Climate proofing Australia's infrastructure

Infrastructure has a critical role in Australia. It supports economic activities, provides services to communities, contributes to productivity and enhances our lives. Infrastructure is often long-lived, which poses a particular set of challenges with respect to climate change – infrastructure designed today must withstand the changes in climate anticipated for fifty or more years in the future.

Key Points

Infrastructure is often long-lived, and what is designed today must withstand changes in climate fifty or more years in the future. To ensure design, building, financing and maintenance of infrastructure are all adapting to climate change requires:

- Agreement and support from multiple levels of government, service providers, customers and regulators to decide that it is prudent and timely to take action (i.e. to adapt), and what action to take.
- Understanding of when incremental actions are sufficient (for example, through upgrading maintenance) and when large-scale investment in new infrastructure is required.
- Exploration of opportunities and funding models to build back better following natural hazards, especially by having enabling mechanisms already in place.
- Long-term planning, beyond regulatory or election cycles, and which allows flexibility and innovation in materials, designs, and institutional arrangements.
- Managing uncertainty by considering a range of future scenarios, understanding where system sensitivities lie and working to enhance resilience.
- Educating the public to understand the trade-offs between security of supply and cost under the requirements for adaptation and carbon reduction imposed by climate change.

NCCARF's evidence-based Policy Guidance Briefs address key challenges to effectively adapting Australia to a variable and changing climate. They provide high-level policy advice designed for use by policy makers at Commonwealth and State level. This Guidance Brief deals with climate proofing Australia's infrastructure.

1 The climate context

The nation's infrastructure serves communities, industries and businesses across the vast and geographically diverse continent of Australia. Infrastructure is often long-lived, which poses a particular set of challenges – infrastructure planning must take account of changes in climate projected for fifty or more years in the future, bearing in mind that uncertainties in climate change projections grow over time.

Projected changes in Australian climate include (Whetton, 2011):

- Annual average warming by 2030 (above 1990 temperatures) of approximately 1.0°C across Australia, with warming of 0.7 to 0.9°C in coastal areas and 1 to 1.2°C inland. By 2070 warming is expected to reach between 2.2 and 5°C above 1990 temperatures.
- Drying in southern areas of Australia, especially in winter, and in southern and eastern areas in spring. Changes in summer tropical rainfall in northern Australia remain highly uncertain.
- Intense rainfall events in most locations will become more extreme, driven by a warmer, wetter atmosphere. This may be expected to lead to an increase in flood events (IPCC, 2012).
- Drying plus increased evaporation means soil moisture is likely to decline over much of southern Australia. An increase in fire-weather risk is likely, as is the risk of dust storms in arid areas.
- Whereas the number of cyclones is not projected to increase, there is expected to be an increase in their intensity (stronger winds and heavier rainfall) (IPCC, 2012).

Much of Australia's infrastructure is located close to the coast, and is vulnerable to sea-level rise. Rising sea level will mean storm events are more likely to lead to storm surge. More than $226 billion in commercial, industrial, road, rail and residential assets are potentially exposed to inundation and erosion hazard for a sea-level rise of 1.1 m (high end scenario for 2100) (DCCEE, 2011).

2 Current effects, impacts and issues

Infrastructure, whether publicly or privately funded, requires a significant capital outlay and on-going maintenance costs. Wear-and-tear on infrastructure generally includes an element of climate impacts – be it simple weathering (e.g. solar break-down of paint, salt-water corrosion) or major damage or destruction during extreme events. The rate of deterioration will depend on design choices, construction processes, building materials, and the environment in which a structure is built. Decisions about what and how to build infrastructure will take into account lifespan (usually several decades), life-cycle maintenance costs and return on investment.

Major climate-related damage to infrastructure can be a considerable burden on society and governments.

Coastal protection. Coasts are some of the most highly developed areas of Australia, and are exposed to storms, cyclones, storm surge, erosion and inundation. High demand for coastal land has meant development has occurred in areas of instability (erosion or accretion) and flooding. This presents ongoing challenges to local authorities to manage development, and to provide associated secure infrastructure.

Transport. Rail and road are vulnerable to flooding and heat damage (e.g. rail buckling, road cracking, bridge washout); airports can be closed during severe electric storms, their runways may be rendered unusable by flooding; seaports are vulnerable to storms and storm surge. Severe damage to transport infrastructure can block emergency supply of food and goods as well as impeding evacuation.

Utilities. Both drought and flooding threaten water supply security: droughts limit water availability, floods can directly damage infrastructure such as purification plants, or increase turbidity to the point where the cost and time required to purify becomes prohibitive. Storms, dust storms, fire and heatwaves can damage or impair the function of electricity generation and transmission as well as telecommunications infrastructure. High service demand (e.g. electricity during heatwaves, telecommunications during extremes) can lead to electricity supply interruption (planned as rolling blackouts, or unplanned) and closure of mobile phone networks to the general public as these are reserved for emergency services.

3

Future effects, impacts and issues

A unique feature of infrastructure planning is the very long timescales involved (see Figure 1). Given the uncertainties associated with climate change projections at these very long timescales, planners are faced with a truly wicked problem.

The potential for losses to existing infrastructure can be great. For example, the estimated costs of impacts to coastal assets from inundation and shoreline recession combined is (based on 2008 replacement values):

- 5,800 to 8,600 commercial buildings, with value $58 - 81 billion;
- 3,700 to 6,200 light industrial buildings, with value $4.2 - $6.7 billion; and
- 27,000 to 35,000 km of roads and rail, with value $51 - $67 billion (DCCEE, 2011).

Planning and designing infrastructure will require consideration of potentially new climate and operating conditions projected to the end of the infrastructure design life. This may require new operating and maintenance practices, designs and materials. The opportunity to build fit-for-purpose infrastructure only occurs at the start of the life of a new or replacement asset. Changing climate may mean the ongoing function of existing infrastructure is compromised, forcing earlier investment and lower returns for existing investment. Retrofitting to manage climate change impacts is generally costly and to be avoided if possible. The risks from failed or inefficient infrastructure arising from climate change can be summarised as:

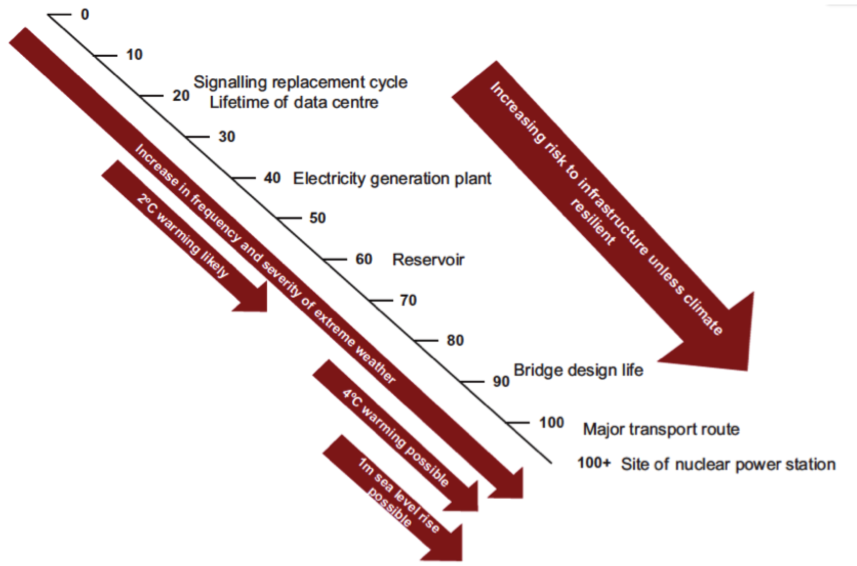

Figure 1: Lifetime of infrastructure with illustrative climate change timescales (DEFRA (UK), 2011)

- the risk of financial losses to operators from poorly adapted assets (loss of revenue, damaged or inefficient assets);
- the risk of financial losses to investors; and
- the risk of increased financial losses to insurers and re-insurers.

Ultimately government may act as the risk bearer of last resort, stepping in to assist with losses suffered in extreme circumstances.

4

Adaptation: what this means for managing the sector

As shown in Table 1, planning and adapting for climate change are in their early stages and preparations differ between infrastructure sectors. Climate change isn't an issue in isolation – and adaptation is often embedded in 'business as usual' activities. For many organisations a business case must be developed through assessment and prioritisation to ensure today's upgrades don't create tomorrow's problems. Sometimes the need to act is imposed by impacts of extreme events; for example, Sydney Water fast-tracked improvements to infrastructure and water supply sources following severe drought in 2000.

Adaptation planning for future climate change needs to acknowledge that some uncertainties cannot be overcome. Actions are likely to be 'low-regrets', to avoid wasteful investments in overcapacity or in the wrong place. Public resources for infrastructure investment are invariably limited. Flexibility, keeping options open and staged approaches are useful strategies.

Cross-sectoral issues
Impacts on one infrastructure sector can have flow-on effects to another, e.g. loss of electricity can halt train operations and disrupt road traffic signalling. The electricity sector is one that most other sectors rely on. Consumers expect that the electricity supply will not fail. In fact, failure rates are low, but supply cannot be guaranteed 100%.

Consideration of these extra-sector risks is generally embryonic, only recognised when problems arise. However, for the construction industry, which is extremely reliant on other sectors, risks tend to be managed through contingency planning (e.g. generators for power loss, alternative suppliers).

Drivers of adaptation
Safety: Public and employee safety is an important concern for all sectors, and can lead to adaptation action. On some construction sites, safe-work temperature thresholds of 30°C mean increasing numbers of very hot days will stop work more frequently. The response is to air-condition plant and machinery. Similarly, public health may be threatened by very high temperatures on public transport during heatwaves, requiring installation of fans and air conditioning.

Adaptation: what this means for managing the sector ... continued

Sector	Key risks (climate and other)	Current and planned adaptation options	Planning for:	Constraining or extraneous factors	Inter-sector dependencies
Rail	Extreme temperatures (medium risk), flooding (high risk); high rainfall impacts on track foundations	Drainage and ventilation improvements; systematic risk assessment; overhead wire and wooden sleeper upgrades	2030, 2050, 2070 scenarios; qualitative assessment in the future	Heavily regulated, customer tolerance of costs (maintenance-repair-invest balance)	Electricity, telecommunications, fuel supply (transport, ports)
Electricity	Public safety, wind events, thermal/temperature events, bushfire, lightning, dust storms	Meet demand; re-engineering; network intelligence; smart metering, reliance on telecommunications; response times, seasonal deployment of staff; maintenance and process review; improve planning for outages	Agile network, changed return periods; design for extremes, greater uncertainty; changes in peak usage and usage patterns	Performance pressure (policy driven); costs and customer/political tolerance; perception of over-investment; maintenance-repair-invest balance	Supply (transport), water
Construction	Heat (temperature >30°C stops work), flooding	*OHS:* Air-conditioned plant equipment *Buildings:* Investing in active air-conditioning, passive heat and heat-island solutions; training programs; compulsory risk assessment process. *Design phase:* risk assessment includes climate change	Climate change assessed during tendering process depending on client brief	Delay costs money; market-driven business	Supply (transport), electricity, water
Ports: air and sea	Sea-level rise; inundation (king tides, storm surge), wind, heat	*Air:* Moving away from reliance on water, electricity, emergency management *Sea:* widen operating limits e.g. for cranes in high winds; plan breakwaters and roads that can be raised/lengthened as needed; channel dredging may reduce	*Air:* 20 year phases; not yet at investment stage *Sea:* investment underway (e.g. Sydney Port expansion using 0.9m SLR by 2100)	Actions triggered/forced by other aspects of business; flow-on risks for economy	Electricity, supply (transport)
Transport	Coastal surge, extreme storms, floods and bushfires	First step is climate risk and assessment plans. Long-term master transport plans a marker for organisations to meet. Assessment and prioritisation	Managing to minimise environmental impacts and strengthen resilience		Telecommunications, electricity
Telecommunications	Floods, fire	Not yet planning for future impacts		Demand for reliability in extreme events	Electricity
Water	Drought, wind storms and bushfires (immediate risks); inundation (long term risk)	Investment is in buried infrastructure (expensive to upgrade); urban water industry $10 billion investment during 2000s to address drought (e.g. conservation measures, desalination, recycling)	Long-term water balance	Drought conditions have fast-forwarded adaptation (e.g. Sydney Water, Watercorp WA); customer costs	Electricity, telecommunications

Table 1: Summary of sector risks, actions and issues in New South Wales organisations.

Policy and regulation: Regulation plays an important role in many sectors. Regulation through the sustainability measures of the Building Code has meant some limited progress towards adaptation has been made in the construction sector.

In the electricity and gas sectors the Australian Energy Regulator (AER) sets the price for using networks (electricity poles and wires, gas pipelines). The challenge is to ensure balance between the cost impacts of long-term adaptation investment, and protecting the best interests of the consumer.

Customer perceptions and tolerances: In industries driven by consumer expectations, the perception of cost and need can be a significant factor in the ability of sectors to invest in adaptation. The public perceives that electricity prices are too high but, at the same time, expects that supply will meet demand. This may not be possible under climate change without substantial investment requiring price rises. Public opinion can, however, be mobilised in response to climate extremes to support major infrastructure investment (e.g. desalination plant).

Innovation and augmentation: Planning for climate change can provide opportunities for innovation in products and designs, thinking, connecting and cooperation. Use of smart meters to control electricity use in homes to lower peak demand, and hence avoid costly investment in seldom-used generating capacity is one example.

Alternative supply sources for electricity and water are often proposed as solutions to increasing demand, as ways of reducing greenhouse gas emissions and, in the case of water, augmenting diminishing supply. A key challenge with this approach is reliability of supply. Wind energy, for example, is reliant on windy conditions so that back-up supplies must be available to switch in if the wind resource fails. The transmission grid in Australia is designed to deliver power from large-scale point supplies to a distributed network of consumers – it is not designed with distributed small-scale power sources such as wind turbines and trigeneration plants in mind. Costly investment may be required to make the grid fit-for-purpose if there is to be large investment in distributed power sources. The NCCARF Policy Guidance Brief *Ensuring Australia's urban water supplies under climate change* explores the need to utilise all water supply sources in order to climate-proof the supply under a drying climate.

5 Policy implications

Managing uncertainty

Uncertain climate change projections: Some uncertainty cannot be avoided, but can be dealt with by considering a range of futures and risk thresholds, and by identifying system sensitivities and working to build resilience to climate shocks.

Consistent framing policy: While infrastructure management is mainly at local, regional or company level, it operates most effectively in the context of policies and policy guidance which are consistent across tiers of government and election cycles. This is an opportunity for clear state and federal strategic direction.

Agreeing supply level targets: Under the requirements of adaptation and carbon reduction, it may no longer be possible to meet the public expectation of a secure uninterrupted supply without very large investment which would need to be met from price rises and/or the public purse. Public debate is required to understand the trade-offs and to reach a broadly-agreed position.

Decision-making, planning and managing

Adaptation is not a standalone issue, but needs to be integrated into core business. It can then operate as a lever to incentivise transition from a 'siloed' approach to a fully integrated, flexible and dynamic planning/funding/delivery model for infrastructure management. Decision-making for adaptation should incorporate simple criteria at each decision point. Key questions include:

- What must be protected at all costs?
- What can be sacrificed?
- How can we facilitate consideration of infrastructure adaptation in land-use planning processes?
- When should infrastructure planning consider shorter time frames to facilitate a transition phase?
- What can be engineered to build resilience and what are the cost, specification, timing and availability challenges?

Levers and tools

Some levers and tools to achieve effective and timely adaptation are:

- *Risk management:* mainstreaming adaptation into the wider management of operational, environmental, economic and budget risks;
- *Financial tools for decision-making:* employing tools such as cost-benefit analysis, financial analysis and forward budgeting[1];
- *Instruments such as service level agreements, leases, policies, building codes, standards and guidelines* to ensure consistent frameworks for adaptation across the multiple levels of complex organisational structures;
- *Innovation* (e.g. products and designs, thinking, connecting, cooperation) to foster resilience: regulatory mechanisms need to provide opportunities for innovation (e.g. encouragement to go beyond building code minimum standards);
- *Legislation and regulation* to support infrastructure adaptation should be forward-looking and should not constrain the ability to adapt;
- *The planning process* should incorporate adaptation, for example by setting thresholds and trigger points for decision-making about investments (e.g. for sea-level rise).

Communication requirements

Effective communication to ensure alignment of purpose between multiple levels of government, service providers, customers and regulators is essential to establish a good business case for adaptation action.

Investment and investment models

Investment models for infrastructure adaptation may include: 'wait for failure and replace', ongoing repair and incremental change, or significant investment expenditure. For some infrastructure types, run to failure is not an option (e.g. bridges). Improved maintenance, planning and operational approaches may be far more affordable than simply building new. However, once the decision to invest in new infrastructure is made, that is the point at which adaptations for future climate change should usually be incorporated, since retrofitting to deal with change is expensive.

The role of insurance

Insurance can prompt or discourage adaptation. It can act as a quasi-adaptation management tool placing market pressures on high-risk locations or infrastructure. However, following loss or damage, insurance can dampen adaptation, as it does not encourage improvement of infrastructure, rather funding replacement of like with like.

Betterment

Following extreme events there is often a political imperative to rebuild – to get back to 'normal' – yet this is an opportunity to build back better. Ensuring mechanisms to encourage 'building back better' are in place and approved before an event, including some thought given to funding models, may enable betterment and so improve resilience to climate change.

[1]An example of an appropriate economic cost benefit analytical tool is: NSW Government Guidelines for Economic Appraisal Guidance for Infrastructure and Climate Change http://www.treasury.nsw.gov.au/__data/assets/pdf_file/0003/18570/TC10-12_dnd.pdf
which is required for NSW Government agencies.

Approach

The policy guidance provided in this brief was developed at a workshop held in Sydney. The workshop was attended by policy makers and managers from within NSW State Government agencies, Geoscience Australia, Sydney Water, Water Services Association of Australia, TransGrid, Ausgrid, Sydney Airport, Sydney Ports, Optus, Railcorp, Infrastructure Sustainability Council of Australia, Institute of Public Works Engineering Australia, BlueScope Steel, Lendlease Construction, private consultants, Ron Cox (University of New South Wales), Darryn McEvoy (RMIT University), Paul Bell (University of Queensland) and NCCARF staff.

NCCARF's research programs have delivered over 140 reports on climate change adaptation, many of which address the topics of the Policy Guidance Briefs. For more information, see: www.nccarf.edu.au/publications

NCCARF is producing a portfolio of twelve Policy Guidance Briefs in 2012–13 on critical climate change adaptation topics. For a complete list of available Policy Guidance Briefs, please go to: www.nccarf.edu.au/publications/policy-guidance-briefs

References

Department of Environment, Food and Rural Affairs – DEFRA 2011. *Climate Resilient Infrastructure: Preparing for a Changing Climate.* Department of Environment, Food and Rural Affairs, UK.

DCCEE 2011. *Climate change risks to coastal buildings and infrastructure. A supplement to the first pass national assessment.* Department of Climate Change and Energy Efficiency, Canberra.

IPCC 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation In *A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change.* Field CB. et al. (eds). Cambridge University Press, Cambridge, UK and New York, pp. 1-19.

Whetton P 2011. Future Australian climate scenarios. In *Climate Change: Science and Solutions for Australia.* H. Cleugh et al. (eds). CSIRO Publishing, Canberra