]. This risk increases to 31% towards the end of the century[4]. The areas of our network with the biggest exposure to extreme weather from climate change are the:

- Upper Hunter with extreme heat and bushfire
- the East Coast of our network area with storms.

Projected impact of climate events

Using the outcomes from our climate modelling, we then modelled the impact of various future climate risks both operationally and financially on Ausgrid's network assets. These were measured against Ausgrid's historical and external data: asset failure rates, costs, and the time that customers would be without supply.

The extreme weather events modelled were:

- heatwaves[5]
- bushfire
- windstorms
- flooding.

Impact modelling shows that Ausgrid's network or asset failures, from extreme weather events, will increase by more than 23% by. It also shows that direct asset repair costs from these extreme weather events will more than 21%[6] by 2050.

When taking into consideration indirect costs (e.g., unserved energy from customer demand that cannot be supplied by the electricity provider), we see costs associated with climate related events also increase by more than 23% by 2050.

Modelling of customer time without electricity supply and through speaking with customers who have experienced prolonged outages, demonstrates to us that the impacts of climate related prolonged outages have profound impacts on the communities we serve. The areas of our network with the biggest exposure to the impacts of climate change related extreme weather events is primarily the along East Coast in northern Sydney and the Central Coast from windstorms. This is mainly due to the heavily vegetated areas of the network that have a lot of overhead lines.

The need for climate resilience

Building resilience to the impacts of climate change is imperative for future generations. Without accounting for climate change impacts when making network investments today, we will inevitably be locking in higher costs and greater risk for the customers being served by that network over its 50-year life.

As it stands now, the resilience of the assets that provide our current electricity supply is dictated by the decisions and design principles at the time of installation 40-50 years ago. Likewise, those people being supplied by the electricity network in 2065 will be living with the risk and cost implications of the investment decisions we make today. It is therefore critical that Ausgrid use science-based data to consider how our climate might change long term (over the life of the asset), not just the next 5 years.

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[3] Ausgrid Climate Impact Assessment 2022 (full report) , Ausgrid commissioned report for which this document is the summary, 2022

[4] Modelled under RCP 4.5 – averages pulled from "Projected changes in the main hazard parameters"

[5] For the purposes of this study a heatwave was defined as 3 or more days above 35 °C

[6] Modelled under RCP 4.5 – and RCP 8.5 – direct costs per annum

2

Climate change – key impacts

2.1 Climate Change

Climate change is having a significant impact on economies and societies across the globe. Seven of the world's hottest years have occurred in the last decade[7] and there is growing evidence linking an increase in frequency and intensity of extreme weather events, to anthropogenic (i.e. human induced) climate change.[8] [9]

Land areas in Australia have warmed by around 1.4°C between ~1910 and 2020, inducing extreme heatwaves, rainfall (more time in drought, but more intense heavy rainfall events), more high fire danger days and a longer fire season. This is the future Ausgrid must face as a provider of an essential service for millions of people and businesses.

Acknowledging the risks already locked in for future decades, Ausgrid is placing resilience central to its strategy now and in the coming decades. Given the long-term nature of our assets we need to plan for and respond to the challenges our network and communities will face in the decades ahead.

Physical risks to the network can be either:

- chronic risks that cause slow but cause noticeable damage to assets eventually leading them to fail before their planned end-of-life which cause interruption to customer supply (e.g., increasing air temperature)
- acute risks that become more frequent and intense extreme weather events (e.g., storms) can break infrastructure and cause widespread long duration outages.

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[7] https://www.giss.nasa.gov/research/news/20170118/
[8] https://www.carbonbrief.org/mapped-how-climate-change-affects-extreme-weather-around-the-world
[9] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

2.2 Future climate scenarios

To describe what might happen by 2100 for both greenhouse gas emissions and global climate warming we used low, medium, and high scenarios using relevant historical information and recommended data sets for selected extreme weather events (heatwaves, bushfires[10], windstorms, and floods). Each extreme weather event was modelled individually through the scenarios to provide Ausgrid with projections for each climate risk and across, across each location of Ausgrid's network, until the end of the century. The scenarios we used for this research are called Representative Concentration Pathways (RCP)[11].

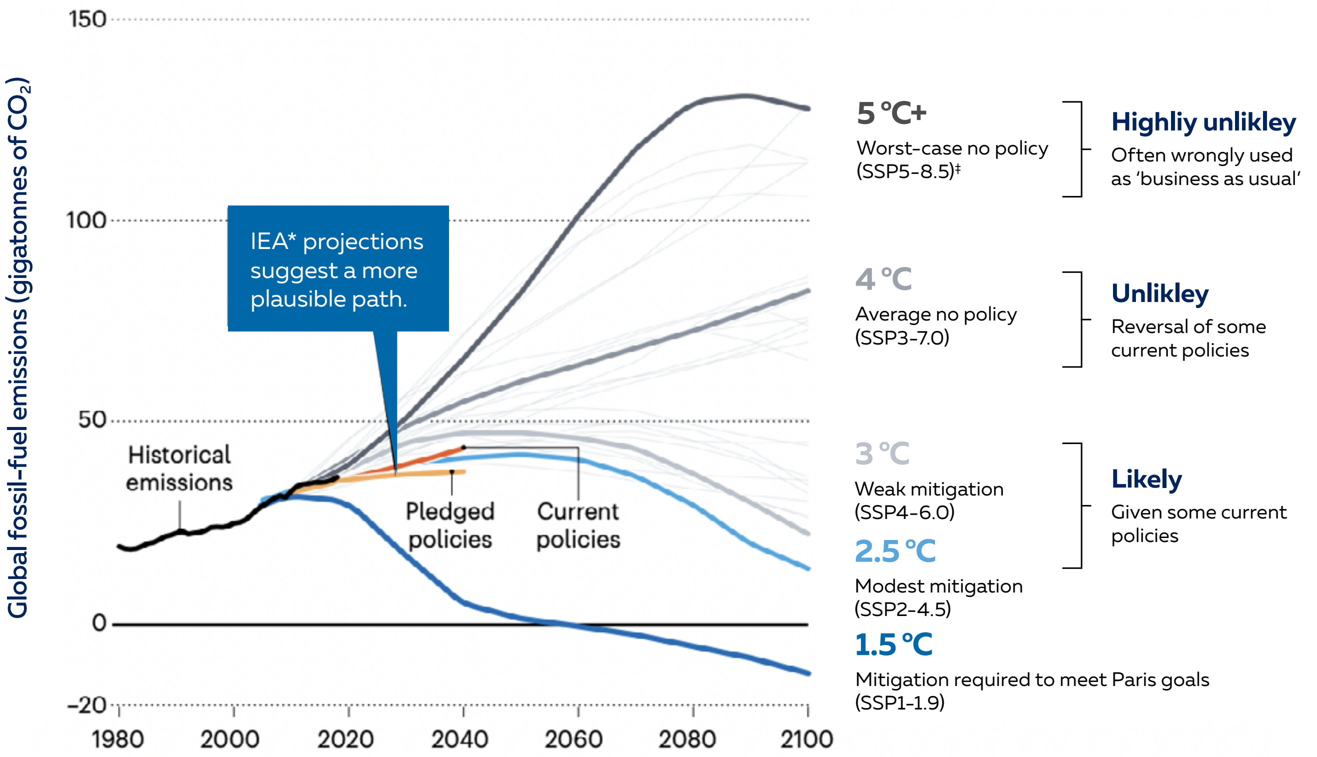
- **low** - RCP 2.6 - global warming is kept to below 2°C, this is in-line with the ambition of the Paris Climate Agreement
- **medium** - RCP 4.5 - modest action on climate change, where global warming would be approx. 3°C by the end of the century
- **high** - RCP 8.5 - a fossil fuel intensive future where global warming could exceed 5°C.

The world is heading towards the medium emissions scenario of 3°C of warming by 2100. According to research published from the United Nations, Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2021: The Physical Science Basis*, 'unless there are immediate, rapid and large-scale reductions in greenhouse gas emissions, limiting warming to close to 1.5°C or even 2°C will be beyond reach'.

Global warming is heavily influenced by economic and geopolitics for example the war in Ukraine and stability in energy markets. Both global greenhouse gas emissions and land use also play a part, therefore it is important to explore multiple scenarios. We cannot predict what will happen in the future either economically or politically. Current pledges under the Paris Agreement suggest that, approximately 3°C warming is the most likely scenario (RCP 4.5 - medium). Analysis by the International Energy Agency with its 31 member countries and eight association countries, supports this.

A worst case scenario although is considered unlikely, could still happen. Despite commitments worldwide to lower emissions, it is still worthwhile considering the scenario where warming could be 5°C or more (RCP 8.5-high).

Figure A: Global fossil fuel emissions by future climate scenario



The International Enegy Agency (IEA) maps out different energy-policy and investment choices. Estimated emissions are shown for it's Current Policies Scenario and for its Stated Policies Scenario (includes countiries' current policy pledges and targets). To be comparable with scenarios for the Shared Socioeconomic Pathways (SSPs), IEA scenarios were modified to include constant non-fossil-fuel emissions

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[10] Network ignited bushfires were not included as part of the scope.
[11] https://ar5-syr.ipcc.ch/topic_summary.php

2.3 Tipping points

A tipping point is a threshold. When we cross this threshold, it can lead to large, irreversible changes to the climate system. Current climate models do not include tipping points. Some of the main possible tipping points are:

- the collapse of the Greenland and West Antarctic ice sheets
- Amazon rainforest dieback
- permafrost melting and associated methane release.

Unfortunately the world will cross many of these thresholds[12], but we do not know when. Ausgrid's climate scientists recommend preparing for both the medium and high emission scenarios as the current forecast aligns with 2-3°C of warming, and would consider these tipping points.

The primary climate data sets used in the modelling for the medium and high emissions scenarios were the Energy Sector Climate Information Project (ESCI) and other datasets found in **Appendix A**.

To account for possible errors in the modelling, we used the averages from a minimum of three (3) models. The amount of variation between the models provides an estimate of uncertainty, see **Appendix B**.

The climate model projections are also based on a minimum 20 year average to account for natural variability (i.e. for bushfires; some years would be worse than the 20 year average, such as the Black Summer of 2019-2020 and some less such as these past two La Nina Summers).

2.4 Overall Climate Risk to Ausgrid Network

The climate risks that were modelled were extreme heat days, heatwaves, bushfire (frequency of fire weather days, not liability associated with a network fire start), windstorms (East Coast lows, rain, wind speed), riverine flooding and coastal inundation (and the precipitation associated). The areas of our network with the biggest exposure to extreme weather from climate change are:

- the Upper Hunter - heatwave and bushfire
- the East Coast – windstorms.

Ausgrid's network area is exposed to an increasing risk of extreme weather. From today, under a medium emissions scenario this increases 26% by 2050, and 31% by 2090. These are averages across Ausgrid's network, and some areas will have considerably higher exposure than the average amount (and some lower). The table below outlines the increased risk by extreme weather event type, and further information about confidence levels can be found in **Appendix B**.

Table A: Projected risk increase to climate perils on Ausgrid's network (medium emissions scenario)

Metric	What this means	Change 2050	Change 2070	Change 2090	Confidence
Consecutive Hot Days – Total	The total number of heatwave days, where a heatwave is defined as 3 or more consecutive days > 35 deg C	103%	123%	123%	Very High
Consecutive Hot Days – Maximum	The longest run of consecutive hot days > 35 deg C	22%	24%	29%	Very High
Windspeed maximum	Speed of sustained wind gusts in m/s	3%	3%	3%	Medium
Windstorm	Primarily related to days where East Coast Lows make landfall	23%	30%	30%	Medium
Very heavy Precipitation Days	Days with more than 30mm of precipitation which is linked to flooding	20%	-4%	4%	Medium
High Fire Danger Days	Days with a forest fire danger index above 25	0%	23%	17%	High
Extreme (and above) Fire Danger Days	Days with a forest fire danger index above 50	13%	21%	11%	High
Average across network		**26%**	**31%**	**31%**	**n/a**

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[12] Dr. Stuart Browning, Risk Frontiers, 2022

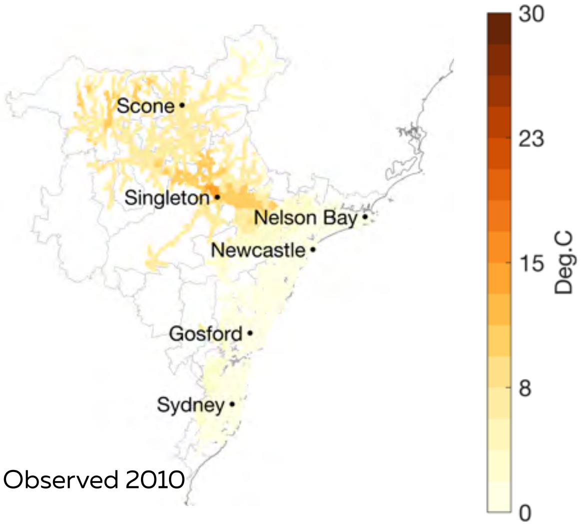
3.4 High-Risk Suburbs

Areas of Ausgrid's network are impacted differently. This section shows the highest risk suburbs for specific future extreme weather event risks.

Table B: Heat related climate risk suburbs

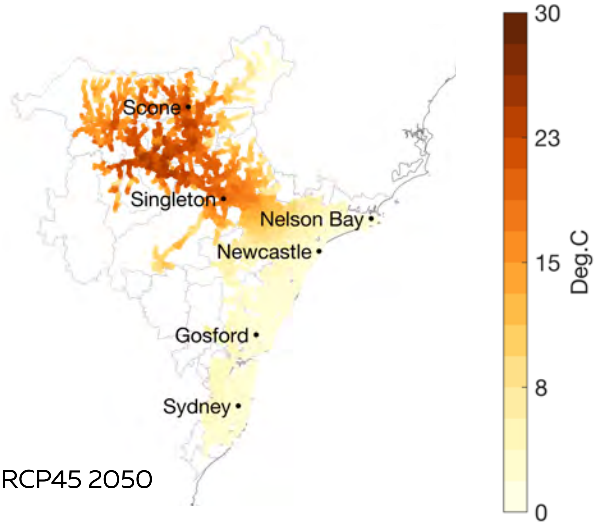
	Hot days (35 C+)			Consecutive hot days			Very high fire danger days (FFDI >25)		
	2050 (RCP 4.5)	Days	% inc.	2050 (RCP 4.5)	Days	% inc.	2050 (RCP 4.5)	Days	% inc.
1	Denman	36.5	31	Denman	7.3	27	Singleton	36.5	1
2	Muswellbrook	35.2	32	Muswellbrook	7.2	29	Muswellbrook	35.7	5
3	Aberdeen	32.2	34	Aberdeen	7	30	Denman	35.2	2
4	Singleton	32.1	31	Merriwa	6.7	32	Singleton MA	34.6	1
5	Singleton Military Area	29.6	32	Murrumbo	6.6	32	Branxton	34.2	-1
6	Branxton	29	31	Scone	6.5	29	Aberdeen	32.6	5
7	Scone	27.8	36	Singleton MA	6.1	23	Greta	32.6	-4
8	Greta	27.2	31	Singleton	5.5	18	Scone	28.3	4
9	Merriwa	27.1	37	Branxton	5.3	16	Merriwa	27.5	6
10	Murrumbo	26.3	33	Greta	4.9	11	Rutherford	27	-5

Consecutive hot day total at poles



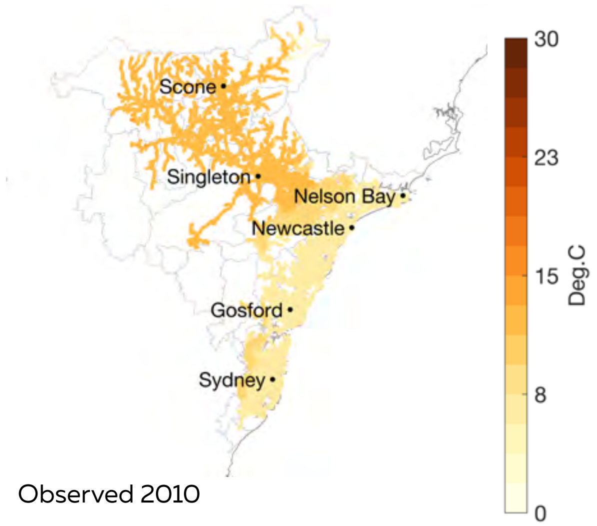
Observed 2010

Consecutive hot day total at poles



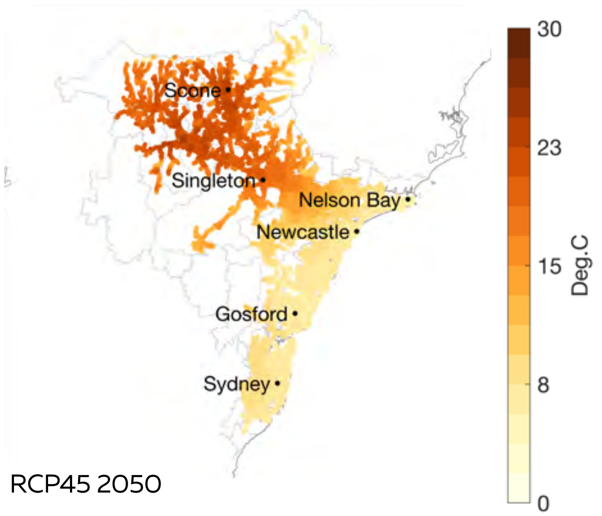
RCP45 2050

Consecutive hot days at Poles



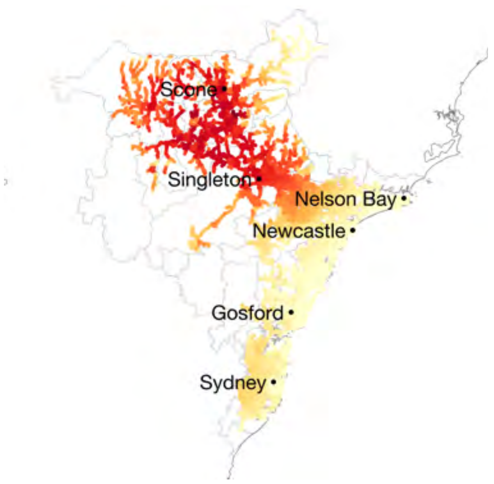
Observed 2010

Consecutive hot days at Poles



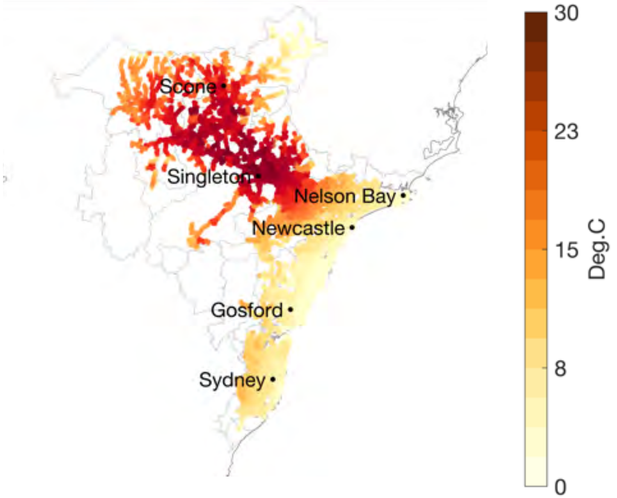
RCP45 2050

Very High and above fire danger days at Poles



Observed 2010

Very High and above fire danger days at Poles

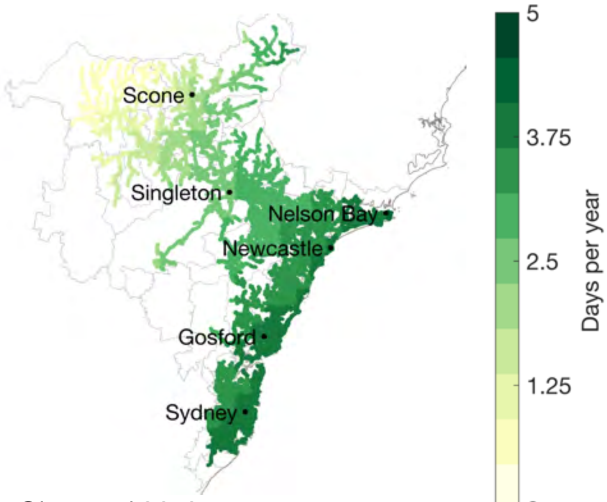


RCP45 2050

Table C: Windstorm and flood related climate risk suburbs

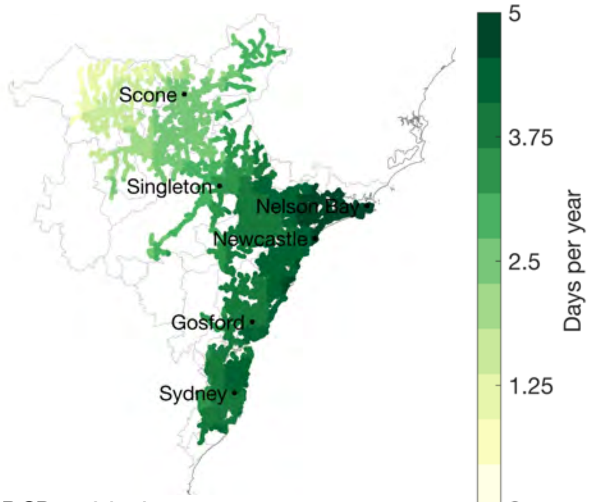
	Storms			Rain (> 30mm)			Wind		
	2050 (RCP 4.5)	Days	% inc.	2050 (RCP 4.5)	Days	% inc.	2050 (RCP 4.5)	Days	% inc.
1	Nelson Bay	5.3	25	Terrigal	11.7	24	Collaroy	15.8	3
2	Salamander Bay	5.3	25	Kincumber	11.4	26	Mona Vale	15.8	3
3	Lemon	5.2	26	The Entrance	11.1	23	Warriewood	15.8	3
4	Anna Bay	5.2	26	Umina Beach	10.5	27	Bayview	15.8	3
5	Medowie	5	26	Allambie	10.5	24	Newport	15.7	3
6	Raymond Tce	4.9	26	Woy Woy	10.4	18	Narrabeen	15.6	3
7	Newcastle West	4.8	24	Palm Beach	10.4	16	Church Point	15.6	4
8	Carrington	4.8	24	Lake Haven	10.3	14	Avalon Beach	15.6	4
9	Fern Bay	4.8	24	Avalon Beach	10.3	14	Palm Beach	15.6	4
10	Cooks Hill	4.8	24	Ourimbah	10.3	14	Kincumber	15.1	5

East coast low days at Poles



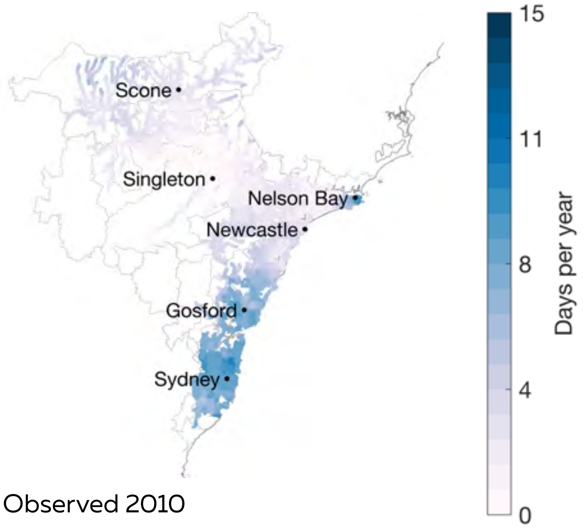
Observed 2010

East coast low days at Poles



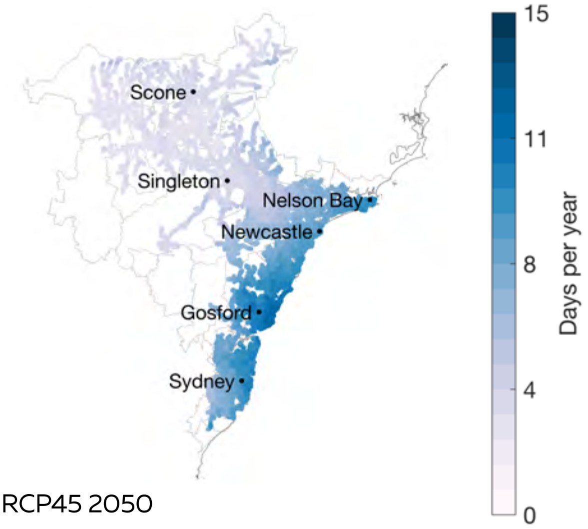
RCP45 2050

Very heavy precipitation days at Poles



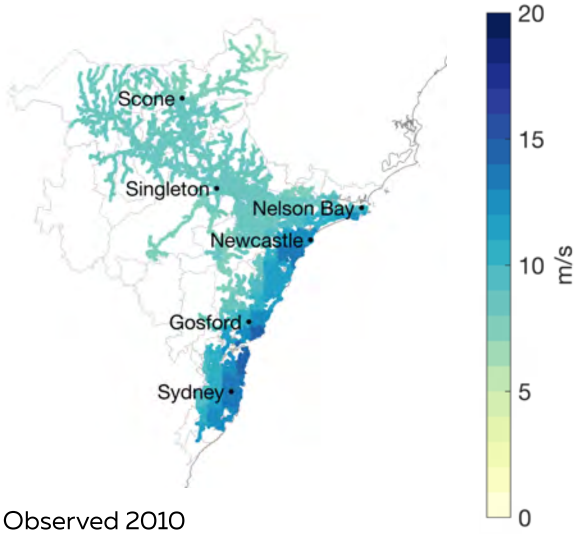
Observed 2010

Very heavy precipitation days at Poles



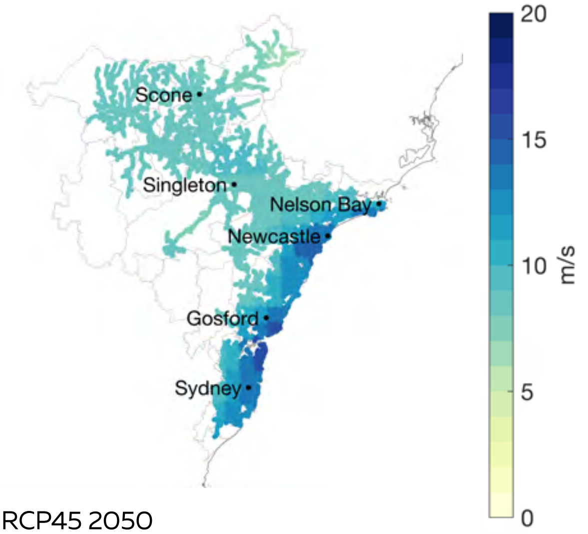
RCP45 2050

Wind max at Poles



Observed 2010

Wind max at Poles



RCP45 2050

3

Climate impacts – key impacts

4.1 Overall risk to Ausgrid network

We have assessed the operational and financial impacts of extreme weather events on Ausgrid's network area by using network asset information, financial data, and customer information. The impact analysis was broken into three primary sets of results: rate of which assets would fail or break, costs and the time that customers would be without supply.

These results were calibrated against historical data, external databases, international research, and expertise from Ausgrid engineers. The results show the anticipated average costs each year associated with growing climate risk.

With the various climate risks, this modelling shows that compared to today, by 2050, customer can expect climate related outages to last 23.8% longer. This increased outage time is due to assets failing 23.9% more frequently, with an associated increase in costs of 23.5%.

The biggest future climate impacts on Ausgrid's network are windstorm.

4.2 Top geographic areas for impact

Ausgrid's network area is diverse, ranging from urban cities to rural areas, and includes various types of topography and terrain. Based off the climate impact modelling demonstrated in Figure C, the areas of our network projected to be the highest risk in the future, are the heavily vegetated suburbs on the coast. This is due to the high winds, risk of vegetation breaking off and hitting network assets, and the configuration of the network. Figure B outlines from a climate risk perspective, windstorms are Ausgrid's biggest risk.

Figure B: Impact Costs – Climate Risk 2050 RCP 4.5

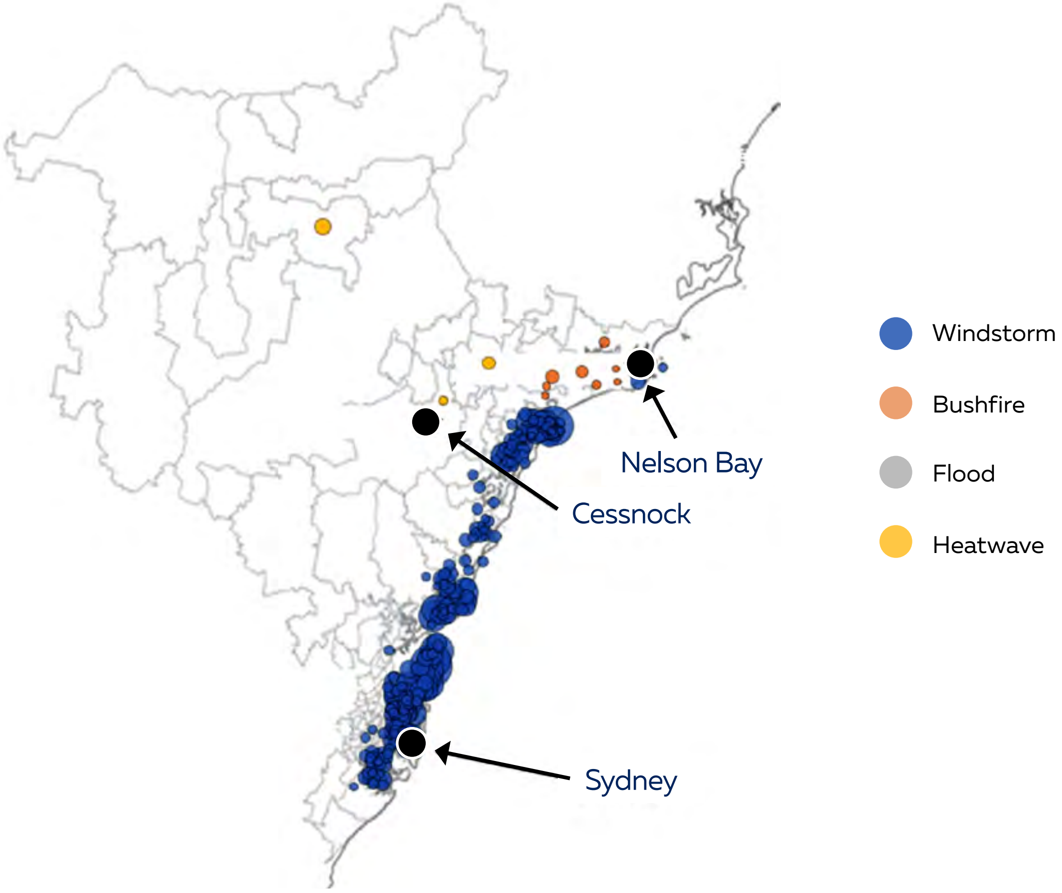


Figure C: Impact Costs – Heatmap 2050 – RCP 4.5

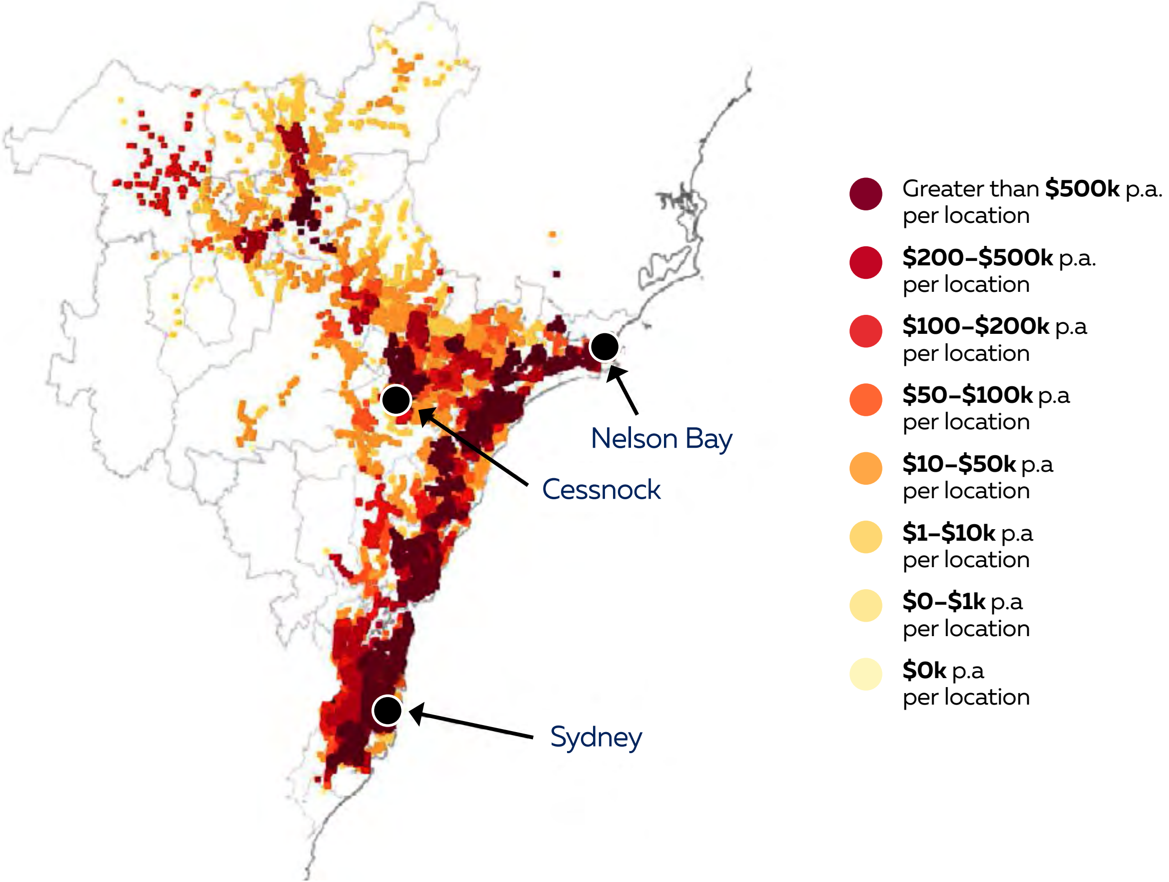


Table D outlines a list of the most affected suburbs by climate risk. The ranking is assessed using two metrics:

1. costs to replace broken or damaged network assets (asset replacement)
2. costs when energy is not being supplied to customers (value of unserved energy).

These two metrics are assessed using each of the acute climate risks (windstorm, bushfire and flood).

A significant cost is when energy is not being supplied to customers. For many suburbs this much more significant than the direct financial costs of network damage.

Table D: Top affected areas by bushfire, windstorm and flood risk in 2050 (medium emissions scenario)

	Bushfire Risk		**Windstorm Risk**		**Flood Risk**	
	Asset replacement	**Value of unserved energy**	**Asset replacement**	**Value of unserved energy**	**Asset replacement**	**Value of unserved energy**
1	Tanilba Bay	Raymond Terrace	Mona Vale	Mona Vale	Rutherford	Mona Vale
2	Tomago	Medowie	Avalon Beach	Carrington	Maitland	Rutherford
3	Medowie	Karuah	Picketts Valley	Avalon Beach	Tuggerah	Rockdale
4	Kooragang	Salamander Bay	Toronto	Newport	Kogarah	Tuggerah
5	Heatherbrae	Taylors Beach	Newport	Cromer	Denman	Milperra
6	Mount Thorley	Salt Ash	Frenchs Forest	North Narrabeen	Lisarow	Maitland
7	Salamander Bay	Heatherbrae	Cromer	Toronto	Fern Bay	Denman
8	Bobs Farm	Shoal Bay	Mosman	Umina Beach	Muswellbrook	Georges Hall
9	Raymond Terrace	Anna Bay	Bayview	Warriewood	Mardi	Kogarah
10	Loxford	Cessnock	North Narrabeen	Terrigal	Greenacre	Wyong

4.3 How impacts have been assessed

We have assessed the physical impact of climate change on the Ausgrid network.

The acute climate risks modelled were:
- windstorm
- bushfire
- river flooding.

The chronic climate risks modelled were:
- heatwave
- sea level rise.

Limitations to the modelling can be found in **Appendix C**.

Windstorm:

We forecast a maximum daily windspeed using data from the climate modelling to simulate a windstorm event. We then converted the this daily windspeed to a maximum three second wind gust which was the key metric used to model damage to our network during storms.

With this information we can predict when the network is most likely to break or stop working, or when the powerline may need to be de-energised to stay safe.

Our windstorm modelling stochastically (randomly) determines if part of the network breaks or stops working due to a three second wind gust, and the subsequent impact including:

- material costs to repair network assets e.g., powerlines
- labour
- customers without power
- time to restore the asset
- the value of unserved energy.

Windstorm has the most significant impact on our network assets and liability. This is predominantly driven by flying debris during a windstorm.

Bushfire:

We analysed the potential impact of bushfire on our network by simulating a fire start location and the spread of that fire (a bushfire footprint).

Network assets e.g., poles that are vulnerable to fires, may burn if they are within

- one kilometre of the direct bushfire footprint
- one kilometre of main bushland
- 20 metres of a grassland area.

Our bushfire modelling randomly determines if an asset (e.g., pole or substation) is burnt by a bushfire, and the subsequent impact including:

- cost for repairing assets e.g., powerlines
- labour
- customers without power
- time to repair the assert and restore power
- the value of unserved energy.

Bushfire is a serious risk to Ausgrid's assets and liability. Frequent and intense high fire danger days increase the likelihood fires will ignite and become out of control, threatening lives, damaging bushland, properties, assets, and infrastructure. The bushfire risk season in Ausgrid's network area coincides with the driest part of the year during spring and summer. Liability around network started fires was not done in this study.

Flood:

We modelled the impact flood would have on the network by using flood depth and then calculating the risk of assets being submerged under water. Some assets are easily damaged by being under water, and need to be replaced.

The flooding we modelled does not present a material risk to Ausgrid in terms of assets and liability, however this modelling does not account for:

- flash flooding
- restoration delays due to access restrictions
- other chronic risks associated with prolonged exposure to moisture.

Ausgrid recognises that additional modelling in this area will need to be undertaken.

Heatwave (at least three consecutive days of 35 C+):

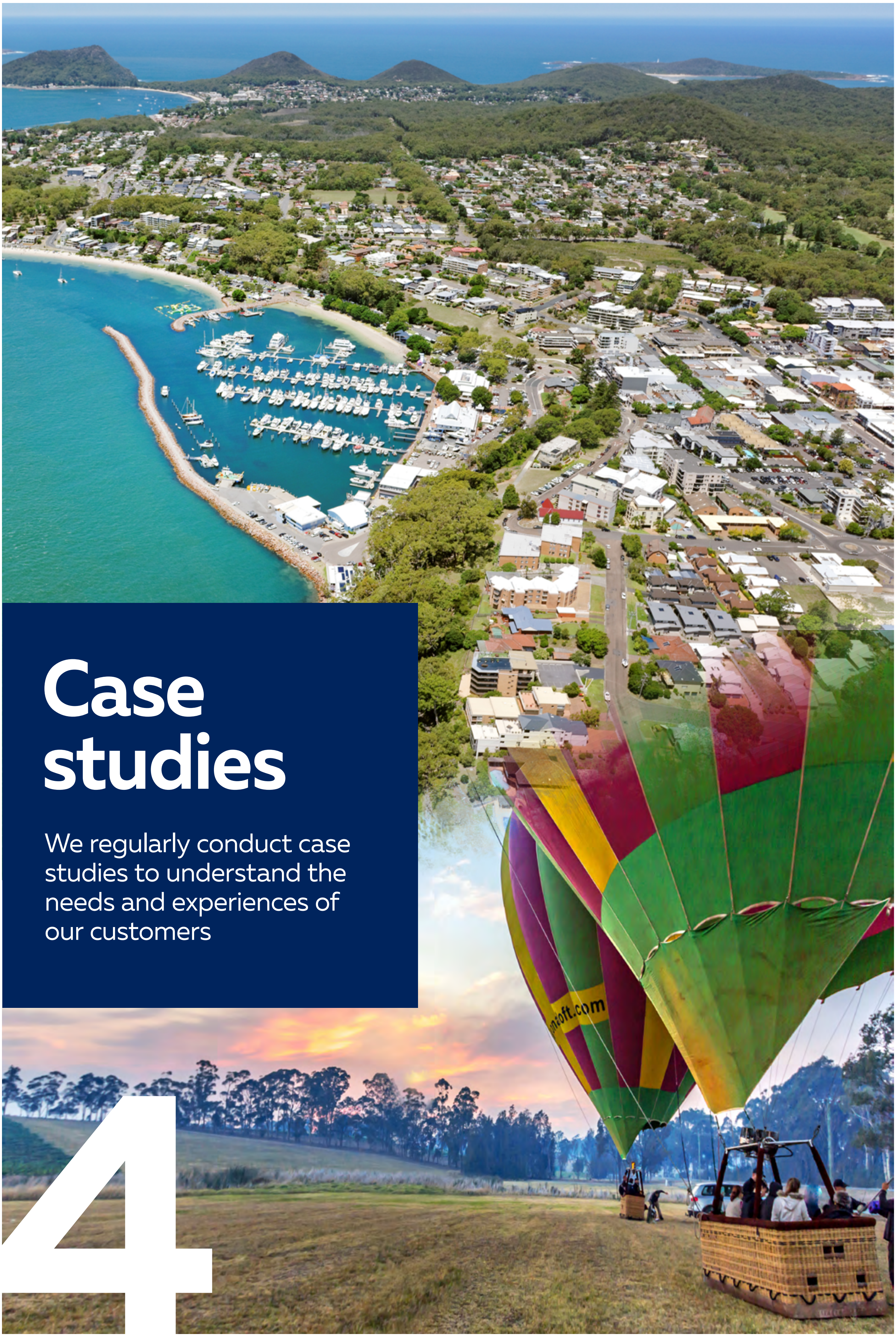
We modelled the impact heatwaves would have on the network using the additional electricity load during heatwaves (e.g. air conditioning), and lost capacity on the network. The model assumed that there was a 0.25% chance that substations would be offline due to overheating for a two-hour duration in these events.

Ausgrid recognises that additional modelling in this area will need to be undertaken.

Sea-level rise (coastal inundation):

Climate change causes rising sea levels through warming and glaciers melting, adding to huge volume of water to the ocean. Sea level rise causes increased flooding of low-lying coastal and tidal areas. It will also increase coastal erosion and cause beaches to disappear.

Higher storm surges will affect coastal communities and infrastructure. A significant proportion of Australia's population live on the coast and infrastructure is concentrated in these areas. We modelled this risk in the same way as flooding but found that there would not be a significant impact to the Ausgrid network.



4

Case studies

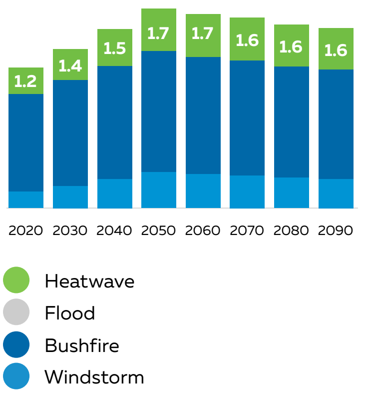
We regularly conduct case studies to understand the needs and experiences of our customers

Nelson Bay

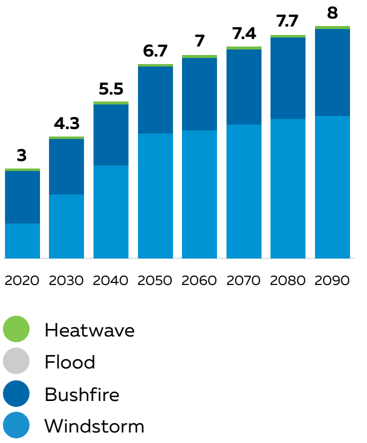
Case study

Nelson Bay has a maritime-influenced humid climate with increasing exposure to bushfire and windstorm perils. Over 25% of the population is aged over 65%. Unemployment rates are higher than average, with employment focused in professionals and trades.

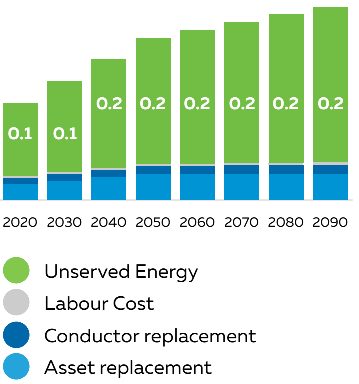
Failures per annum – RCP 4.5



Annual cost ($m) – RCP 4.5



Annual hours (Hr) – RCP 4.5



Key Statistic	Indicator
Population	6,000
Customer type	Suburban residential
Bare OH HV Assets Bare OH LV Assets	64% (31km) 80% (29km)
Vegetation (NDVI)	73.9%

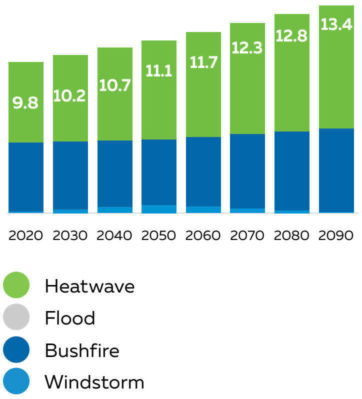
Solution Option	Type	Time Horizon
Covered / insulated conductors (HV)	Network (capex)	Before the event
Co-developed community resilience plans	Community (opex)	Before the event
Multi agency mobile community support hub	Innovation (capex)	During the event
Network segmentation	Network (capex)	After the event

Cessnock

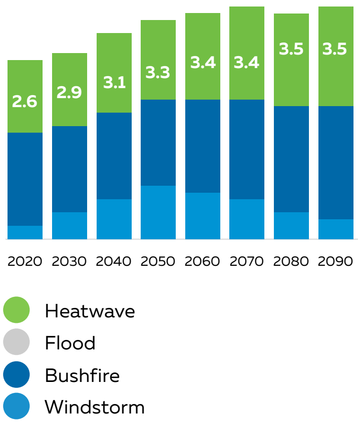
Case study

Cessnock is a mining city of Hunter Valley with a temperate climate, significant rainfall throughout the year, and increasing exposure to windstorm and bushfire perils. Employment is in mining and aged care, with higher than average unemployment rates.

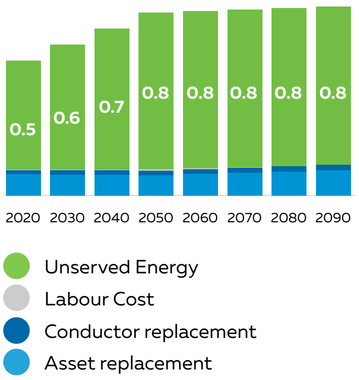
Failures per annum – RCP 4.5



Annual cost ($m) – RCP 4.5



Annual hours (Hr) – RCP 4.5



Key Statistic	Indicator
Population	15,000
Customer type	Rural, Mining and Residential
Bare OH HV Assets Bare OH LV Assets	69% (49km) 73% (65km)
Vegetation (NDVI)	60.9%

Solution Option	Type	Time Horizon
Covered / insulated conductors (HV and LV)	Network (capex)	Before the event
Community resilience grants	Community (capex/opex)	Before the event
Multi agency mobile community support hub	Innovation (capex)	During the event
Network segmentation	Network (capex)	After the event

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Customer and stakeholder expectations

Managing the impact of climate change and extreme extreme events is a common priority across the communities we serve.

Some communities experienced firsthand the severe windstorms effecting their homes and businesses, which brought down large parts of our network in both 2015 and 2020. Large storms and flooding events have continued throughout 2021 and 2022.

Prolonged outages caused by these events have major implications for life support and other vulnerable customers. They also cause major disruptions to the lives and livelihoods of all our customers. As we continue to electrify our network and transition to a more connected society – communities' reliance on electricity will continue to grow for transport, heating and cooling and more.

We have undertaken deep and thorough engagement with our key stakeholders. We have heard from our customers, employees, shareholders, industry partners, emergency services and Indigenous communities that we need to respond to a changing climate.

They have told us that they want us to invest in resilient network infrastructure, be more innovative and data driven, provide better backup power sources, improve communications, build stronger strategic relationships with other resilience actors which includes co-funding. Customers want Ausgrid to:

- Local communities want greater action from Ausgrid in building community resilience
- Access to communication services is the top priority for residents during extreme weather events
- Access to personal amenities is a high priority for residents after extreme weather events
- Prolonged power outages can exacerbate the financial impact of extreme weather events
- Community networks play an important role in coordinating the community's emergency response
- Customers believe that resilience will become more important in future

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Next steps

We know that climate change is causing more frequent extreme weather events. These events are causing profound loss and disruption to communities, especially during prolonged power outages.

Our customers, stakeholders and governments are urging Ausgrid to review our plans, network designs and operations to consider steps we can take to maintain network performance in a changing climate. We want to reduce the impacts damages have to our network assets and minimise outages, as these events increase.

In response to customer expectations, we will use the science-based data from this climate impact assessment to continue building a more resilient network that is able to withstand changing climate risks.

These results will feed directly into our industry leading Resilience Framework, *Promoting the long-term interests of customers in a changing climate: A decision making framework*, co-designed with our Reset Customer Panel (customer advocates). This will help us compare options for the most cost-effective mix of solutions, in the highest risk locations.

Solutions aim to address resilience before, during and after events and will include

- more traditional network investments, e.g., more robust assets
- innovative technologies that help us develop new approaches to prepare for and respond to climate risks-
- better ways to respond during an emergency
- community support services e.g., education and partnership opportunities.
- Customers are central to the formulation of Ausgrid's responses and options.

By taking a forward-looking approach toward climate resilience, we aim to ensure that our network remains safe, reliable, and fair to those most exposed to climate impacts both now and towards the end of the century.

Ausgrid remains committed to investing in future climate modelling to better understand the impacts of perils such as extreme heat on communities.

Appendix

Appendix A – Data sets used in climate risk assessment

Datasets used in Climate Risk Assessment

ERA-5 reanalysis: historical weather data from the European Centre for Medium Range Weather Forecasting (ECMWF) ERA5 and ERA5-Land reanalysis. ERA5-Land provides a comprehensive range of hourly weather variables on a 0.1x0.1 degree grid, which is approximately 9km spatial resolution Medium Con

AWAP: The Australian Bureau of Meteorology (BOM) Australian Water Availability Project (AWAP) provides gridded hydrological and temperature data on a 0.05-degree grid (approximately 5km) for all of Australia.

ESCI: Energy Sector Climate Information (ESCI) Project evaluated a wide range of simulations from different RCM-GCM combinations. Simulations were bias corrected using Quantile Mapping for Extremes (QME) and evaluated for suitability at representing rainfall and temperature for two scenarios: RCP 4.5 and RCP 8.5

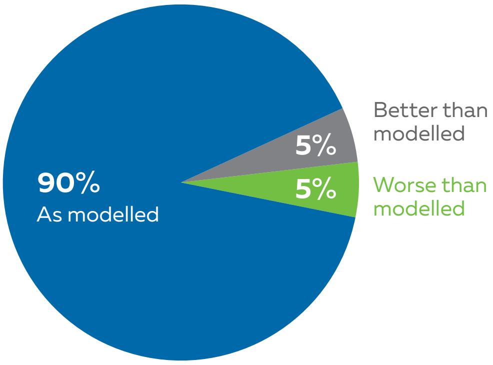
NARCliM1.5: The NSW and ACT Regional Climate Model (NARCliM) climate model simulations version 1.5. NARCliM1.5 data are produced as part of a NSW government-led project providing high resolution climate change projections across NSW for two scenarios: RCP 4.5 and RCP 8.5. NARCliM1.5 outputs have been bias corrected using Quantile Mapping.

CORDEX-GERICS: Data for the RCP 2.6 scenario is sourced from RCM-GCM simulations developed by the Climate Service Center Germany (GERICS) as part of the Coordinated Regional Downscaling Project (CORDEX) and bias corrected using Quantile Mapping.

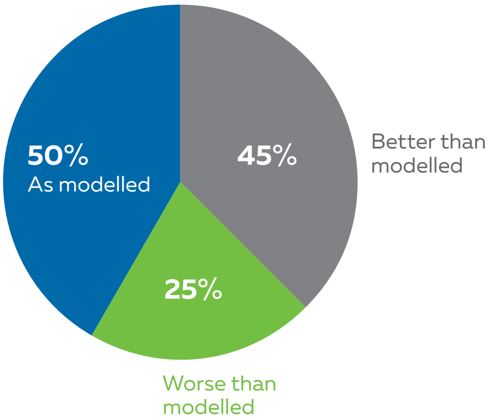
Appendix B – Confidence Levels

A confidence level is the likelihood a result occurs as shown in the modelling, with the remaining chance split between results that exceed or are below the expected outcome. Variance in projections is an important consideration and differs to confidence. The variance captures how different the results can be.

Very High Confidence Projection



Medium Confidence Projection



Changing climate hazard	Confidence Level*
Rising temperatures – Increases in average and extreme temperature	**Very high** confidence
Increased frequency, severity, and extent of bushfires – Increase in extreme fire weather	**Medium–high** confidence
Extreme winds – Decrease in number of high wind events and cyclone frequency, possible increase in severe Category 4–5 cyclones	**Medium** confidence**
Increased variability or reduction in r**ainfall, dam inflows and flooding** Decrease in winter/spring rainfall and increase in extreme rainfall events	**Medium** confidence
Compound extreme events Increase in frequency and magnitude	**Low** confidence

The level of confidence in the data varies across different climate variables:

- Temperature projections have the highest confidence.
- Projections for rain and atmospheric circulation changes are less certain.

Individual climate projections uncertainty is partly addressed by using output from at least three different models. This uncertainty correlates with variability (ie standard deviation) between different models. Confidence levels are formed by evaluating evidence and variability. Using three different data sets and reviewing how close they are in terms of output gives us a higher level of confidence.

** Projections for maximum annual wind speed were calculated from the NARCliM1.5 regional climate model simulations. Average projections for maximum annual wind speed in 2050 under RCP4.5 show a small, non-significant increase of 3%. There is a medium level of confidence in the projection that there will not be a significant change in maximum annual windspeed. This is consistent with the Energy Sector Climate Information Project (ESCI) 2021) report which attributed low confidence to projections there would be a significant rise in future windspeed extremes.*

Below is a summary of the associated levels of confidence.

Confidence Level	Degree of confidence in being correct
Very high confidence	At least 9 out of 10 chance
High confidence	About 8 out of 10
Medium confidence	About 5 out of 10
Low confidence	Medium confidence
Very low confidence	Less than 1 out of 10

Scales of scientific confidence used by the IPCC: https://archive.ipcc.ch/publications_and_data/ar4/wg1/en/ch1s1-6.html

Appendix C – Limitations of modelling completed to date

General limitations

The modelling done for this project has inherent uncertainty and there are limitations in the approach and assumptions.

- Modelling was not able to capture ever scenario or possible outcome.
- Calibration of the model is as accurate as possible, contains limitations of historical data availability.

The modelling done to date did not include the following:

- Explicitly consider network damage from debris coming into contact with cables e.g. through windstorms or during a flood.
- There were two forms of asset failure for windstorms. This included network failures due to damage which needed replacement, and failures due to assets not needing replacement e.g. leaning pole. This criteria was developed by expert judgement of windspeeds.
- Consider the difference of windspeed around soil conditions e.g. droughts.
- For windstorms, the number of asset failures due to the most extreme wind conditions was over representative in the simulation results when assumed to be random. To better reflect the nature of most windstorm asset failures, these results were lowered to be reflective of historical failure rates.
- For windstorms, the model assumed that there was one extreme event, per year, in each location. Given the nature of windstorms, this is an inherent underestimate.
- The model's heatwave impact modelling was high level, assuming a 0.25% chance that substations would "trip" for a 2-hour duration.
- The model did not consider the time it takes for hazards to dissipate e.g. flood waters receding. It assumed that service crews can access failed assets immediately.
- The model results are a point in time estimate based on today's current portfolio of assets. The exception is the model assumed that poles were to be replaced by a new pole of the same material once they reach 75 years.

Climate Risk	Modelled	Not yet modelled
Windstorm	Modelled acute impacts – maximum wind gust conversion to overhead network failures. Sourced windspeeds from Energy Sector Climate Information Project ESCI, simulated a conversion factor to produce the max 3s wind gust annually per location which captured wind generated events (e.g. ECLs) assumed 90% of failures are related to causes pole failures, network failures where pole doesn't fail but conductor clashes Modelled speed of restoration based on number of concurrent outages and resource availability	• Service wire failures • Modelling of network contingencies (i.e. all model's assume network is in an 'as designed' state at the beginning of any climate event) • Compounding event variables such as soil condition, presence of dust, impact of heavy rain fall, lightning, and ECL clustering. • Impact of and change in frequency and severity of thunderstorms/microcells • Chronic risks associated with more frequent exposure to mechanical stress
Bushfire	Simulated fire footprints of acute events	• Restoration delays due to access restrictions (assumes asset repair from BF can occur immediately) • Change in probability of grid initiated fire start and any associated liability (e.g. damage to personal property caused by Ausgrid)
Flood	Modelled damage to ground based distribution assets exposed to flood depths from water levels rising within a river system and as coastal surge of acute events	• Restoration delays due to access restrictions (assumes asset repair from flood can occur immediately), and need to conduct safety inspections for installations (residences, schools, etc.) that have been inundated with water • Impact on overhead networks and zone substations / sub-transmission network • Flash flooding • Chronic risks associated with prolonged exposure to moisture
Heatwave	High level modelling which estimated frequency of distribution substation failure during heatwave conditions	• Inclusion of increased network load, other asset classes impact by heatwave, asset ratings and impairment to ratings under heatwave conditions, • Chronic risks associated with cables and sensitive electronic equipment (secondary systems) and more frequent or severe exposure to heat

Contact us

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