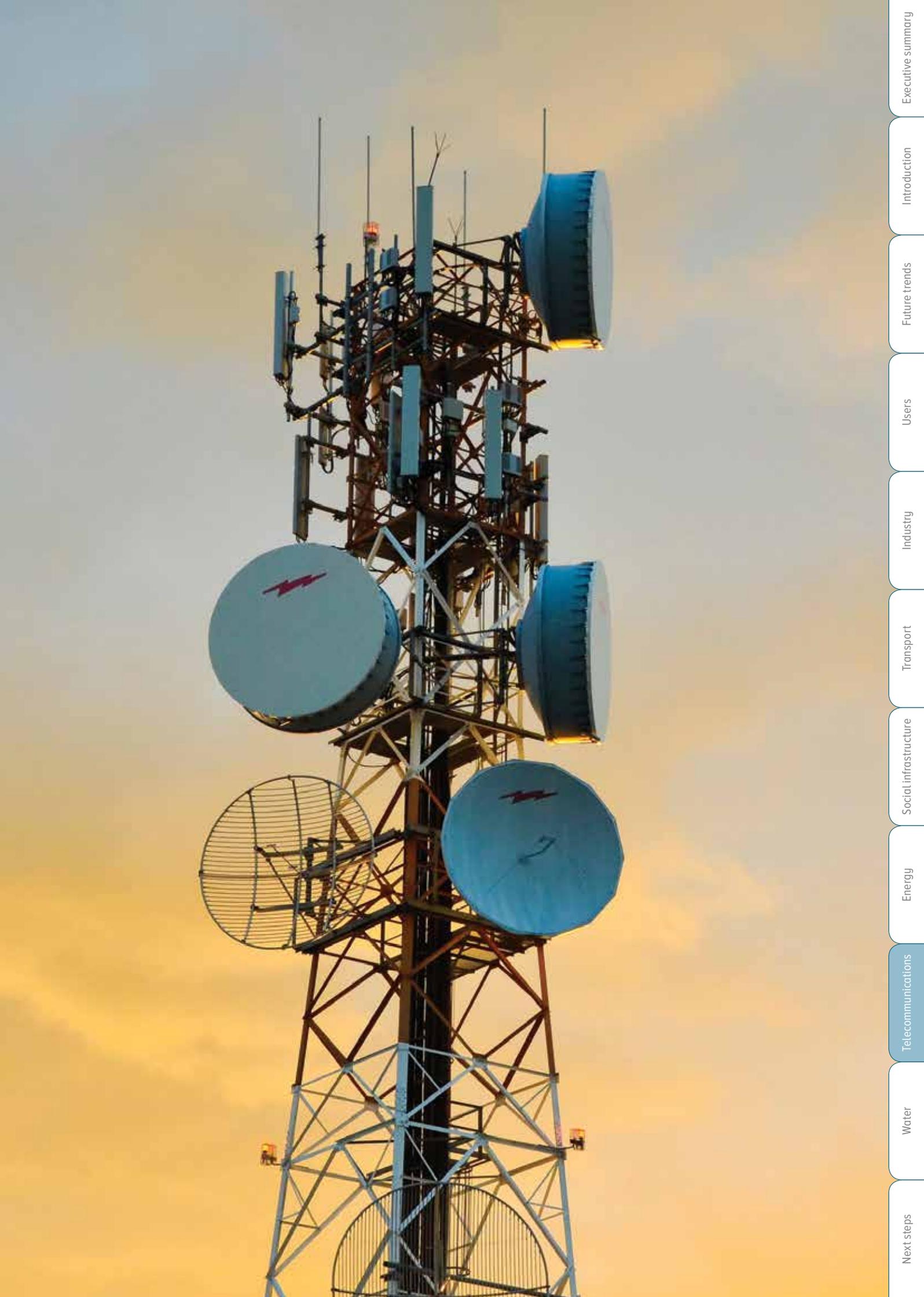


Telecommunications

Telecommunications infrastructure covers the networks that carry voice and data between users across Australia, and our connections with the rest of the world, impacting on our liveability and productivity.

This includes wires, fibre, towers, sensors, satellites, radio spectrum and physical infrastructure such as data centres and cable landing stations, which come together as networks to deliver communications to and from our devices, whether we live and work in fast-growing cities or remote communities.

The inclusion of a federal regulatory power over 'telephonic, and other like services' in Australia's Constitution in 1901 means that, since Federation, telecommunications is the only broad public infrastructure sector with an overarching national character.¹ Australia's first telephone call was made just over 20 years earlier in 1879.² Telecommunications have since grown, with the help of significant technological advancements, to support the entire economy, and influence how we live our lives.





8.1 Introduction



The state of the telecommunications sector

- Telecommunications is more central to our lives at home and work than it has ever been.
- Significant investment is occurring in the telecommunications sector, responding to growth in demand for data-driven services and new uses for telecommunications.
- Generally, consumers are positive about quality and access to networks but are concerned about paying more.
- There are opportunities to improve the telecommunications services for the digitally disadvantaged, and for rural and remote communities and businesses.
- The specific needs of rural and remote users are often overlooked in upgrades to national telecommunications infrastructure.



Telecommunications is more central to our lives than it has ever been

Telecommunications is increasingly central to our personal lives and to the way we work and do business. It is becoming ubiquitous. Business and government are rapidly moving services online. As almost all of us rely on these services, access to networks that keep us connected is becoming essential.

Almost 90% of Australians accessed the internet through their mobile phone in 2018.³ Some 59% of Australians now use four or more devices to access the internet.⁴ On average, Australian adults spent over two full days per month accessing content on their smartphones in 2018.⁵

Telecommunications networks are constantly evolving

Of all infrastructure sectors, telecommunications is today the least recognisable sector from a generation before. Change is set to continue, as we are in the midst of the construction of Australia's fixed line broadband network, and on the cusp of investment in a new generation of mobile networks.

Most of the telecommunications infrastructure in Australia is privately owned. The notable exception is the publicly-owned National Broadband Network (nbn), which is still under construction but has begun delivering services to users. The nbn network was designed to ultimately become the predominant wholesale provider of fixed line access services.

nbn's governing legislation contemplates a change of ownership, from public to private hands, after it is built. With the nbn rollout due to be completed in 2020, how this major investment is utilised, upgraded and ultimately integrated with services from the private sector will significantly impact Australia's telecommunications accessibility, quality and affordability.

nbn is solely a wholesale provider of broadband services, and sells access to its network to over 150 large and small retail service providers nationally,⁶ including major players such as Telstra and Optus, and smaller retailers such as Bendigo Telco, Central Coast Internet and Telecom West.

In the mobile service area, the three major mobile network operators (MNOs) are Telstra, Optus and Vodafone. These operators sell access to their networks to a range of over 50 other mobile service operators.⁷ These retailers are often active in particular parts of the country.



The nbn network rollout continues and we are on the cusp of building new 5G networks

Australians’ use of fixed broadband and mobile data has increased by 175% and almost 250% respectively, since 2015, but with 93% of the data delivered via fixed broadband.⁸ These are growth rates many times faster than our economy overall.

The 2015 Audit indicated the transformative role the nbn would play in Australia’s future telecommunications landscape, and this promise holds true. In 2015, the Audit noted that 818,000 premises were nbn ready (about 7% of all premises), and that 346,000 had connected to the service by February 2015 (3% of premises). Today, the nbn is over half way to its target of delivering peak wholesale download data rates of at least 25 megabits per second to all premises, and 50 megabits per second to 90% of fixed line premises by 2020.⁹ By March 2019, 8.8 million premises (around three quarters of all premises) were ready to connect to the network, and 5.1 million were already connected.¹⁰

In 2015 we focused on 3G and 4G mobile services. In 2019, 2G and 3G mobile networks are largely obsolete, while there is significant ongoing private investment in 4G network upgrades. The arrival of 5G networks is on the horizon, with trials having begun already, and the likely step change is substantial.

Australians are positive about quality and access to networks but are concerned about paying more

Consumers are generally positive about the quality of their telecommunications services.¹¹ However, significant issues remain in rural and remote areas for mobile and broadband services.

There is a stronger positive view about the ease of access to telecommunications services, although once again, rural and remote Australians are less positive about their experience.¹²

Consumers broadly see their telecommunications services as more costly than affordable, and there is resistance to paying more,¹³ even as providers of broadband and mobile data services are increasing data quotas.

Maximising opportunities for the digitally disadvantaged is a challenge

The Australian Digital Inclusion Index (ADII) is an annual survey of Australians' access to, and ability to access, digital resources. It provides a key success touchstone of telecommunications access universality, with the record to date indicating there is more progress to be made.¹⁴

Income, age, disability, education and Aboriginal and Torres Strait Islander status are all factors that influence levels of digital inclusion. For particular groups, the challenge is how to both increase digital

literacy where infrastructure already exists, and to make telecommunications access affordable. This is important given its inherently regressive nature imposes costs on those who do not need wholesale internet connectivity to the benefit of the most resource intensive users.

Geography also matters. In rural and remote settings, the cost of providing telecommunications infrastructure increases and the returns reduce as population densities decline. In some cases, this limits the scope for universal coverage by commercially-focused private sector operators, without government intervention.

In this chapter

To identify and examine the key telecommunications infrastructure challenges and opportunities in Australia, this chapter focuses on four major themes:

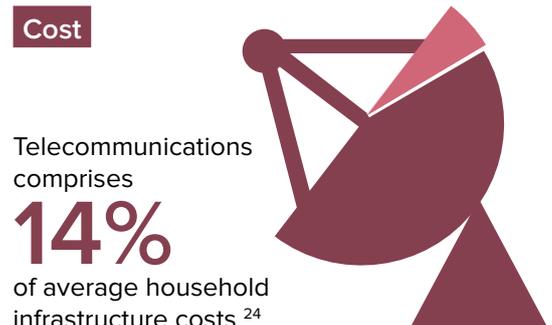
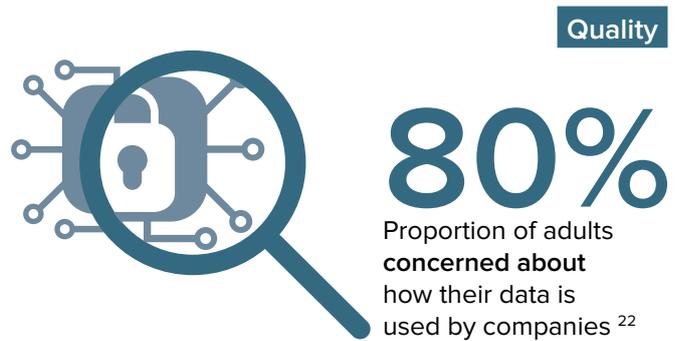
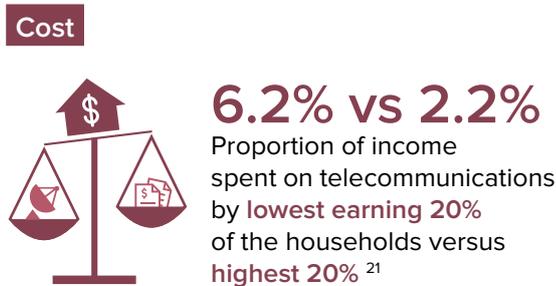
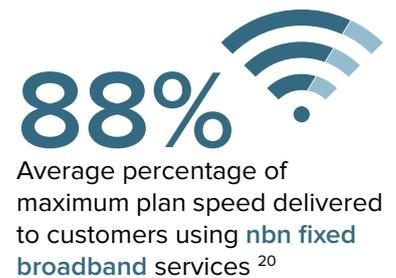
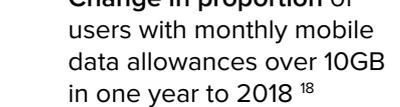
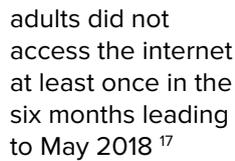
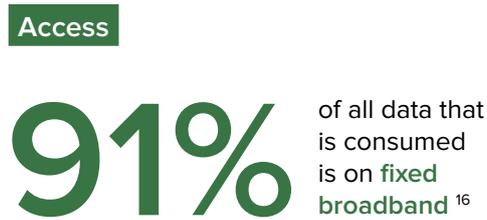
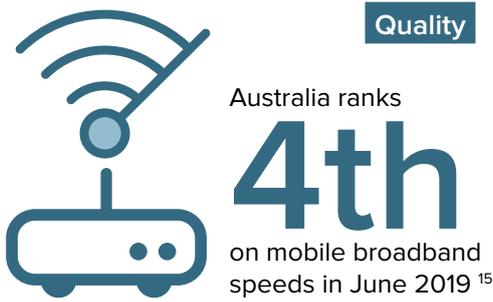
8.2 Telecommunications enable productivity and innovation considers how telecommunications infrastructure can support new services for businesses and people.

8.3 The mobile coverage dilemma looks at Australia's strengths in the provision of mobile services, and the challenges and opportunities presented by a pending 5G step-change.

8.4 Maximising the benefits of nbn investment considers how we can capitalise on this one-in-a-lifetime investment by Australian taxpayers.

8.5 Social inclusion and affordability for telecommunications services explores the challenge of extending connectivity to those Australians at risk of being left behind in the digital world, and assess user affordability issues for consumers and businesses.

Performance of the sector



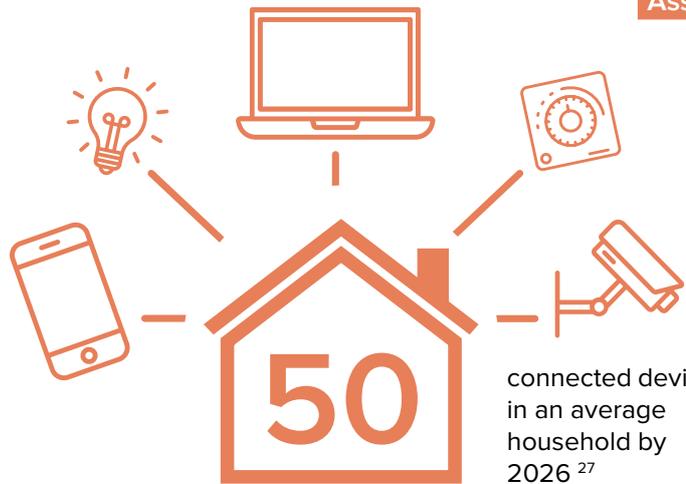
Scale of the sector

Customer



26.9 million
mobile handset subscribers in Australia ²⁶

Asset



50
connected devices in an average household by 2026 ²⁷



Asset

11.7 million
premises will be ready to connect to nbn by mid-2020 ²⁸

Access

Australia ranks first for key enablers of mobile internet takeup ³¹



Industry



\$1.78 billion
Annual community service obligation subsidy in telecommunications ³²

Customer

340%
Estimated growth in household data usage between 2016 and 2026 ²⁹

Access

14%
Estimated proportion of nbn-ready households using fibre to the premises at the end of the rollout ³⁰

Access



70%
of regional households will have access to a fixed broadband connection at the end of the nbn rollout ³³

Customer



5.5 million
Estimated premises connected via the nbn network by mid-2019 ³⁴

Industry

867
Mobile black spot base stations part-funded by government ³⁵



Asset

99.4%
of the population are able to access mobile services at home ³⁶

Industry

Telstra's shares in 2016
41%
of mobile phone market



51%
fixed broadband ³⁷



8.2 Telecommunications enable productivity and innovation

At a glance

Opportunities are emerging in telecommunications, with generational leaps in fixed line and mobile networks. But to be effective in meeting user needs, our networks must be fit for purpose. We lead the world in mobile telecommunications, but our broadband speeds lag far behind.

This section explores the technology that will support productive growth, particularly the National Broadband Network (nbn) and 5G mobile networks. By focusing on end users and spreading the benefits widely we can ensure no Australian is left behind.

The section also looks at growing threats to cybersecurity and our need to protect user privacy.

Digital development is happening apace

Over the last thirty years, Australia and the world have been on a digital journey, which has occurred in three waves. Each has been driven by new technologies, escalating connectivity and flows of data (Figure 1). Our evolving telecommunications infrastructure networks have enabled these waves of change in services. Fixed line networks include dial-up internet, which has now progressed to broadband through cable, digital subscriber line (DSL), fibre (including access, backhaul and dark), and subsea cable infrastructure. Wireless networks include radio, mobile networks (which have progressed through generations from 2G and 3G, now into 4G and 5G), satellite, and Machine to Machine (M2M) and Internet of Things (IoT) networks.

While Australian consumers are globally regarded as early adopters of new technologies and services, Australian businesses and governments do not have a strong record for innovation. Australia’s large companies ranked 21st out of 32 OECD countries on

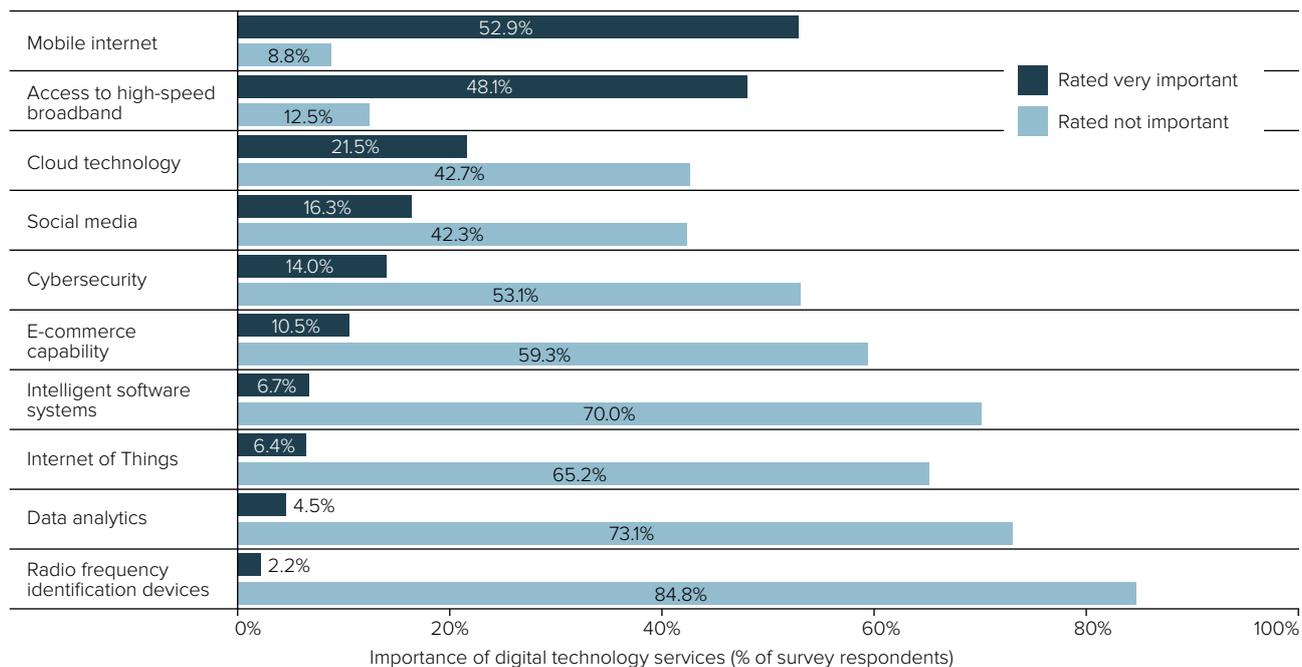
the proportion of businesses innovating, below other resource-exporting countries like Brazil and South Africa.³⁸

Australian Bureau of Statistics (ABS) data for 2015-16 showed mobile internet and access to high-speed broadband as clearly the two most important digital technologies according to Australian businesses (Figure 2). While other technologies are also rising in importance, effective fixed and mobile broadband infrastructure remains essential to improving performance by businesses, and in meeting consumers’ evolving needs.

To manage the growth in data to and from Australia, there has been continued investment in subsea cables with three new subsea cable systems deployed in 2018 bringing significant new capacity. In addition, there has been significant investment and continued growth in data centres across Australia as companies continue to move their data and IT systems to the cloud.

Figure 1: Transformative digital development has been occurring for the past 30 years

| Wave 1: Automation | Wave 2: Connectivity | Wave 3: Business applications |
|---|---|---|
| 1990s to 2000s | 2000s to 2010s | 2010s to the present |
| <ul style="list-style-type: none"> • Desktop computing • Internet • Search engines | <ul style="list-style-type: none"> • High-speed broadband • Smartphones, laptops and tablets • Cloud storage and computing • Social media • The Internet of Things (IoT) | <ul style="list-style-type: none"> • Artificial intelligence and machine learning • Advanced robotics • Additive manufacturing • Distributed ledgers • Virtual and enhanced reality • Mobile applications • Supercomputing |

Figure 2: Businesses rate telecommunications backbone services very highly

Source: Australian Bureau of Statistics (2017)³⁹

Telecommunications infrastructure supports economic growth

Telecommunications infrastructure networks play a critical role in supporting Australia's economic productivity. This role is increasing as our economy becomes more reliant on digital technology and connectivity.

The nbn alone was estimated to generate \$1.2 billion per annum in additional GDP in 2017 through new jobs, new businesses and increased productivity.⁴⁰ This is expected to grow to over \$10 billion by 2021.⁴¹ 5G technology is also likely to improve Australia's economic productivity by enabling fast signal speeds (lower latency), which underpin responsive technologies and applications, such as robotics. Conservative estimates calculate the contribution of 5G technology to GDP at \$1,300 to \$2,000 per capita after the first decade of rollout.⁴² These estimates do not take into account the full consumer and non-market benefits, or potential benefits from distributional effects within and between industries.

There are also significant potential gains from 5G uptake in industries with low existing telecommunications technology intensity. IoT technologies and services are estimated to provide an annual boost to five key industries (construction, manufacturing, healthcare, mining and agriculture, fishing and forestry – representing around one-quarter of our economy today) of between \$200 billion and \$300 billion.⁴³ The largest gains are expected in the construction industry, where a large amount of technical equipment is used, but adoption has been slowest to date.⁴⁴

Governments, businesses and households are already embracing new technology

Evolving telecommunications infrastructure is already enabling governments, businesses and households to leverage new technologies to increase access to information, improve efficiency in service delivery, boost economic productivity and improve liveability. For example:

- **Governments** are using new technologies in health, education, smart cities and public safety applications. Online platforms are increasingly used to deliver services to citizens – examples are the Australian Government's MyGov and Western Australia's ServiceWA. At local government level, waste contractors have been using Radio Frequency Identification (known as RFID) technology for a decade, improving route management and allowing weighing of waste by household and to identify out of location bins.⁴⁵
- **Businesses** are embracing cloud computing, IoT, artificial intelligence and advanced robotics. Cloud storage and computing are reducing business costs. Businesses and governments are rapidly embracing cloud-based solutions to garner benefits including reduced hardware costs, mobile accessibility, and savings on security and redundancy. In 2017-18, Telstra reported an increase in cloud revenue of 14.4%.⁴⁶
- **Households** are becoming smarter as they embrace new technologies aimed at improving convenience and automating processes. This includes IoT technologies such as virtual assistants, smart lights, heating, air conditioning and security systems.

The Internet of Things

The IoT is a collection of internet-connected devices that are added to things – objects, infrastructure, places or worn by people.

These devices communicate with one another quickly and reliably, sending and receiving information, and in some instances controlling aspects of objects. This enables automation of a wide range of household and business processes, from smart watches and smart home applications such as virtual assistants, to autonomous vehicles, to sensors tracking hospital bed use, and autonomous drones carrying out predictive maintenance on remote infrastructure assets.

The Australian Communications and Media Authority (ACMA) quotes industry estimates that 29 billion devices will be connected worldwide by 2022, over 60% of which will relate to the IoT.⁴⁷

While many IoT devices already operate today, the introduction of 5G networks in Australia will accelerate the growth of the IoT in Australia. 5G networks will provide greater speed and higher data rates to increase the capacity of IoT technology, which will drive its uptake across a range of industries. The Bureau of Communications and Arts Research (BCAR) has estimated that the average Australian household will have at least 50 IoT devices by 2026. Other estimates anticipate double that amount.⁴⁸

Supporting the Internet of Things in cities and regions

Telstra is deploying two technologies to significantly expand its IoT coverage in buildings and wide areas.

Cat-M1 operates on the 4G network and enables IoT devices to have greater reach in distance and depth into buildings. Cat-M1 supports devices that by their nature are low complexity which makes it suitable for a variety of uses across agriculture as well as utilities, healthcare and supply chains. Coupled with range extension capability, Telstra provides customers with a Cat-M1 enabled device with a network footprint that is around three million square kilometres in area and penetrates far deeper into city buildings than 4G coverage has previously.

Narrow Band IoT (NB-IoT) targets both outdoor and deep indoor coverage, supporting long battery life. Uses include livestock and crop monitoring. In 2018, Telstra tested a long-range NB-IoT connection, a step towards increasing Telstra’s mobile footprint in rural and regional Australia. With this new capability, enabled with a software upgrade, Telstra’s NB-IoT coverage will increase to more than 3.5 million square kilometres (about 45% of Australia’s landmass).⁴⁹



152. Opportunity

Digital technologies are using telecommunications networks to enhance Australia’s economic productivity. Embracing these new technologies can be a source of competitive advantage for Australia and can improve outcomes for users.

When this will impact:



Where this will impact:



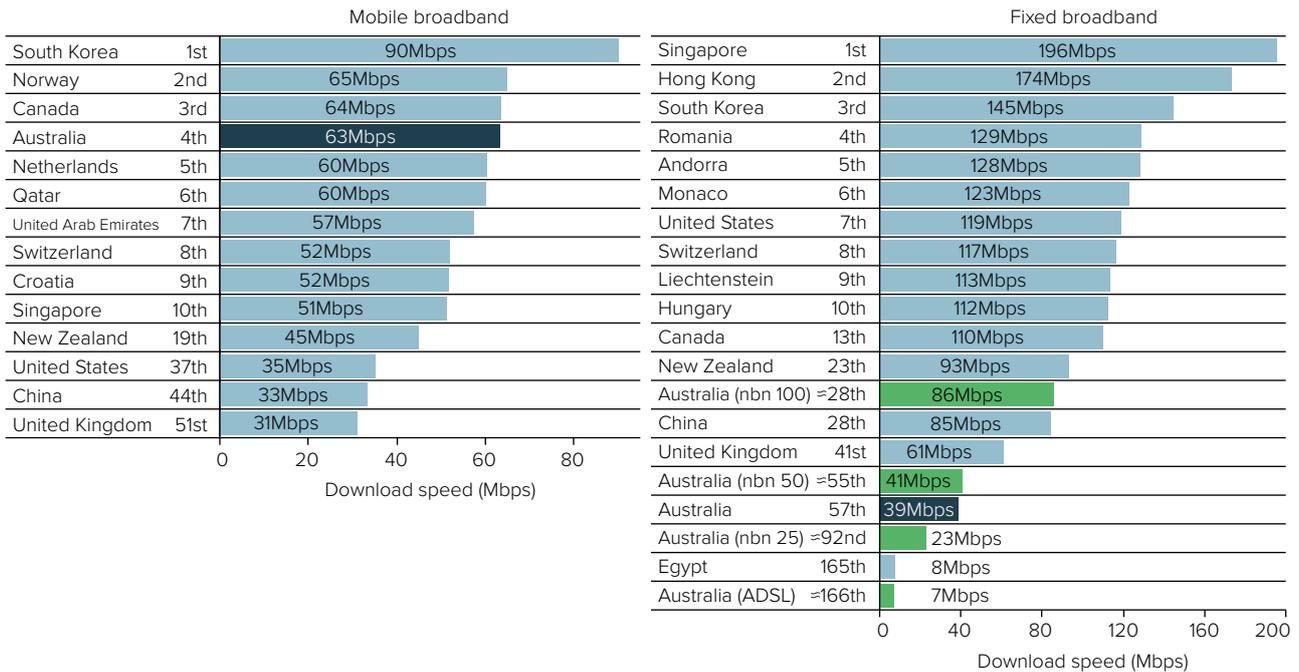
Australia leads on mobile speeds but lags on fixed broadband speeds

Australia is widely considered a world leader in mobile telecommunications. This is supported by Australia’s ‘Leader’ ranking in the GSM Association Mobile Connectivity Index.⁵⁰ As Figure 3 shows, we rank 4th in the world for average mobile broadband speeds. However, our fixed internet speeds are much slower. In June 2019, we ranked 57th in the world on fixed broadband speeds, well behind comparable

developed nations.⁵¹ While the top nbn speed tiers place us at the equivalent of 28th in the world, our ADSL speeds place us closer to 166th.

At the same time, demand for data, particularly mobile and wireless broadband, is increasing apace. For example, mobile handset data consumption increased by 41% between June 2017 and June 2018, and wireless broadband data consumption increased by 49% over the same period.⁵² Australia will need to continue to deliver increasing amounts of data, at high speeds, into the future to meet this demand.

Figure 3: Australia performs well on mobile speed rankings, but poorly on fixed broadband speeds



Note: Fixed broadband speeds for nbn speed tiers and for ADSL (green bars) are average busy-hour download speeds during May 2019. The ranking for these entries show where these speed tiers would sit on the international rankings. The dark blue bar for Australia represents performance across all internet connections nationally.

Source: Ookla (2019), Australian Competition and Consumer Commission (2019)⁵³

153. Challenge

Australia’s comparative performance for fixed broadband speeds is poor, and we lag well behind comparable nations. Failure to rapidly improve speeds could be a constraint on boosting productivity and liveability, and attracting businesses that require high levels of digital access.

When this will impact:

0-5

5-10

10-15

15+

Where this will impact:

Focusing on users is critical

Reflecting strong competition in the market, mobile service providers continually strive to understand and meet user needs in terms of network coverage and quality, price, data allowances and customer service. The ‘use case’ focus (that is, a focus on specific applications where a product could be used) of 5G development suggests this will continue for the new generation technology and its associated applications.

The vertical separation of the majority of fixed broadband supply – wholesale nbn and separate retail service providers – risks less effective customer focus and service differentiation, as nbn operates at a distance from users, and retail services providers are restricted in their service offerings to the speed tiers and wholesale products that nbn delivers.

While most Australian consumers and businesses enjoy access to the range of telecommunications services, this is not the case for all. Rural and remote areas, and certain demographic groups, risk being left behind digitally.

While Australia’s mobile footprint includes over 99% of the population (at their premises), it covers only one-third of total landmass, meaning little or no service for those working and travelling in rural and remote areas. IoT networks are likely to have more extensive coverage than mobile data due to longer signal ranges, but still leave large parts of the continent uncovered.

Securing networks requires protecting data and balancing privacy

Cybersecurity is the practice of defending networks from malicious attacks. It involves commitment and action across sector regulators and participants, and requires proper governance, capacity building and cooperation. Australia has a strong international standing on cybersecurity. In 2017, the International Telecommunications Union placed Australia in the top ten for preparedness of the 162 countries surveyed, ahead of Canada and France but below the leaders Singapore and the United States.⁵⁴

Data governance is management of the integrity, use, availability, useability, and security of digital data owned or controlled by individuals, companies and governments. Australia’s data privacy regulation and enforcement has been rated as “heavy”.⁵⁵ The Privacy Commissioner has the power to initiate and conduct investigations, ensure compliance with the *Privacy Act*, and seek civil penalties for serious or repeated breaches of the Privacy Principles where remediation has not been implemented.⁵⁶ There is also sector-specific consumer data right regulations being implemented to empower consumers on use of their data, initially being implemented for banking.⁵⁷

Nonetheless, in a 2018 survey, Deloitte found over 80% of Australian adults surveyed expressed concern about how their personal data is used, stored and shared as a result of their online interactions with companies.⁵⁸ In 2016, Deloitte surveyed industry use of the latest regulatory compliance approach.⁵⁹ The best-ranked sectors were banking, finance, government, energy and telecommunications. Lower-rated sectors were retail, social media, media and real estate.

While Australia ranks highly on cybersecurity and data governance, community concern is high and cybercriminal techniques are constantly improving. As such, cyber-related policy and regulation need to continually stay ahead of new threats and reflect escalating data prevalence and importance.



154. Challenge

Cybersecurity risks, such as data privacy and system resilience, are growing as more Australians use more interconnected digital services. Failure to manage these risks could affect user engagement with new services, and reduce the potential benefits of these services. Network efficiency could also suffer.

When this will impact:



Where this will impact:



8.3 The mobile coverage dilemma

At a glance

While Australia's mobile footprint includes over 99% of the population, it covers only one-third of total landmass, meaning there is limited service in particular rural and remote areas, for example along transport corridors.

5G mobile technology provides a potential step change in mobile telecommunications infrastructure for Australia, offering huge benefits including faster mobile data, minimal delays and the ability to separate services on the same network. However, the cost of rolling out 5G is high, and without a change in prioritisation, existing issues may be exacerbated in rural and remote areas.

This section also looks at how we allocate mobile spectrum. This is a finite resource that underpins mobile telecommunications, and affects service quality and cost.

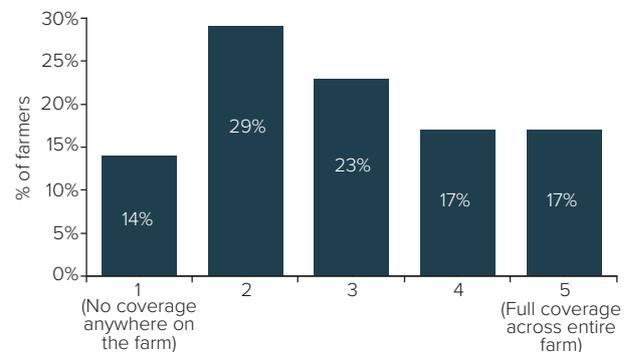
Mobile coverage prioritisation creates challenges in rural and remote Australia

While Australia has among the fastest mobile networks speeds in the world, coverage across the country is a challenge. This is because, while Australia's mobile footprint includes over 99% of the population, it covers only one-third of total landmass. Mobile network coverage, quality and choice of providers therefore remain significant issues in parts of rural and remote Australia.

Delivery of new and upgraded mobile coverage is prioritised where population densities are highest – places where people live and businesses are located. While coverage in these places is essential and contributes to improved liveability and productivity, this prioritisation results in limited coverage in other crucial areas with lower population densities, such as along transport corridors, or in large landholdings away from homes and businesses, such as farms and stations.

A 2017 study led by CSIRO showed that more farm respondents (43%) reported 'poor to no coverage' across their farm, than those who reported 'good to full coverage' across their farm (34%) (Figure 4).⁶⁰ This difference is likely to reflect the combination of size of farms and proximity to urban centres (where mobile base stations are typically located).

Figure 4: Farmers have varying levels of coverage across their properties



Note: Respondents were asked "How do you describe your mobile coverage across your entire farm?"

Source: Zhang et al. (2018)⁶¹

Mobile network coverage, quality and choice of providers remain significant issues in rural and remote Australia. Australian major cities and inner regional areas account for 88.6% of the population yet only cover 3.5% of the total landmass.⁶² BCAR has observed that for approximately one million square kilometres (around 13% of Australia's total land area), Telstra is the only available mobile network, although this area includes less than 1% of the Australian population (Table 1).⁶³

Table 1: 3G and 4G population coverage is high, but the last 1%-2% of population have no service or lack choice

| Provider | 3G coverage | | 4G coverage | |
|-----------------------|-----------------|-----------------|----------------------------|---------------------|
| | % of population | % of population | km ² (millions) | % of Australia area |
| Telstra | 99.3% | 98% | 2.4 | 31% |
| Optus | 98.5% | 95% | 1.0 | 13% |
| VHA (Vodafone) | 97% | 96.9% | 0.9 | 12% |

Note: VHA coverage includes roaming agreement with Optus.

Source: Australian Competition and Consumer Commission (2016)⁶⁴

The Australian Communications Consumer Action Network, which represents smaller users, notes that rural and remote users have lower access to emergency communications, including on major roads.⁶⁵ In their view, this is partly because valuation of remote emergency services is limited, which constrains investment cases to more densely populated areas. They refer to the lack of investment in passive dishes, as has occurred in some parts of the Northern Territory, despite the cost of each being lower than projects funded under other government programs.⁶⁶

Regional Australians have seen a focus on mobile black spot locations through a range of federal, state and territory funding schemes. The Australian Government’s Mobile Black Spot program brings state and local governments together with Optus, Telstra and Vodafone, along with local businesses and communities to invest in infrastructure to improve mobile coverage and competition across Australia.

While the program has successfully delivered over 1,000 new base stations,⁶⁷ there are a range of challenges with this program, including:

- Prioritisation of funding based on residential population density, rather than an assessment of social or economic need.
- A lack of coordination of co-location and shared infrastructure, such as towers, to maximise choice of networks for users.
- The need for a more comprehensive evidence base on mobile coverage, to improve decision making around the placement of new mobile infrastructure.⁶⁸

In Victoria, the Connecting Regional Communities Program includes a range of regional initiatives to address digital black spots in nine regions. One example is the Regional Rail Connectivity project, which aims to provide commuters with end-to-end internet mobile connectivity across five regional rail lines – Geelong, Ballarat, Bendigo, Traralgon and Seymour – through the deployment of cellular repeaters installed on regional trains. Similar regional city and town focused projects are underway in New South Wales, Western Australia and the Northern Territory.⁶⁹



155. Challenge

Prioritisation of mobile network upgrades in rural and remote areas creates gaps in crucial areas, such as on productive land and along transport corridors. Failure to deliver services to these areas affects community safety, liveability and productivity.

When this will impact:



Where this will impact:



5G provides a step change for our mobile telecommunications infrastructure

5G technology offers a step change from the functionality provided by 4G networks. 5G data speeds are expected to be at least one and a half to two times faster than current 4G speeds, which is up to ten times faster than initial 4G networks.

The benefits of 5G for users include:

1. **Faster data speeds:** 5G will provide much faster mobile data speeds for uses such as media and entertainment, but could also allow newer technologies to be more widely adopted, such as augmented reality (where a computer generated view is overlaid on a real world view).

2. **Ultra-reliability and low latency:** greater reliability and reduced delays (lower latency) in networks speeds could provide significant benefits for sectors that require continuous, interactive, or precise telecommunications services. For example, in transport to connect autonomous vehicles, for some IoT uses in homes and urban environments, or in health for uses such as remote surgery.
3. **Network slicing:** the ability to segregate different services over the same network will allow service differentiation based on the actual use it supports, for example for essential services or autonomous vehicle networks.

Australia is well positioned as an early adopter for 5G technology

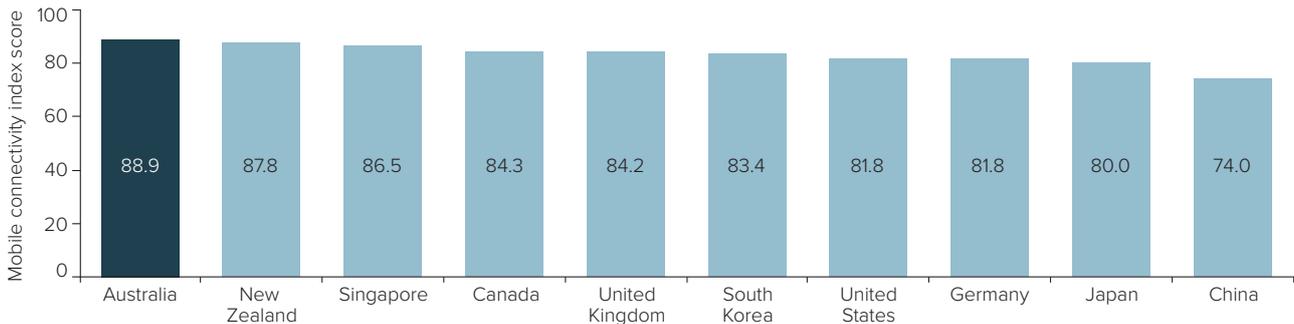
Australia is well positioned as an early mover in the rollout of 5G networks. We rank as the overall world leader in key enablers of mobile internet adoption according to the GSM Association (GSMA), a leading global industry body in the mobile sector.

The 2017 Mobile Connectivity Index, a leading measure compiled by the GSMA, compares Australia

against 162 other countries.⁷⁰ We rank at the top of G20 nations overall, in terms of infrastructure, affordability and consumer readiness (Figure 5). Australia has led the overall index every year since 2014. This suggests there is potential for 5G adoption to be stronger and faster than previous mobile generations in Australia.

Telstra, Optus and Vodafone have announced plans to build national 5G mobile networks, with launches expected from all three in 2019.

Figure 5: Australia leads key competitors on readiness for mobile adoption



Source: GSM Association (2017)⁷¹

156. Opportunity

5G technology presents an opportunity for Australia and we are well positioned to embrace it ahead of other nations. Delivering 5G networks will help to accelerate Australia's digital transformation, providing significant benefits to people, businesses and governments.

When this will impact:



Where this will impact:

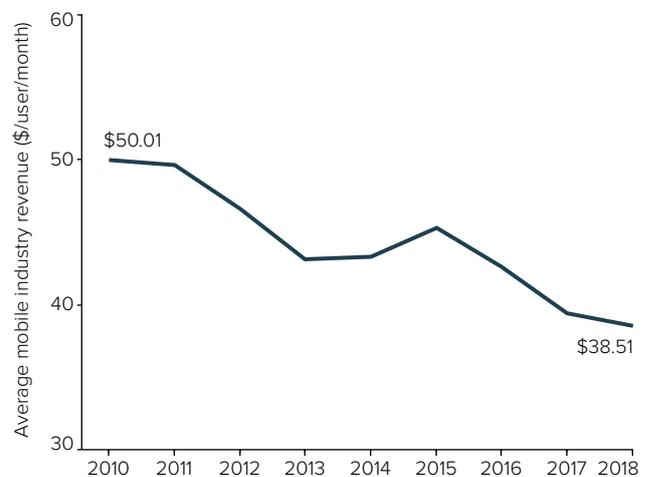


Mobile telecommunications is a highly competitive market

There is a significant amount of competition in the mobile industry. There are three major players (Telstra, Optus and Vodafone) as well as smaller operators who utilise these networks. Mobile products are increasingly commoditised and show little variation between providers. Price is the main decision factor for consumers as there is less differentiation arising from their mobile networks, coverage and customer experience. Unlimited plans are becoming more common, reducing differentiation on capacity.

Complicating the competitive landscape, average revenue per user is falling for mobile network operators (Figure 6). This may be associated with new applications, such as internet based services that act as substitutes (for example, Skype and WhatsApp), displacing revenue-generating voice and mobile message services. The decline in traditional revenue sources incentivises mobile operators to move into new markets.

Figure 6: Mobile industry revenue per user is falling (including handset)



Source: Venture Insights (2018)⁷²

Major operators are expanding free Wi-Fi in large and small cities

Traditional mobile services are also being displaced by expanding use of free Wi-Fi. Governments and MNOs are implementing Wi-Fi hotspots in public places across Australia, often for free, to maximise the potential of their network assets. Free Wi-Fi frequently offered to patrons in bars, cafes, and libraries complements mobile network coverage areas. For example, free Wi-Fi can now be found in shopping centres and in some CBD areas in cities.⁷³ TPG has provided backhaul to VicFreeWiFi in the Melbourne CBD, Bendigo and Ballarat, while Telstra's Wi-Fi network provides its customers with access to over one million hotspots across Australia.⁷⁴

These public networks are more readily available in our cities and regional centres and where existing infrastructure is prevalent and covers dense populations, lowering the cost of additional expenditure to improve capabilities. Lower teledensities outside of cities and towns means that there are areas with no mobile coverage, or only one provider (usually Telstra). This is reflected in Telstra's significantly higher market share in regional areas – particularly high in the non-urban parts of Tasmania and Western Australia.⁷⁵ However, new generation low Earth orbit satellites and high altitude platform stations (or high-altitude pseudo-satellites) may present opportunities to expand mobile coverage across much wider geographical areas, making these networks more economical in rural and remote areas.

Rolling out 5G could create cost and planning challenges

The advent of 5G will require a new wave of infrastructure investment. While forecasts suggest that network costs could double as investors upgrade 4G and manage the evolution to 5G,⁷⁶ it is likely that MNOs will largely absorb and manage the additional required capital investment.

A major contributor to this cost is the need for more physical infrastructure than 3G and 4G. 5G requires

higher densities of towers and cells to address higher traffic loads and enable the use of higher radio frequencies. This will necessitate a shift towards using smaller cells in closer proximity to one another, and the deployment of a deep-fibre network. This creates challenges in retrofitting cities and in creating sufficient densities in more remote areas. However, analysis suggests that upgrading mobile tower sites, delivering small cells in high-density areas and moving towards nationwide rollout could be achieved within existing capital expenditure envelopes if carefully staged over the next five to seven years.⁷⁷

Though MNOs have some existing powers relating to telecommunications infrastructure deployment and installation,⁷⁸ there has been recent public opposition to the rollout of more cells without community consultation, particularly in cities.⁷⁹ Concerns around security and health are most commonly cited oppositions to these small cells, though experts have maintained that these concerns are no greater than those presented by larger telecommunications towers that already exist.⁸⁰

Currently, under the *Telecommunications Act 1997* (Commonwealth), necessary equipment can be installed on public infrastructure such as light poles without the need to gain council approval.⁸¹ The denser 5G rollout may increase operator focus on consultation with the community around use of these powers. The ACCC expects MNOs to be interested in sharing 5G cell infrastructure, particularly in fast-growing cities.⁸² The use of other street objects and furniture, such as public transport signage and structures may help to reduce both the capital costs of rollout and allow smaller players to still maintain a presence in the market.

In rural and remote areas, it is likely that existing challenges faced with 3G and 4G coverage will be exacerbated with the rollout of 5G. This is because 5G services require higher densities of cells, and therefore higher costs to network owners. It is likely that rollouts will prioritise more densely populated areas, where the number of users is higher and the fixed costs can be met by a higher number of users.



157. Challenge

5G networks will require substantial new infrastructure, creating both cost, planning and security challenges.

In cities, this means retrofitting new cells into existing streetscapes, and in rural and remote areas, this means creating adequate densities and improving coverage beyond that of 3G and 4G. Adequately balancing shared and competing tower and cell sites will affect the scale of investment, and ultimate costs users pay.

When this will impact:



Where this will impact:



Finite mobile spectrum allocation has implications for users

The availability of spectrum is key to the success of mobile operators. Spectrum is the finite radiofrequency that underpins mobile telecommunications. Different parts of the radio spectrum have different attributes, making them more or less suitable for different uses, but also creating competition between different uses. Sharing spectrum can create interference, requiring the creation of a form of property rights for different uses, such as defence, emergency services, broadcasting and mobile applications.

Access to spectrum is a barrier to entry into wireless telecommunications markets. Allocation of spectrum by the ACMA, generally by auction, aims to balance the different needs of these stakeholders, while providing opportunity for MNOs to acquire access to spectrum that meets their users' needs and geographical footprints. In turn, access for mobile operators to spectrum range impacts competition in the mobile market. The large telecommunications providers (including Telstra, Optus and Vodafone, as well as nbn) are the major holders of commercial spectrum, both in urban and regional areas.

Recent auctions will be significant to the 5G rollout. Higher frequency spectrum is more suited for denser coverage areas with larger data consumption and will likely be used in cities in conjunction with the rise of small cell networks. Lower frequency spectrum is expected to be used in regional, rural and remote areas.

There are challenges in Australia's current approach to spectrum allocation, including harmonisation of band according to the global ecosystem, making more available by spectrum transfer (for example, satellite band), clearing spectrum faster for use, and enabling secondary market operation for operators to trade and swap spectrum to achieve optimum network performance.

Wide-area narrow band networks are being delivered across many parts of regional Australia, supporting low bandwidth uses, such as simple IoT for water monitoring in agriculture.

These networks are also used for emergency services, however their future as a fit-for-purpose solution could be compromised by issues of reliability and capacity. Some state jurisdictions, New South Wales and Victoria, have made some progress upgrading to more contemporary solutions, such as an Long-Term Evolution standard that offers mission-critical press-to-talk over a dedicated network. However, the provision of a nationally consistent, integrated solution is lacking thereby potentially impacting cooperation amongst jurisdictions during emergencies.

158. Challenge

Government needs to balance different demands, including from mobile service providers, to deliver efficient and competitive allocation of radiofrequency spectrum. This will affect the quality and cost of mobile services for users.

When this will impact:

0-5

5-10

10-15

15+

Where this will impact:



8.4 Maximising the benefits of nbn investment

At a glance

With the nbn rollout almost complete, we must look at how to harness its benefits. This section covers:

- Tensions between nbn user outcomes and the need to provide a return on the capital investment from taxpayers
- Technological changes during the rollout that have affected quality
- The need for comprehensive national coverage and associated funding challenges
- Possible privatisation once the nbn is fully operational and the impact on market structure.

There is an inherent tension between user outcomes and return on investment for the nbn

The government-owned nbn was announced in April 2009 as a replacement for Telstra’s copper access network. The central aim was that every person and business in Australia, no matter where they were located, would have access to affordable, fast broadband.

It was structured off-budget and is required to eventually pay its way, including providing a return to the Australian Government, as owner. nbn provides wholesale services to commercial network operators, and other retail service providers.

The sole shareholder, the Australian Government, states the core objective for nbn as:

“...ensuring that all Australians have access to very fast broadband as soon as possible, at affordable prices, and at least cost to taxpayers. The Government expects the network will provide peak wholesale download data rates (and proportionate upload rates) of at least 25 megabits per second to all premises, and at least 50 megabits per second to 90 per cent of fixed line premises as soon as possible. nbn should ensure that its wholesale services enable retail service providers to supply services that meet the needs of end users”.⁸³

In effect, the nbn needs to achieve four goals:

- Supply technology to support defined minimum speeds (quality of service)
- Provide access to all premises no matter where they are located (accessibility)
- Sell wholesale access to retailers at prices that enable end user take up (affordability)
- Make a return on taxpayer investment (profitability).⁸⁴

The first three of these goals are focused on direct user outcomes, and over time may compete with the fourth goal, to make a return on the taxpayer capital investment.

For example, with consumer resistance to paying more for telecommunications services, there is pressure on nbn to reduce its wholesale prices. nbn implemented some changes to its wholesale prices in 2018, and there is evidence that this has increased take up, and improved speeds.⁸⁵ To the extent wholesale price reductions are passed on to consumers, this should increase retail take-up of nbn services at higher speeds. To the extent that wholesale prices are too high, this will reduce nbn take up, subdue the economic benefits of the infrastructure network, and encourage network duplication from the private sector.

Including the proposed Regional Broadband Scheme, nbn has forecast it will achieve an internal rate of return of 3.2% from:

- Steeply rising average revenue per user
- Users opting for higher speed tiers and downloading more data
- Limited market share loss to competing fixed and mobile networks.⁸⁶

However, there are concerns around the realisation of these assumptions given users’ apparent unwillingness to pay more for additional services, challenges in achieving fast speeds across all technologies, and the imminent rollout of competing 5G fixed wireless and mobile networks.

nbn has been structured as an off-budget entity, meaning that there is an expectation that shareholder equity will be repaid, with a return, from its growing operations. There are early budget impacts from the government’s cost of borrowing to make equity injections, and it has contingent liabilities noted in the budget. However, the ultimate outcome for taxpayers and the budget may not be known until the nbn is valued by the private sector in a sale process, including if prior write-downs were to occur.⁸⁷

The ACCC has expressed a concern that the nbn may not meet its financial targets. It has raised the possibility of taxpayer price relief via a range of means such as debt payment concessions or direct budget funding of non-commercial services, to better promote the efficient use of the network and the long-term interests of end users.⁸⁸



159. Challenge

There is an inherent tension between the nbn’s strategic goals, requiring potential trade-offs between achieving user outcomes and delivering a return on the capital investment made by taxpayers. If all goals cannot be achieved, the ability for Australians to access affordable and high-quality nbn services may be negatively affected.

When this will impact:



Where this will impact:



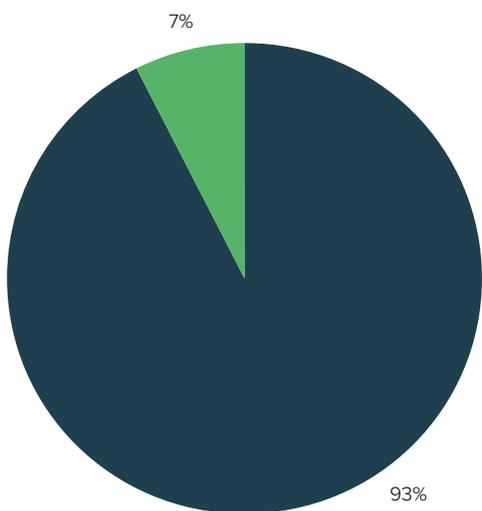
Changes to nbn technology will affect service quality

The nbn was primarily designed for residential and small business users. The original (2010) plan was for fixed line Fibre to the Premises (FTTP) for the approximately 93% of users in readily-accessible locations in our fast-growing cities, regional centres and towns. The remaining 7% of the population would receive fixed wireless (fringes of our cities and towns, and close-by rural hinterland) and satellite (rural communities and remote areas, and other hard to access locations).

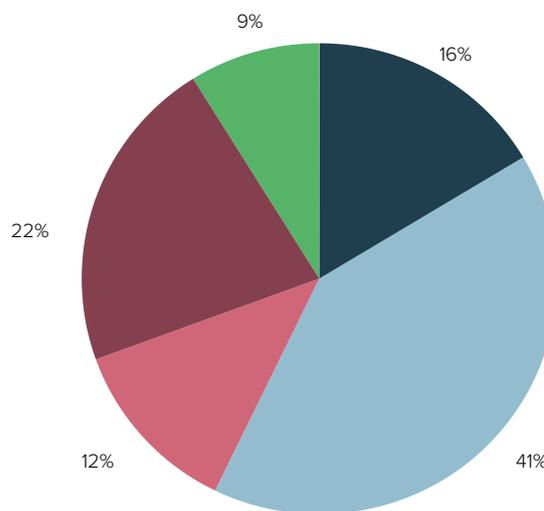
The FTTP focus has moved to what is now called a multi-technology mix. This different mix has altered projected infrastructure costs. For example, the need for upgrades to Hybrid Fibre Coaxial (HFC) connections under the current plan drives up capital costs and operating expenses. Figure 7 shows the different nbn technology mixes for the two approaches based on end of rollout forecasts for premises that are passed and connected (original plan) and ready to connect (current plan).

Figure 7: The nbn technology mix has changed since 2010

2010 Plan – at June 2021



Current Plan – at June 2020



- Fibre to the Premises
- Hybrid Fibre Coaxial
- Fibre to the Node/Basement
- Fixed wireless and satellite
- Fibre to the Curb

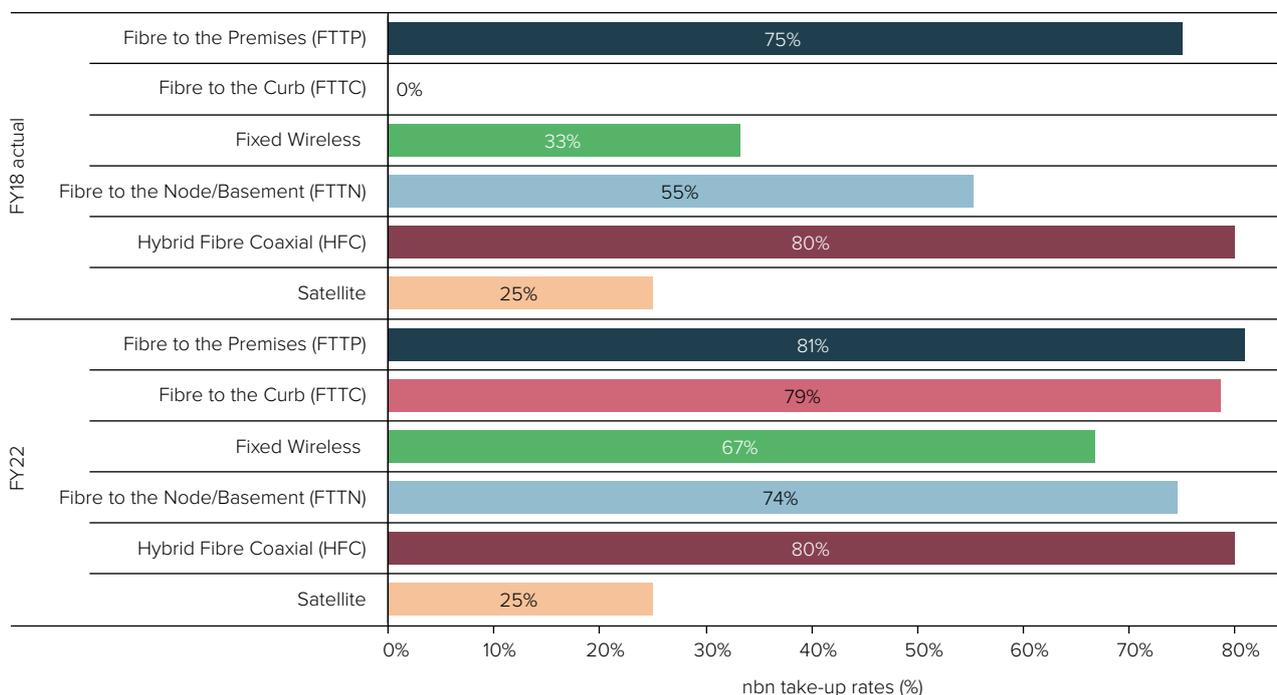
Source: nbn (2010, 2018)⁸⁹

There are inherent differences in performances depending on the type of technology used to deliver underlying broadband services. Each type (for example, Fibre to the Node (FTTN), Fibre to the Curb (FTTC), Fixed Wireless, and Satellite) has different speed capability, equipment and installation requirements, and power outage backup capacity.⁹⁰ While there is potential scope to increase data throughput of fibre and short copper connections, there are wireless spectrum-related limits to fixed wireless services and transponder capacity limits and inherent time delay issues for satellite services.

A range of nbn process and performance issues have arisen as rollout has proceeded and users have migrated to the network. Some issues have been or are in the process of being addressed, such as copper-nbn migration processes, disparities between claimed and actual speed performance,⁹¹ fixed wireless throughput bottlenecks at peak use times, and satellite service data limits.

The nbn short-term forecast is for underutilisation of satellite capacity by premises served by that technology, with the other technologies forecast at 75% or higher take up rates (Figure 8). Actual take up will be impacted by pricing strategy, and the relative value of alternative offerings.

Figure 8: nbn take-up rates by technology are expected to vary, with satellite the lowest



Source: nbn (2018)⁹²

The capital costs of the different technologies vary. Table 2 shows the estimates prepared by nbn of capital cost per premises for most of its technologies for the completed rollout.

As the rollout progresses, decisions are being made about nbn’s technology boundaries and upgrade paths – this includes options to:

- Incrementally push out FTTP to more homes and businesses
- Expanding other options for fixed wireless upgrades, such as migration to 5G
- Expanding the amount of fibre within the HFC network
- Extending fixed wireless into satellite areas where this can be done without serious cost escalation.

In particular, there is potential for fixed mobile substitution through 5G fixed wireless access, providing broadband speeds and user experience equivalent to nbn for some segments of the market, particularly dwellings with Service Class 0 nbn status (premises that are within a Ready for Service fibre area, but require further work prior to activation, such as additional cabling).⁹³ The potential for fixed mobile substitution is especially high for those technologies, such as FTTN and FTTC, where achievable maximum speeds are variable and dependent on copper quality and length. MNOs are also at an advantage in this situation, compared to the nbn, because they are generally also fixed line providers and have more information regarding the characteristics of end users and so can tailor fixed wireless products.

Table 2: Capital costs per premises and speeds vary for each nbn technology

| Technology | \$ per premises | Maximum current download speed (megabytes per second) |
|----------------------------|-----------------|---|
| FTTP in existing buildings | 4,400 | 1,000 |
| FTTP in new buildings | 2,100 | 1,000 |
| FTTN/B | 2,300 | 100 |
| FTTC | 3,000 | 100 |
| HFC | 2,500 | 100 |
| Fixed Wireless | 4,300 | 50 |
| Satellite | N/A | 25 |

Source: nbn (2018)⁹⁴

160. Challenge

The technology mix for the nbn has diversified, meaning different users will receive different types of connections. This change will deliver varied outcomes for users, and some may shoulder higher costs or receive lower-quality services.

When this will impact:

0-5

5-10

10-15

15+

Where this will impact:



Extending the nbn opportunity to all corners of Australia is a challenge

Uniform national pricing and competition in our fast-growing cities and our regional centres means nbn faces funding challenges. The per-user cost of telecommunications networks rises as population density falls. Due to uniform national pricing, this means that serving many regional and remote users will incur a net cost. While a purely commercial operator would stop pushing out the network at some point, the nbn is required to be built beyond that point into 'sub-commercial' locations.

A proposed Regional Broadband Scheme would levy a surcharge of approximately \$7 per service per month on all high-speed fixed line broadband providers (including nbn itself) to cover the cost of the non-commercial services.⁹⁵ The levy would not extend to fixed wireless and mobile services. In this sense, fixed line broadband users would be paying for all Australians to have minimum 25 megabits per second (Mbps) broadband, wherever their premises are located.

Looking forward, risks for the nbn include competition from ongoing fixed line services and 5G fixed wireless substitution. There is also the possibility of competition in remote locations from emerging low Earth orbit satellite technologies and other satellite technologies.⁹⁶ However, this is also an opportunity for the nbn to leverage these technologies to deliver better services in its existing fixed wireless and satellite coverage areas. The 2018 Regional Telecommunications Review has noted that about 70% of premises outside urban areas will have a fixed line broadband service by 2020.⁹⁷ However extreme remoteness makes connectivity for the remaining 30% harder as populations get sparser.

nbn's use of fixed wireless and satellite technologies limits the choice of available broadband speeds and download quotas, particularly for remote areas. However, these services are often the only option for regional Australian consumers and businesses. Although nbn is launching business-grade nbn services, these do not currently extend to nbn's fixed wireless and satellite access technologies. nbn is planning to deliver a business-grade satellite service in 2019.⁹⁸



161. Opportunity

Private market broadband and mobile operators are providing competitive services in commercial locations to fill nbn gaps. Leveraging competition can provide greater choice for users, supporting affordable and high quality services.

When this will impact:



Where this will impact:



Structuring the nbn for the future will need to balance value for shareholders and users

The history of the nbn has involved technology and strategic change, and an often charged political debate about the quality and cost of services, and how to balance the size of the taxpayer investment with the expected benefits.

The future of the nbn, as indicated in its legislation, could see it privatised after it is declared 'built and fully operational' and subject to the Productivity Commission and the Parliament having assessed sale structure options.⁹⁹ This issue is expected to emerge from 2020 as the rollout is completed.

This raises questions as to whether or not the network will be sold, and if so, how the assets would be sold and therefore how the market will be structured. This means considering how to balance the need to deliver value for shareholders, through restructuring and sale, while still achieving the user outcomes for the nbn and delivering value into the future for Australians as the population continues to grow, and the importance of digital connectivity increases. These choices will affect the quality, access and cost outcomes for users, particularly for vulnerable groups such as remote communities and small businesses.



162. Challenge

A proposed eventual sale of the nbn to the private sector raises challenges in striking the right balance between realising its value for shareholders and achieving long-term goals for users.

Decisions about restructuring and sale can affect both short- and long-term service delivery and outcomes for users.

When this will impact:



Where this will impact:



8.5 Social inclusion and affordability for telecommunications services

At a glance

Australians are generally happy with their telecommunications service quality. As these services become more essential to modern society, governments are investing significantly to fill gaps and support growth.

But not all Australians have the same access. This section looks at gaps in service quality for particular groups of Australians. We will need community service obligations (CSOs) to address these inequalities.

Consumers rate services as costly, but still support more investment in these services. The last decade has seen great improvements, with service plans offering more data for less money.

This section also identifies a disproportionately large cost burden on lower-income households, and the tension between businesses' rising demands and their resistance to paying more. It looks at how we can enhance consumer choice and experience to strengthen the sector.

Telecommunications is now essential to participating in society

While telecommunications has always been essential for communication between people, the growth and pervasiveness of digital technology and connectivity in Australia today means that telecommunication networks play a critical role in how our society operates.

In 2018, ACMA noted that Australians are consuming more data and content than ever before, with 89% of Australian adults accessing the internet and 34.8 million mobile services in operation.¹⁰⁰

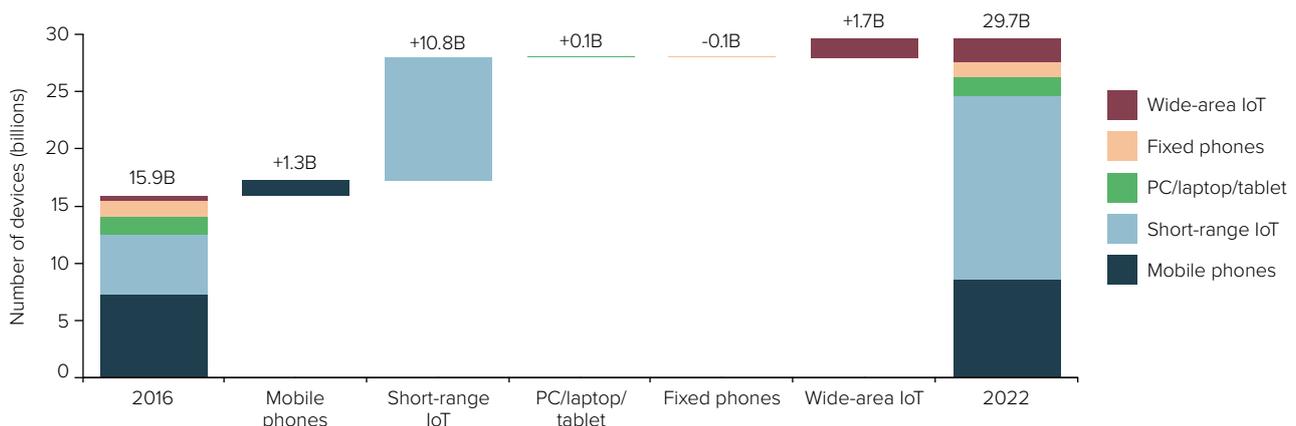
Participation in online commerce is mostly undertaken by middle-aged Australians, with lower rates for younger adults likely reflecting lower disposable income. Older people also have low rates of online commerce use due to less familiarity with the online world. In all groups, participation is increasing.¹⁰¹

In coming years, Australians' dependence on telecommunications infrastructure will rise further as:

- Businesses move more of their services and data into the cloud.
- Governments move online. The Australian Government is seeking to migrate all government service delivery to be digital by 2025.¹⁰² As many users of government services are among the least digitally included, there is a need to facilitate inclusion as part of the transformation.
- Consumers use smart devices and technology to enhance a range of aspects of daily life – from cashless payments on smartphones and watches, to tracking public transport services in real time.
- The use of IoT devices increases, connecting people and machines. This enables organisations to redefine their industry value chains, and helps people to better manage day-to-day household activities.

IoT devices and connections are expected to contribute almost 20% to the global growth in data traffic between 2016 and 2022.¹⁰³ As Figure 9 shows, forecasts suggest there will be almost 30 billion connected devices in the world by 2022, of which around 18 billion will be related to IoT.¹⁰⁴

Figure 9: Actual and forecast connected devices are growing quickly worldwide



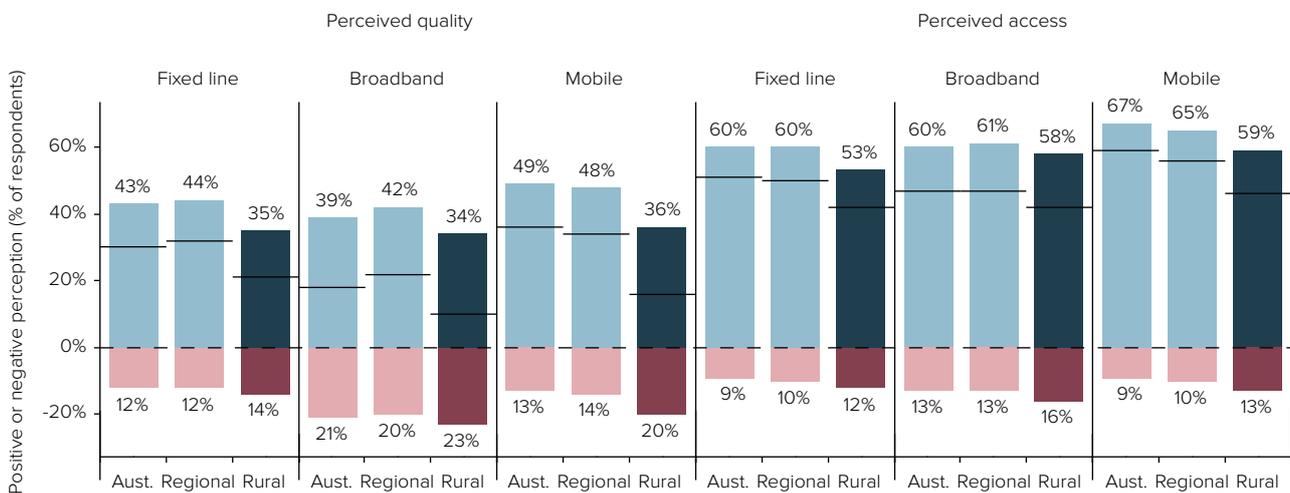
Source: Ericsson (2018)¹⁰⁵

Australians are generally happy with the quality of telecommunications services

The vast majority of Australians (greater than 75%) view telecommunications services as either average or good, with the quality of mobile networks and services the best at 85%.¹⁰⁶ Less than 16% of people believe that the quality of telecommunications is worse now than it was five years ago, and is likely to be worse five years from now.¹⁰⁷ More than 60% of Australians feel all types of telecommunications infrastructure is accessible, with mobile slightly more accessible than broadband and fixed line.¹⁰⁸ While consumers expect access to traditional fixed line services to stay the same, there is a firm expectation that accessibility for both broadband and mobile telecommunications will improve over the next five years.¹⁰⁹

Geographically, sentiments about telecommunications services are close to the national average in regional areas, but rural and remote communities are least positive about quality and access (Figure 10). While those living in rural and remote areas overall rate telecommunications as ‘good’ more than they do ‘poor’, people in these areas are more likely to have concerns about the quality of mobile (net 16% positive compared with 36% nationally) and fixed broadband services (net 10% compared with 18% nationally).¹¹⁰ This likely reflects changes in technology to fixed wireless, satellite and mobile technology beyond the regional fringe, and the associated speed, coverage and reliability issues as populations become sparser.

Figure 10: Consumers are more positive about access to telecommunications services than the quality of services



Note: The value at the top shows the percentage of survey respondents who had a positive perception, and the value at the bottom shows the percentage of survey respondents who had a negative perception. The black line shows the difference between the two values.

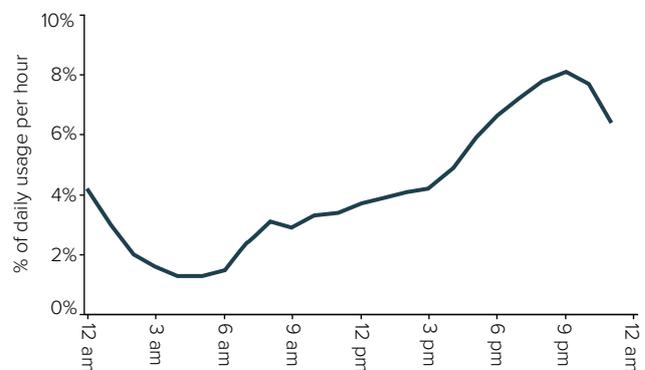
Source: JWS Research (2018)¹¹¹

Not all Australians have the same quality of service

Like most infrastructure systems, distances and congestion present challenges to networks as populations become either sparser or denser.

In our fast-growing cities, and in regional areas served by wireless broadband services, network crowding effects can occur across the network at peak times caused by bandwidth congestion as many people access data at the same time. BCAR estimates current peak broadband usage between 8pm and 10pm (Figure 11).

Figure 11: Broadband usage peaks in the evening, creating potential congestion



Source: Bureau of Communication and Arts Research (2018)¹¹²

There are also differences in allowable usage, which are driven by the type of infrastructure. For example, while some fixed nbn plans allow for unlimited downloads (subject to nbn’s fair use policy),¹¹³ nbn’s Satellite Sky Muster service typically has usage limitations due to the capacity constraints of the technology, which can in turn limit remote users’ access to the internet compared with those in cities.

To better understand actual broadband performance relative to the broadband plan, the Australian Government provided funding to the ACCC to implement an independent nbn performance monitoring and reporting program. The third ACCC Measuring Broadband Australia report showed that fixed line broadband speeds did not slow significantly in the busy hours (7-11pm), with average speeds across all busy hours reducing by just 1% compared with the average.¹¹⁴

The report also found that the differences between urban and regional fixed line services was not significant, with those in urban areas receiving 84.8% of maximum speeds on average compared with 83% of speeds in regional areas.¹¹⁵ Significantly, the ACCC does not measure fixed wireless or satellite speeds, which tend to occur in regional areas, and which

would reduce the overall average regional speed performance.

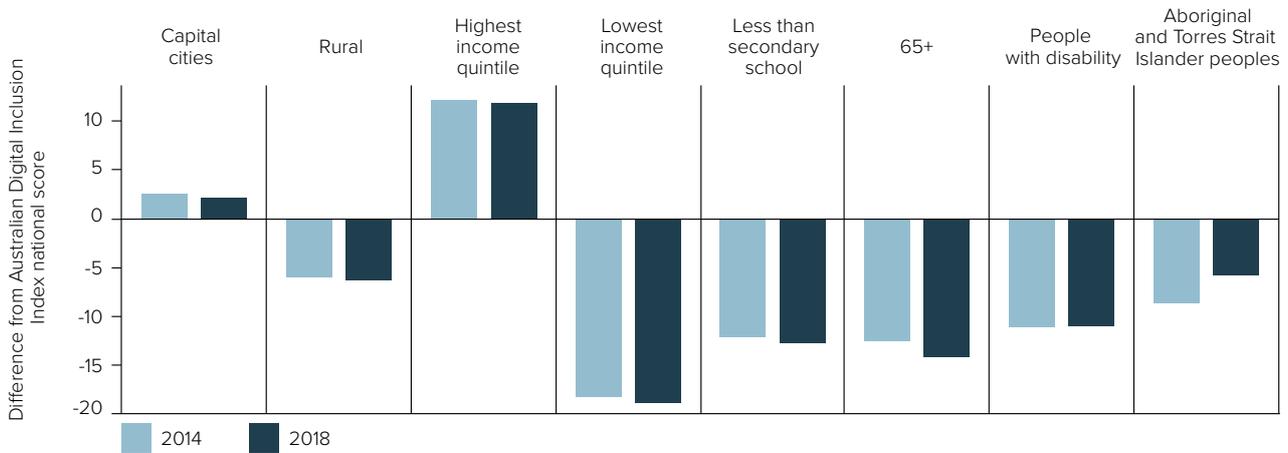
The ADII also showed differences between rural and urban areas.¹¹⁶ As Figure 12 shows, digital inclusion is low outside of fast-growing cities, particularly in rural areas, with limited improvement between 2014 and 2018.

While the 2018 ADII found that overall digital inclusion is improving over time, it also highlighted a substantial digital divide between certain segments of Australian society.¹¹⁷ Nationally, the groups that lag the Australian score in 2018 by over ten points include:

- The lowest 20% of households by income
- People who did not complete secondary school
- Those aged over 65
- People with disability.

The 2018 ADII also shows that Aboriginal and Torres Strait Islander peoples score 5.8 points below the national score, despite improvements since 2014. They also spend a greater proportion of their household income on internet connectivity while receiving less data for each dollar of expenditure.¹¹⁸

Figure 12: Digital inclusion is lower for those experiencing disadvantage and in rural areas



Note: Positive values represent digital inclusion higher than the national score, while negative values represent digital inclusion lower than the national score.

Source: Thomas et al. (2018)¹¹⁹

Ali Curung

The ADII includes a special survey of the remote Aboriginal community of Ali Curung, located 300 kilometres north of Alice Springs (112 individuals of a population of about 500 surveyed). The survey showed that this community uses the internet more than the Australian average to undertake activities such as online shopping, accessing government services, and accessing news.

However, the access index was much lower than the community overall due to the unreliability of mobile connectivity. Very few have a fixed broadband connection and the better objective value it provides users.

The higher absolute cost of a gigabyte of data (and smaller data allowances) on a mobile network compared with fixed broadband meant that affordability was very poor.¹²⁰



163. Challenge

The quality of telecommunications services varies for different groups across Australia, with digital inclusion lagging for low-income households, people who did not complete secondary school, those aged over 65 and people with disability. Without action, these people will be increasingly excluded from an increasingly digital world, exacerbating disadvantage.

When this will impact:



Where this will impact:



Enhancing consumer choice and experience

A competitive market helps drive the efficient use of existing assets, well-considered new investment, and greater choice for users. With market constraints on the ability to raise revenue for basic services, profits for telecommunications service providers are generally maximised through either cost efficiencies or product differentiation.

Despite the fact that Australia has a large degree of market consolidation in terms of operator market shares (with Telstra holding 51%), there is evidence of increasing competitive intensity for both mobile and fixed services. This reflects price and non-price competition by telecommunications providers in both fixed and mobile services. Providers are responding to strong consumer demand for communications services by providing greater choice and products at a range of price points.

The market for broadband plans has been relatively dynamic, with service providers constantly introducing new plans and removing or altering existing plans. Between 2013–14 and 2016–17, on average, less than half (43%) of the plans that were available in a given year were also available in the previous year.¹²¹ This suggests that characteristics of plans are currently changing considerably.

Analysis of mobile phone plans suggests that, with other characteristics including price unchanged, data quotas improved by 41% per year on average between 2014 and 2017.¹²²

In November 2017, the Australian Government announced the introduction of a consumer data right in Australia.¹²³ The consumer data right will improve consumers' ability to compare and switch between products and services. It will also encourage competition between service providers, leading not only to better prices for customers but also more innovative products and services.

The government has determined that the consumer data right will first apply to the banking sector, under a framework that will be known as Open Banking. The energy and telecommunications sectors are expected to follow banking. This should reduce the costs of switching and potentially spur innovation by service providers.

Reworking community service obligations in telecommunications

CSOs in telecommunications are likely to be required into the future as the challenges of digital inclusion remain, and digital connectivity becomes more central to people's lives.

CSO research commissioned by Infrastructure Australia has identified 18 defined CSOs in place across the telecommunications sector, at an estimated annual cost of \$1.8 billion.¹²⁴ Most of these costs are from CSOs put in place by the Australian Government.

The key findings of Infrastructure Australia's CSO research include:

- 62% of costs are for the provision of services above a commercial level or at below cost (primarily the nbn CSO)
- 35% of costs are for discounts, concessions and rebates (for example, the pension telephone allowance)
- Most of these CSOs were not provided in competitive markets, but generally formed parts of larger services (for example, as part of the nbn rollout)
- Over 80% of these costs were likely to remain stable into the future (not increase or decrease substantially over time)
- Only 44% of the telecommunications CSOs were found to be transparent in terms of their policy intent and target group, and reporting of costs and historical cost data.¹²⁵

The current Telecommunications Universal Service Obligation (TUSO) requires the provision of standard telephone services or payphones on request to every premises in the country, within defined timeframes. Telstra has the responsibility to deliver the TUSO and receives \$230 million per annum to provide fixed telephone services and \$40 million per annum for payphones. The Australian Government contributes \$100 million per annum, and industry contributes the remainder with Telstra contributing the most of any carrier.¹²⁶ This arrangement is currently in place until 2032.

In December 2017, the Australian Government changed the TUSO to acknowledge that the telecommunications market was now dominated by broadband and mobile technologies.¹²⁷ In December 2018, the Australian Government announced details of its new Universal Service Guarantee (USG), which will update the TUSO to give Australians guaranteed access to broadband as well as voice services – while ensuring current fixed telephone and payphone services are maintained in rural and remote areas.¹²⁸ The government has also stated that, while the USG will retain payphone services, there will be an examination of payphone locations given the uptake in mobile services.

164. Challenge

Telecommunications community service obligations lack transparency, competition and specificity, and are often technology prescriptive. Without action, both taxpayer and user outcomes will be further compromised, and CSOs will not service the locations and communities where need exists.

When this will impact:

0-5

5-10

10-15

15+

Where this will impact:



Australians are using more data for less

While consumer demand for telecommunications services has grown rapidly, average affordability of these services has also improved in the last decade (Figure 13). This is in contrast with most other types of infrastructure, including water, energy and transport.

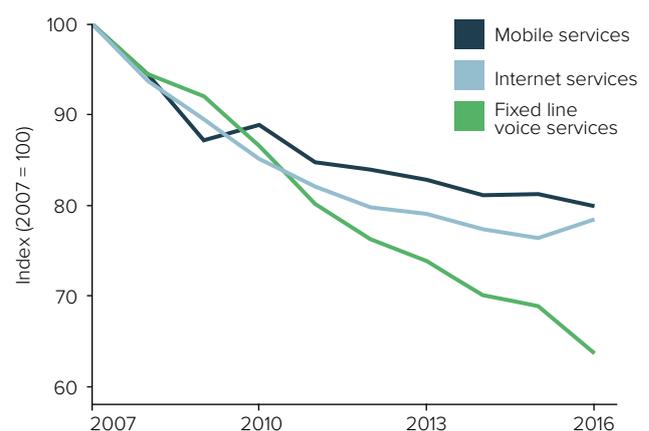
The rise of the smartphone, falling costs of data and an increase in adoption of applications such as Skype, WhatsApp and Facebook Messenger has meant that consumers have unprecedented choice when it comes to communications services. In the past 15 years, average household spending on communications services as a percentage of disposable income has generally fallen.

However, what is not captured in Figure 13 is that data limits for fixed and mobile services have substantially increased since 2012-13, as have product inclusions.¹²⁹ While it is not clear that this has resulted from direct customer demand, actual usage has strongly risen (Figure 14).

The average fixed broadband data consumption for a household is forecast to increase 340% from 95 GB a month in 2016 to 420 GB a month in 2026.¹³⁰ This will be driven by advances in technology such as high-definition content (4K/8K video), gaming, and augmented and virtual reality applications. It is estimated that the average speeds required to support this increased household consumption will

need to increase from between 11–20 Mbps in 2016 to between 20 and 49 Mbps in 2026, with only 2% of households expected to demand more than 49 Mbps in data speeds.¹³¹ The speed demand for businesses will vary by the nature of the business, and is likely to differ from household speed needs.

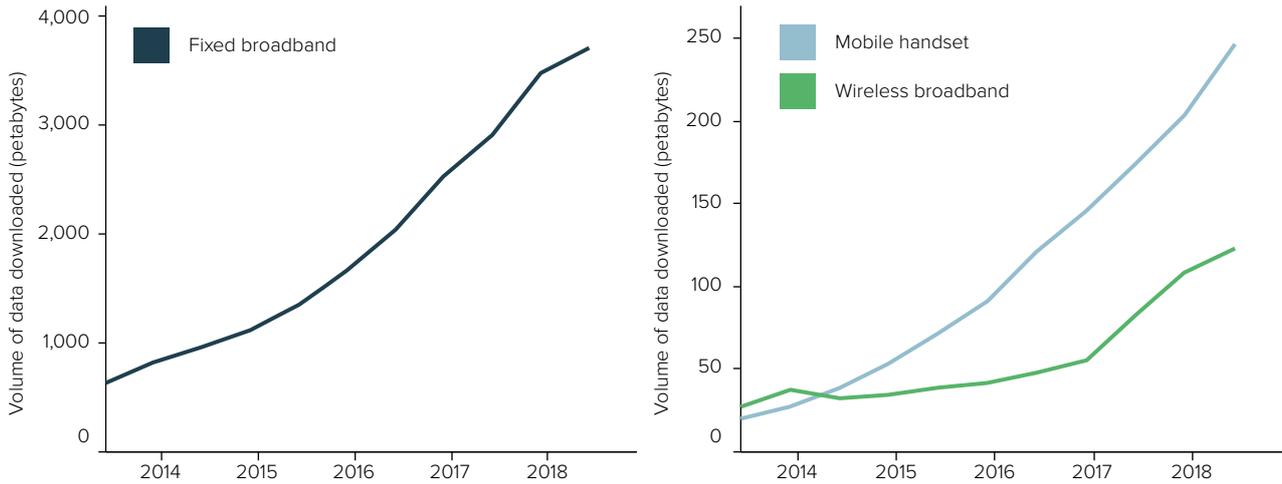
Figure 13: Telecommunications services have become cheaper over time



Note: The fixed line voice index is a measure of real changes in prices paid for fixed line voice services supplied using the public switched telephone network (PSTN) and voice over internet protocol (VoIP) technology. The mobile services index is a measure of real changes in prices paid for both prepaid and post-paid mobile services. The internet services index is a measure of real changes in prices paid for DSL, cable, wireless broadband and nbn internet services.

Source: Australian Competition and Consumer Commission (2017)¹³²

Figure 14: Data usage is growing, particularly for fixed broadband services



Source: Australian Bureau of Statistics (2018)¹³³

However, consumers rate telecommunications as costly

Australians generally feel that they spend more on telecommunications services today than they did five years ago.¹³⁴

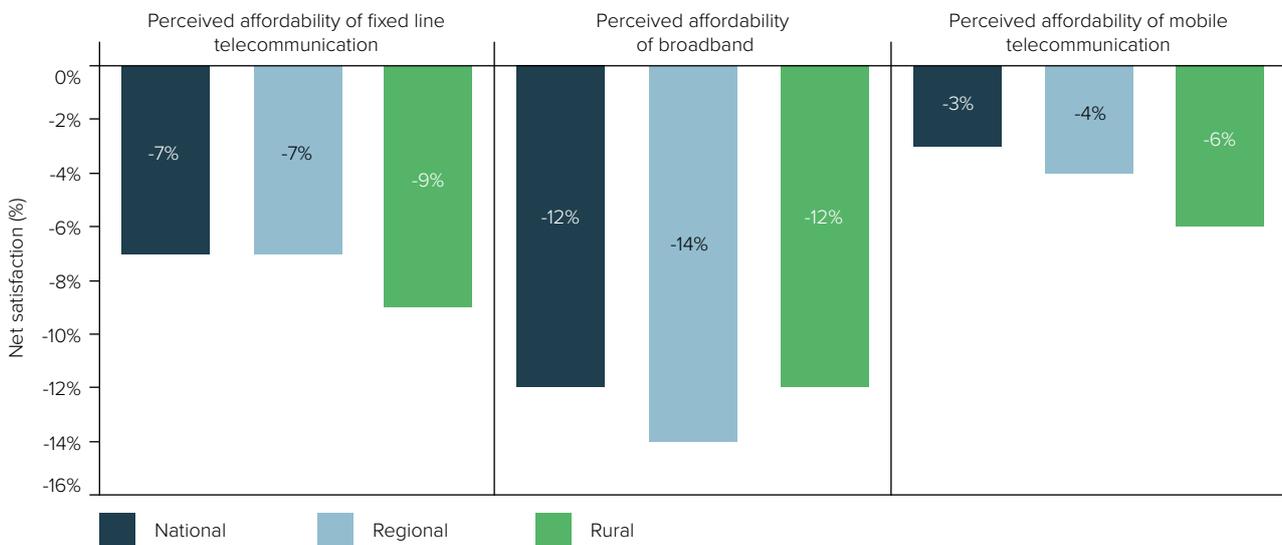
Figure 15 shows that consumers are more negative than positive about the affordability of fixed line, broadband and mobile services. Almost half of consumers rate broadband services as costly (44%, including 13% who rate them as ‘very costly’) and 31% rate them as affordable.¹³⁵ For mobile services, 39% of consumers rate services as costly, including 10% who rate them as ‘very costly’, and 36% rate their mobile services as affordable.¹³⁶ When compared to 27 categories of infrastructure costs, telecommunications ranks third, behind electricity and health and aged care, as the most costly.¹³⁷

However, when asked preferences for more or less investment in telecommunications infrastructure, the majority of consumers (greater than 66%) indicate they wanted more investment in both broadband and mobile telecommunications services.¹³⁸

Poorer households have a larger cost burden

While spending on telecommunications services as a percentage of disposable income is trending downward for the average Australian household, more vulnerable groups (such as low-income households) have seen their spending increase as a proportion of their disposable income (Figure 16). In fact, households in the lowest quintile are estimated to spend almost three times the proportion of their income on telecommunications services and equipment (such as handheld devices, routers and other hardware) as the highest quintile.¹³⁹

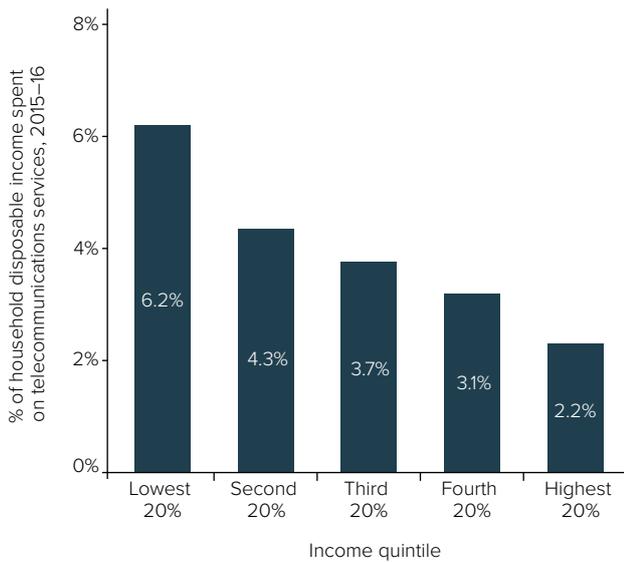
Figure 15: More consumers are negative than positive about telecommunications affordability



Note: Net satisfaction refers to the percentage of respondents who had a positive perception of telecommunications affordability minus who had a negative perception of telecommunications affordability.

Source: JWS Research (2018)¹⁴⁰

Figure 16: Poorer households spend more of their income on telecommunications services than wealthier households



Source: Australian Communications Consumer Action Network (2017)¹⁴¹

For those on pre- and post-paid mobile plans, there are differing pressures for those on lower incomes, even with some eligibility for limited government support (Centrelink Telephone Allowance).¹⁴² Major network operators also have their own programs to assist users and communities to afford telecommunications services. On the one hand, pre-paid plans avoid cost spikes by restricting usage once a monthly limit is reached, constraining access but maintaining affordability. On the other hand, post-paid plans can have add-ins or billing cycles that make bill management harder.¹⁴³

In regional and remote Australia, connectivity is just as important an issue as affordability. To ensure continuous reliable coverage, many regional Australians are paying for multiple services to factor in redundancies for failing technology. Research from the Better Internet for Rural, Regional and Remote Australia volunteer group suggests that equipment costs in regional and remote Australia can be higher in order to maintain connectivity, with their 2016 survey showing that 72% of mobile broadband users had to purchase additional equipment (costing between \$1,000 and \$2,000) to access reliable mobile coverage.¹⁴⁴

165. Challenge

In fast-growing and smaller cities, telecommunications services are supported by substantial infrastructure that brings fast speeds and data allowances. Access to these services is unaffordable for some groups and can exacerbate socio-economic inequality.

When this will impact:



Where this will impact:



166. Challenge

In regional centres and rural and remote areas, telecommunications infrastructure often delivers costly services which provide poor connectivity, speeds and data allowances. This means people often require extra equipment, such as devices and other hardware, to access services, or can only access mobile data services. This creates impacts for both businesses and individuals, which can exacerbate spatial inequalities.

When this will impact:



Where this will impact:





Business demand for telecommunications services is increasing, but there is resistance to paying more

Cloud computing, videoconferencing and the specific data needs of businesses and governments are driving demand for higher download and upload speeds.¹⁴⁵ It is estimated that 80% of Australian businesses already use cloud computing for software uses and 60% for data storage.¹⁴⁶

But there are costs for businesses in expanding their digital connectivity. This includes additional costs for data allowances, software, hardware and cybersecurity.

Research commissioned by Telstra indicates that, while over three-quarters of 550 surveyed businesses expect a productivity benefit from greater connectivity by 2030, they are split as to whether they are prepared to pay more for this service.¹⁴⁷

This suggests that many businesses are sensitive to pricing and that pricing may prove to be the biggest challenge for telecommunications providers to overcome – especially as they aim to increase 5G adoption amongst businesses. nbn wholesale pricing and business pricing packages are likely to have a major impact on business affordability.



167. Challenge

Businesses are increasingly demanding more from telecommunications services to compete in the digital economy, but increased downloads, speeds and storage come at a cost. Higher costs will reduce the ability for businesses to grow and compete domestically and internationally.

When this will impact:



Where this will impact:



8.6 Challenges and opportunities

Telecommunications enable productivity and innovation

152. Opportunity

Digital technologies are using telecommunications networks to enhance Australia's economic productivity. Embracing these new technologies can be a source of competitive advantage for Australia and can improve outcomes for users.

When this will impact:



Where this will impact:



153. Challenge

Australia's comparative performance for fixed broadband speeds is poor, and we lag well behind comparable nations. Failure to rapidly improve speeds could be a constraint on boosting productivity and liveability, and attracting businesses that require high levels of digital access.

When this will impact:



Where this will impact:



154. Challenge

Cybersecurity risks, such as data privacy and system resilience, are growing as more Australians use more interconnected digital services. Failure to manage these risks could affect user engagement with new services, and reduce the potential benefits of these services. Network efficiency could also suffer.

When this will impact:



Where this will impact:



The mobile coverage dilemma

155. Challenge

Prioritisation of mobile network upgrades in rural and remote areas creates gaps in crucial areas, such as on productive land and along transport corridors. Failure to deliver services to these areas affects community safety, liveability and productivity.

When this will impact:



Where this will impact:



156. Opportunity

5G technology presents an opportunity for Australia and we are well positioned to embrace it ahead of other nations. Delivering 5G networks will help to accelerate Australia's digital transformation, providing significant benefits to people, businesses and governments.

When this will impact:



Where this will impact:



157. Challenge

5G networks will require substantial new infrastructure, creating both cost, planning and security challenges. In cities, this means retrofitting new cells into existing streetscapes, and in rural and remote areas, this means creating adequate densities and improving coverage beyond that of 3G and 4G. Adequately balancing shared and competing tower and cell sites will affect the scale of investment, and ultimate costs users pay.

When this will impact:



Where this will impact:



158. Challenge

Government needs to balance different demands, including from mobile service providers, to deliver efficient and competitive allocation of radiofrequency spectrum. This will affect the quality and cost of mobile services for users.

When this will impact:



Where this will impact:



Maximising the benefits of nbn investment

159. Challenge

There is an inherent tension between the nbn's strategic goals, requiring potential trade-offs between achieving user outcomes and delivering a return on the capital investment made by taxpayers. If all goals cannot be achieved, the ability for Australians to access affordable and high-quality nbn services may be negatively affected.

When this will impact:



Where this will impact:



160. Challenge

The technology mix for the nbn has diversified, meaning different users will receive different types of connections. This change will deliver varied outcomes for users, and some may shoulder higher costs or receive lower-quality services.

When this will impact:



Where this will impact:



161. Opportunity

Private market broadband and mobile operators are providing competitive services in commercial locations to fill nbn gaps. Leveraging competition can provide greater choice for users, supporting affordable and high quality services.

When this will impact:



Where this will impact:



162. Challenge

A proposed eventual sale of the nbn to the private sector raises challenges in striking the right balance between realising its value for shareholders and achieving long-term goals for users. Decisions about restructuring and sale can affect both short- and long-term service delivery and outcomes for users.

When this will impact:



Where this will impact:



Social inclusion and affordability for telecommunications services

163. Challenge

The quality of telecommunications services varies for different groups across Australia, with digital inclusion lagging for low-income households, people who did not complete secondary school, those aged over 65 and people with disability. Without action, these people will be increasingly excluded from an increasingly digital world, exacerbating disadvantage.

When this will impact:



Where this will impact:



164. Challenge

Telecommunications community service obligations lack transparency, competition and specificity, and are often technology prescriptive. Without action, both taxpayer and user outcomes will be further compromised, and CSOs will not service the locations and communities where need exists.

When this will impact:



Where this will impact:



165. Challenge

In fast-growing and smaller cities, telecommunications services are supported by substantial infrastructure that brings fast speeds and data allowances. Access to these services is unaffordable for some groups and can exacerbate socio-economic inequality.

When this will impact:



Where this will impact:



166. Challenge

In regional centres and rural and remote areas, telecommunications infrastructure often delivers costly services which provide poor connectivity, speeds and data allowances. This means people often require extra equipment, such as devices and other hardware, to access services, or can only access mobile data services. This creates impacts for both businesses and individuals, which can exacerbate spatial inequalities.

When this will impact:



Where this will impact:



167. Challenge

Businesses are increasingly demanding more from telecommunications services to compete in the digital economy, but increased downloads, speeds and storage come at a cost. Higher costs will reduce the ability for businesses to grow and compete domestically and internationally.

When this will impact:



Where this will impact:



References

1. *The Australian Constitution 1901* (Cth) s 51(v).
2. Vintage Phones, *History of the Telephone in Australia and Worldwide*, Vintage Phones, viewed 22 May 2019, <https://www.vintagephones.com.au/ccp0-display/history-of-the-telephone-in-australia.html>.
3. Nielsen, *Australians Smartphone use 2018*, Nielsen, Sydney, viewed 22 May 2019, <https://www.nielsen.com/au/en/press-room/2018/february-2018-digital-ratings.html>.
4. Deloitte 2017, *Media Consumer Survey 2017: Australian media and digital preferences* 6th edition, Deloitte, Sydney, p 4, available via: http://landing.deloitte.com.au/rs/761-IBL-328/images/tmt-media-consumer-survey-2017-INB_pdf.pdf.
5. Nielsen, *Australians Smartphone use 2018*, Nielsen, Sydney, viewed 22 May 2019, <https://www.nielsen.com/au/en/press-room/2018/february-2018-digital-ratings.html>.
6. nbn, *List of phone and internet providers*, nbn, viewed 22 May 2019, <https://www.nbnco.com.au/residential/service-providers>.
7. Powertec Telecommunications, *Mobile Virtual Network Operators in Australia*, Powertec Telecommunications, viewed 22 May 2019, https://mobilenetworkguide.com.au/virtual_operators_information.html.
8. Australia Communications and Media Authority 2019, *Communications Report 2017-18*, Australia Communications and Media Authority, Sydney, p 10, available via: <https://acma.gov.au/-/media/Research-and-Analysis/Report/pdf/Communications-report-2017-18-pdf.pdf?la=en>; Australia Communications and Media Authority 2016, *Communications Report 2014-15*, Australia Communications and Media Authority, Sydney, p 9, available at: https://www.acma.gov.au/~/_media/Research%20and%20Analysis/Report/pdf/ACMA%20Communications%20report%202015-16%20pdf.pdf.
9. nbn 2016, *Statement of Expectations*, nbn, Sydney, p 2, available via: <https://www.communications.gov.au/file/19556/download?token=Q7Pg2NPu>.
10. nbn 2019, *We have taken action*, nbn, viewed 22 May 2019, <https://www1.nbnco.com.au/corporate-information/about-nbn-co/updates/dashboard-march-2019>.
11. JWS Research 2018, *Community perceptions of Australia's infrastructure*, prepared for Infrastructure Australia, November 2018, Sydney, available via: <https://www.infrastructureaustralia.gov.au/>.
12. JWS Research 2018, *Community perceptions of Australia's infrastructure*, prepared for Infrastructure Australia, November 2018, Sydney, available via: <https://www.infrastructureaustralia.gov.au/>.
13. JWS Research 2018, *Community perceptions of Australia's infrastructure*, prepared for Infrastructure Australia, November 2018, Sydney, available via: <https://www.infrastructureaustralia.gov.au/>.
14. Thomas, J, Barraket, J, Wilson, CK, Cook, K, Louie, YM & Holcombe-James, I, Ewing, S, MacDonald, T 2018, *Measuring Australia's Digital Divide: The Australian Digital Inclusion Index 2018*, RMIT University, Melbourne, for Telstra, accessed via: *Measuring Australia's Digital Divide: The Australian Digital Inclusion Index 2018*.
15. Ookla 2019, *Speedtest Global Index June 2019*, Ookla, viewed 23 July 2019, available via: <http://www.speedtest.net/global-index>.
16. Australia Communications and Media Authority 2018, *Communications Report 2017-18*, Australia Communications and Media Authority, Sydney, p 61, available at: <https://www.acma.gov.au/theACMA/communications-report>.
17. ACMA 2018, *Communications Report 2017-18*, ACMA, Sydney, p 58, available via: <https://www.acma.gov.au/theACMA/communications-report>.
18. ACMA 2018, *Communications Report 2017-18*, ACMA, Sydney, p 63, available at: <https://www.acma.gov.au/theACMA/communications-report>.
19. Thomas, J, Barraket, J, Wilson and CK, Cook, K 2018, *Measuring Australia's Digital Divide: The Australian Digital Inclusion Index 2018*, RMIT University, Melbourne, available via: <https://digitalinclusionindex.org.au/the-index-report/report/>.
20. Australian Competition & Consumer Commission 2019, *NBN speeds mostly steady, but improvements needed*, media release, ACCC, Canberra, available via: <https://www.accc.gov.au/media-release/nbn-speeds-mostly-steady-but-improvements-needed>.
21. ACCAN 2017, *Telecommunications Expenditure in Australia*, ACCAN, Sydney, p 5, available via: <http://accan.org.au/our-work/research/1460-telecommunications-expenditure-in-australia>.
22. Deloitte 2018, *Behaviour unlimited: Mobile Consumer Survey 2018 - the Australian Cut*, Deloitte, Sydney, p 29, available via: http://images.content.deloitte.com.au/Web/DELOITTEAUSTRALIA/%7B51598b8c-1c72-4ceb-8272-3a052f322992%7D_20181103-tel-inbound-mobile-consumer-survey-2018-report-2.pdf?elq_mid=1006&elq_cid=85080.
23. Columbus, L 2018, 'State of Enterprise Cloud Computing, 2018', *Forbes*, August 30, available via: <https://www.forbes.com/sites/louiscolombus/2018/08/30/state-of-enterprise-cloud-computing-2018/#647a38c7265e>.
24. University of NSW, City Futures Research Centre and Astrolabe Group 2019, *Australia's Household Infrastructure Bill: Analysis Report*, University of NSW City Futures Research Centre and Astrolabe Group, Sydney, p 6, available via: <https://www.infrastructureaustralia.gov.au/>.
25. JWS Research 2018, *Community perceptions of Australia's infrastructure*, JWS Research, Melbourne, p 23, available via: <https://www.infrastructureaustralia.gov.au/>.
26. Australian Bureau of Statistics 2018, *Internet Activity, Australia, June 2018*, cat. no. 8153.0, viewed 22 May 2019, <https://www.abs.gov.au/ausstats/abs@.nsf/mf/8153.0/>.
27. Department of Communications and the Arts 2018, *Demand for fixed-line broadband in Australia*, Australian Government, Canberra, p 6, available via: <https://www.communications.gov.au/publications/demand-fixed-line-broadband-australia>.
28. nbn 2019, *Corporate Plan 2019-2022*, nbn, Sydney, p 58, available via: <https://www.nbnco.com.au/corporate-information/media-centre/corporate-plan-2019-2022>.
29. Department of Communications and the Arts 2018, *Demand for fixed-line broadband in Australia*, Australian Government, Canberra, p 7, available via: <https://www.communications.gov.au/publications/demand-fixed-line-broadband-australia>.
30. nbn 2019, *Corporate Plan 2019-2022*, nbn, Sydney, p 59, available via: <https://www.nbnco.com.au/corporate-information/media-centre/corporate-plan-2019-2022>.
31. GSMA 2017, *Mobile Connectivity Index 2017 – The Global Scores*, GSMA, viewed 22 May 2019, available at: <https://www.mobileconnectivityindex.com/#year=2017&dataSet=indexScore>.
32. Centre for International Economics 2018, *Infrastructure-Related Community Service Obligations*, Canberra, p 1, available via: <https://www.infrastructureaustralia.gov.au/>.
33. Department of Communications and the Arts 2018, *2018 Regional Telecommunications Review – Getting it right out there*, Australian Government, Canberra, p 22, available via: <https://www.communications.gov.au/publications/2018-regional-telecommunications-review-getting-it-right-out-there>.
34. nbn 2019, *Corporate Plan 2019-2022*, nbn, Sydney, p 59, available via: <https://www.nbnco.com.au/corporate-information/media-centre/corporate-plan-2019-2022>.

35. Department of Communications and the Arts 2018, *New round for the Mobile Black Spot Program*, Australian Government, Canberra, available via: <https://www.communications.gov.au/departmental-news/new-round-mobile-black-spot-program>.
36. ACMA 2018, *Communications Report 2017-18*, ACMA, Sydney, p 18, available via: <https://www.acma.gov.au/theACMA/communications-report>.
37. Australian Competition & Consumer Commission 2018, *Communications sector market study final report*, Australian Government, Canberra, p 21, available via: <https://www.accc.gov.au/publications/communications-sector-market-study-final-report>.
38. Department of Industry Innovation and Science 2017, *Australian Innovation System Report 2017*, Department of Industry Innovation and Science, Canberra, p 16, available via: <https://publications.industry.gov.au/publications/australianinnovationsystemreport2017/documents/australian-innovation-system-report-2017.pdf>.
39. Australian Bureau of Statistics 2017, *8129.0 – Business use of information technology, 2015-16*, Australian Bureau of Statistics, Canberra, Table 12, available via: http://www.abs.gov.au/AUSSTATS/subscriber.nsf/log?openagent&81290do002_201516.xls&8129.0&Data%20Cubes&AA1BB818508A5349CA258162001982E9&0&2015-16&20.07.2017&Latest.
40. nbn 2018, *Connecting Australia: The impact of the NBN on Australian lives and the economy*, nbn, Sydney, p 14, available at http://www.connectingaustralia.com.au/pdf/Connecting_Australia_Report.pdf.
41. nbn 2018, *Connecting Australia: The impact of the NBN on Australian lives and the economy*, nbn, Sydney, p 14, available at http://www.connectingaustralia.com.au/pdf/Connecting_Australia_Report.pdf.
42. Department of Communications and the Arts, *Impacts of 5G on productivity and economic growth*, Australian Government, Canberra, p 1, available at <https://www.communications.gov.au/publications/impacts-5g-productivity-and-economic-growth>.
43. Australian Computer Society and PwC 2018, *Australia's IoT opportunity: Driving Future Growth*, Australian Computer Society, p 9, available at <https://www.acs.org.au/content/dam/acs/acs-publications/ACS-PwC-IoT-report-web.pdf>.
44. Australian Computer Society and PwC 2018, *Australia's IoT opportunity: Driving Future Growth*, Australian Computer Society, p 9, available at <https://www.acs.org.au/content/dam/acs/acs-publications/ACS-PwC-IoT-report-web.pdf>.
45. SULO Environmental Technology, *C-trace*, SULO, viewed 22 May 2019, <http://www.sulo.com.au/c-trace-by-sulo/>.
46. Telstra 2019, *Annual Report 2017-8*, Telstra, Sydney, p 21, available via: <https://www.telstra.com.au/content/dam/tcom/about-us/investors/pdf%20F/2018-Annual-Report.pdf>.
47. Australian Communications and Media Authority 2018, *Communications Report 2016-7*, Sydney, p 4, available via: <https://www.acma.gov.au/theACMA/communications-report>.
48. Bureau of Communications and Arts Research 2018, *Demand for fixed-line broadband in Australia*, Bureau of Communications and Arts Research, p 35, available via: <https://www.communications.gov.au/publications/demand-fixed-line-broadband-australia>.
49. Denholm, R 2018, Telstra adds narrowband capability to Australia's leading IoT network, Telstra, 12 January 2018, available via: <https://www.telstra.com.au/aboutus/media/media-releases/Telstra-adds-narrowband-capability-to-Australia-leading-IoT-network>.
50. GSMA Association 2019, *GSMA Mobile Connectivity Index*, GSMA Association, London, p 10, available via: https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2018/09/GSMA_Mobile-Connectivity-Index-GLOBAL-Focus.pdf.
51. Ookla 2019, *Speedtest Global Index June 2019*, Ookla, viewed 23 July 2019, available via: <http://www.speedtest.net/global-index>.
52. Australia Communications and Media Authority 2019, *Communications Report 2017-18*, Australia Communications and Media Authority, Sydney, p 61, available via: <https://acma.gov.au/-/media/Research-and-Analysis/Report/pdf/Communications-report-2017-18-pdf.pdf?la=en>.
53. Ookla 2019, *Speedtest Global Index June 2019*, Ookla, viewed 23 July 2019, available via: <http://www.speedtest.net/global-index>; Australian Consumer and Competition Commission 2019, *Broadband performance data*, Australian Consumer and Competition Commission, viewed 23 July 2019, available via: <https://www.accc.gov.au/consumers/internet-landline-services/broadband-performance-data>.
54. International Telecommunications Union 2017, *Global Cybersecurity Index 2017*, International Telecommunications Union, Geneva, p 17, available via: https://www.itu.int/dms_pub/itu-d/opb/str/d-str-gci.01-2017-pdf-e.pdf.
55. DLA Piper, *Data Protection Laws of the World*, DLA Piper, viewed 22 May 2019, <https://www.dlapiperdataprotection.com/index.html?c=AU&c2=US&go-button=GO&t=law>.
56. DLA Piper, *Data Protection Laws of the World*, DLA Piper, viewed 22 May 2019, <https://www.dlapiperdataprotection.com/index.html?c=AU&c2=US&go-button=GO&t=law>.
57. The Treasury 2019, *Consumer Data Right (Authorised Deposit-taking institution) Designation 2018*, Australian Government, viewed 22 May 2019, <https://treasury.gov.au/consumer-data-right/>.
58. Deloitte 2018, *Behaviour Unlimited: Mobile Consumer Survey 2018 – The Australian Cut*, Deloitte, Sydney, p 30, available at: http://images.content.deloitte.com.au/Web/DELOITTEAUSTRALIA/%7B51598b8c-1c72-4ceb-8272-3a052f322992%7D_20181103-tel-inbound-mobile-consumer-survey-2018-report-2.pdf?elq_mid=1006&elq_cid=85080.
59. Deloitte 2017, *Australian privacy Index 2016: Trust without Borders*, Deloitte, Sydney: <https://www2.deloitte.com/content/dam/Deloitte/au/Documents/risk/deloitte-au-risk-australian-privacy-index-2016-100516.pdf>.
60. Zhang, A and Zakku, E and Llewellyn, R and Baker, E 2018, 'Surveying the Needs and Drivers for Digital Agriculture in Australia', *Farm Policy Journal*, vol. 15, no. 1, p 29, available via: <https://publications.csiro.au/rpr/pub?pid=csiro:EP18226>.
61. Zhang, A and Zakku, E and Llewellyn, R and Baker, E 2018, 'Surveying the Needs and Drivers for Digital Agriculture in Australia', *Farm Policy Journal*, vol. 15, no. 1, p 29, available via: <https://publications.csiro.au/rpr/pub?pid=csiro:EP18226>.
62. Royal Flying Doctor Service, *Defining rural and remote*, Royal Flying Doctor Service, viewed 22 May 2019, <https://www.flyingdoctor.org.au/what-we-do/research/defining-rural-remote/>.
63. Bureau of Communications and Arts Research 2017, *Trends and drivers in the affordability of communications services for Australian households – working paper*, Bureau of Communications and Arts Research, p 25, available via: https://www.communications.gov.au/file/28486/download?token=a_EaL6S9.
64. Australian Competition and Consumer Commission 2016, *Domestic mobile roaming declaration inquiry – Discussion paper October 2016*, p 13, available via: https://www.accc.gov.au/system/files/Mobile%20roaming%20declaration%20inquiry%20final%20report_0.pdf.
65. Australian Communications Consumer Action Network, *Future Consumer: Emerging Consumer Issues in Telecommunications and Convergent Communications and Media*, Australian Communications Consumer Action Network, Sydney, p 22, available via: http://www.accan.org.au/files/Reports/ACCAN_Future_Consumer.pdf.
66. Australian Communications Consumer Action Network, *Future Consumer: Emerging Consumer Issues in Telecommunications and Convergent Communications and Media*, Australian Communications Consumer Action Network, Sydney, p 23, available via: http://www.accan.org.au/files/Reports/ACCAN_Future_Consumer.pdf.
67. Department of Communications and the Arts, *Mobile Black Spot Program*, Department of Communications and the Arts, viewed 22 May 2019, <https://www.communications.gov.au/what-we-do/phone/mobile-services-and-coverage/mobile-black-spot-program>.
68. Australian Competition and Consumer Commission 2018, *Regional Mobile Issues Forum*, Sydney, Australian Competition and Consumer Commission, p 3, available via: https://www.communications.gov.au/sites/g/files/net301f/submissions/australian_competition_and_consumer_commission_accc_1_of_2.pdf.

69. Australian Government 2018, *2018 Regional Telecommunications Review: getting it right out there*, Australian Government, pp 29-30, available via: <https://www.communications.gov.au/publications/2018-regional-telecommunications-review-getting-it-right-out-there>.
70. GSMA Association 2017, *GSMA Mobile Connectivity Index*, GSMA Association, viewed 22 May 2019: <https://www.mobileconnectivityindex.com/#year=2017&dataSet=indexScore>.
71. GSMA Association 2017, *GSMA Mobile Connectivity Index*, GSMA Association, viewed 22 May 2019: <https://www.mobileconnectivityindex.com/#year=2017&dataSet=indexScore>.
72. Venture Insights 2018, *Australian Telecommunications Market Outlook*, Venture Insights, Sydney, available at: <https://www.ventureinsights.com.au/product/australian-telecommunications-market-outlook-pressures-mount-as-nbn-begins-to-dominate-fixed-broadband-mobile-continuing-strong-growth/>.
73. Australian Communications and Media Authority 2018, *Communications Report 2016-7*, Sydney, pp 23-24, available via: <https://www.acma.gov.au/theACMA/communications-report>.
74. Telstra 2019, *About Telstra Air*, Telstra, viewed 22 May 2019, <https://www.telstra.com.au/telstra-air/about-telstra-air>.
75. Australian Competition and Consumer Commission 2016, *Domestic mobile roaming declaration inquiry – Discussion paper October 2016*, p 27, available via: https://www.accc.gov.au/system/files/Mobile%20roaming%20declaration%20inquiry%20final%20report_0.pdf.
76. McKinsey & Company 2018, *The road to 5G: The inevitable growth of infrastructure cost*, 2018, McKinsey & Company, viewed 22 May 2019, <https://www.mckinsey.com/industries/telecommunications/our-insights/the-road-to-5g-the-inevitable-growth-of-infrastructure-cost>.
77. PwC Australia 2019, *To build or not to build? Making a case for 5G: Challenges for Australian mobile network operators*, PwC Australia, Sydney, viewed 22 May 2019, available via: www.strategyand.pwc.com/au/report/to-build-or-not-to-build.
78. Department of Communications and the Arts 2018, *Carrier powers and immunities*, Australian Government, Canberra, viewed 22 May 2019, available via: www.communications.gov.au/policy/policy-listing/carrier-powers-and-immunities.
79. Raper, A and Sas N 'Huawei-made 'small cell' boxes hit suburban Sydney, as residents raise health concerns', *ABC News*, 7 January 2019, available via: www.abc.net.au/news/2019-01-07/huawei-small-cell-network-comes-to-sydney/10688124.
80. Raper, A and Sas N 'Huawei-made 'small cell' boxes hit suburban Sydney, as residents raise health concerns', *ABC News*, 7 January 2019, available via: www.abc.net.au/news/2019-01-07/huawei-small-cell-network-comes-to-sydney/10688124.
81. *Telecommunications Act 1997 (Cth)*.
82. Sims, R, *Competition and the 5G spectrum*, October 2018, available at <https://www.accc.gov.au/speech/competition-the-5g-spectrum>.
83. Australian Government, nbn, *Statement of Expectations*, 24 August 2016, available at <https://www.communications.gov.au/publications/nbnstatementofexpectations>.
84. Australian Government, nbn, *Statement of Expectations*, 24 August 2016, available at <https://www.communications.gov.au/publications/nbnstatementofexpectations>.
85. Sims, R *Competition and the 5G spectrum*, speech, ACMA RadComms 2018, Sydney, 30 October 2018, available via: www.accc.gov.au/speech/competition-the-5g-spectrum.
86. Department of Communications and the Arts 2016, *NBN Co Statement of Expectations 2016*, Australian Government, Canberra, available via: www.communications.gov.au/publications/nbnstatementofexpectations.
87. Parliamentary Budget Office 2016, *National Broadband Network – Impact of the Budget, Report 04/2016*, Australian Government, Canberra, available via: https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Budget_Office/Publications/Research_reports/Report_042016.
88. Australian Competition and Consumer Commission 2018, *Communications Sector Market Study Final report*, Australian Government, Canberra, p 6, available via www.accc.gov.au/publications/communications-sector-market-study-final-report.
89. nbn 2010, 2011-13 Corporate Plan, p 23, available at <https://www.nbnco.com.au/corporate-information/media-centre/media-statements/nbn-co-corporate-plan-released>; nbn 2018, *Corporate Plan 2019-22*, nbn, p 58, available via: www.nbnco.com.au/corporate-information/about-nbn-co/corporate-plan/corporate-plan.
90. Finder 2019, *NBN Multi-Technology Mix Comparison*, Finder, viewed 22 May 2019, available via: <https://www.finder.com.au/nbn-technology-comparison>.
91. Australian Competition and Consumer Commission 2018, *ACCC role in communications*, Australian Government, Canberra available via: <https://www.accc.gov.au/regulated-infrastructure/communications/accc-role-in-communications>.
92. nbn 2018, *Corporate Plan 2019-22*, nbn, pp 58-69, available via: www.nbnco.com.au/corporate-information/about-nbn-co/corporate-plan/corporate-plan.
93. Australian Competition & Consumer Commission 2018, *Communications Sector Market Study*, Australian Government, Canberra, available via: <https://www.accc.gov.au/publications/communications-sector-market-study-final-report>.
94. nbn 2018, *Corporate Plan 2019-22*, nbn, pp 63-64, available via: www.nbnco.com.au/corporate-information/about-nbn-co/corporate-plan/corporate-plan.
95. *Telecommunications (Regional Broadband Scheme) Charge Bill 2018 (Cth)*.
96. Poole, J 'An internet for everyone? Not yet', *The Interconnected Enterprise*, 7 August 2018, viewed 22 May 2019, available via: <https://www.networkworld.com/article/3295597/an-internet-for-everyone-not-yet.html>.
97. Department of Communications and the Arts 2018, 2018 Regional Telecommunications Review, Australian Government, Canberra, available via: <https://www.communications.gov.au/have-your-say/2018-regional-telecommunications-review>.
98. nbn 2018, *Introducing the nbn Business Satellite Service*, nbn, viewed 26 June 2019, <https://www.nbnco.com.au/business/product-and-technical-information/business-satellite-service>.
99. *National Broadband Network Companies Act 2011*, Part 3
100. ACMA 2018, *Communications Report 2017-18*, ACMA, Sydney, p 5, available via: <https://www.acma.gov.au/theACMA/communications-report>.
101. ACMA 2017, *Communications Report 2016-17*, ACMA, Sydney, p 59, available via: <https://www.acma.gov.au/-/media/Research-and-Analysis/Report/pdf/Communications-report-2016-17-pdf.pdf?la=en>.
102. Digital Transformation Agency 2019, *Vision 2025: We will deliver world-leading digital services for the benefit of all Australians*, Australian Government, Canberra, p 13, available via: <https://www.dta.gov.au/digital-transformation-strategy/3-strategic-priorities>.
103. Ericsson 2018, *Internet of Things Forecast*, Ericsson, viewed 22 May 2019, available at: <https://www.ericsson.com/en/mobility-report/internet-of-things-forecast>.
104. Ericsson 2018, *Internet of Things Forecast*, Ericsson, viewed 22 May 2019, available at: <https://www.ericsson.com/en/mobility-report/internet-of-things-forecast>.
105. Ericsson 2018, *Internet of Things Forecast*, Ericsson, viewed 22 May 2019, available at: <https://www.ericsson.com/en/mobility-report/internet-of-things-forecast>.

106. JWS Research 2018, *Community perceptions of Australia's infrastructure*, JWS Research, Melbourne, p 69, available via: <https://www.infrastructureaustralia.gov.au/>.
107. JWS Research 2018, *Community perceptions of Australia's infrastructure*, JWS Research, Melbourne, p 69, available via: <https://www.infrastructureaustralia.gov.au/>.
108. JWS Research 2018, *Community perceptions of Australia's infrastructure*, JWS Research, Melbourne, p 69, available via: <https://www.infrastructureaustralia.gov.au/>.
109. JWS Research 2018, *Community perceptions of Australia's infrastructure*, JWS Research, Melbourne, p 69, available via: <https://www.infrastructureaustralia.gov.au/>.
110. JWS Research 2018, *Community perceptions of Australia's infrastructure*, JWS Research, Melbourne, p 69, available via: <https://www.infrastructureaustralia.gov.au/>.
111. JWS Research 2018, *Community perceptions of Australia's infrastructure*, JWS Research, Melbourne, p 69, available via: <https://www.infrastructureaustralia.gov.au/>.
112. Bureau of Communication and Arts Research 2018, *Demand for fixed-line broadband in Australia*, Australian Government, Canberra, p 10, available at: <https://www.communications.gov.au/publications/demand-fixed-line-broadband-australia>.
113. nbn 2017, Fair Use Policy, *NBN™ Ethernet Product Module Wholesale Broadband Agreement*, nbn, Sydney, available at: <https://www.nbnco.com.au/content/dam/NBNco2/2018/documents/sell/wba/SFAA-Wholesale-Broadband-Agreement-FairUsePolicy-NBN-Ethernet-Product-Module.pdf>.
114. Australian Competition & Consumer Commission 2018, *Measuring Broadband Australia - Report 3*, Australian Government, Canberra, available at: <https://www.accc.gov.au/consumers/internet-phone/broadband-performance-data>.
115. Australian Competition & Consumer Commission 2018, *Measuring Broadband Australia - Report 3*, Australian Government, Canberra, available at: <https://www.accc.gov.au/consumers/internet-phone/broadband-performance-data>.
116. Thomas, J, Barraket, J, Wilson, CK, Cook, K, Louie, YM & Holcombe-James, I, Ewing, S, MacDonald, T 2018, *Measuring Australia's Digital Divide: The Australian Digital Inclusion Index 2018*, RMIT University, Melbourne, available via: <https://digitalinclusionindex.org.au/the-index-report/about-the-index/>.
117. Thomas, J, Barraket, J, Wilson, CK, Cook, K, Louie, YM & Holcombe-James, I, Ewing, S, MacDonald, T 2018, *Measuring Australia's Digital Divide: The Australian Digital Inclusion Index 2018*, RMIT University, Melbourne, available via: <https://digitalinclusionindex.org.au/the-index-report/about-the-index/>.
118. Thomas, J, Barraket, J, Wilson, CK, Cook, K, Louie, YM & Holcombe-James, I, Ewing, S, MacDonald, T 2018, *Measuring Australia's Digital Divide: The Australian Digital Inclusion Index 2018*, RMIT University, Melbourne, available via: <https://digitalinclusionindex.org.au/the-index-report/about-the-index/>.
119. Thomas, J, Barraket, J, Wilson, CK, Cook, K, Louie, YM & Holcombe-James, I, Ewing, S, MacDonald, T 2018, *Measuring Australia's Digital Divide: The Australian Digital Inclusion Index 2018*, p. 21, RMIT University, Melbourne, for Telstra, accessed via: <https://digitalinclusionindex.org.au/the-index-report/about-the-index/>.
120. Thomas, J, Barraket, J, Wilson, CK, Cook, K, Louie, YM & Holcombe-James, I, Ewing, S, MacDonald, T 2018, *Measuring Australia's Digital Divide: The Australian Digital Inclusion Index 2018*, p. 21, RMIT University, Melbourne, for Telstra, accessed via: <https://digitalinclusionindex.org.au/the-index-report/about-the-index/>.
121. Australian Competition & Consumer Commission 2018, *Competition and price changes in telecommunication services in Australia 2016-17*, Australian Government, Canberra, available at: <https://www.accc.gov.au/system/files/Competition%20and%20price%20changes%20in%20telecommunications%20services%20in%20Australia%202016-17.pdf>.
122. Australian Competition & Consumer Commission 2018, *Competition and price changes in telecommunication services in Australia 2016-17*, Australian Government, Canberra, available at: <https://www.accc.gov.au/system/files/Competition%20and%20price%20changes%20in%20telecommunications%20services%20in%20Australia%202016-17.pdf>.
123. Department of Prime Minister and Cabinet 2017, *Australians to own their own banking, energy, phone and internet data*, Australian Government, Canberra, 26 November 2017, available at: <https://ministers.pmc.gov.au/taylor/2017/australians-own-their-own-banking-energy-phone-and-internet-data>.
124. Centre for International Economics 2018, *Infrastructure-Related Community Service Obligations*, Canberra, p 1, available via: <https://www.infrastructureaustralia.gov.au/>.
125. Centre for International Economics 2018, *Infrastructure-Related Community Service Obligations*, Canberra, p 1, available via: <https://www.infrastructureaustralia.gov.au/>.
126. Department of Communications and the Arts, *Universal Service Guarantee Fact Sheet*, Australian Government, Canberra, available via: <https://www.communications.gov.au/documents/universal-service-guarantee-fact-sheet>.
127. Department of Communications and the Arts, *Universal Service Guarantee Fact Sheet*, Australian Government, Canberra, available via: <https://www.communications.gov.au/documents/universal-service-guarantee-fact-sheet>.
128. Department of Communications and the Arts, *Universal Service Guarantee Fact Sheet*, Australian Government, Canberra, available via: <https://www.communications.gov.au/documents/universal-service-guarantee-fact-sheet>.
129. Bureau of Communications and Arts Research 2017, *Trends and drivers in the affordability of communications services for Australian households – working paper*, Australian Government, Canberra, p 13, available via: <https://www.communications.gov.au/documents/trends-and-drivers-affordability-communications-services-australian-households-0>.
130. Bureau of Communications and Arts Research 2018, *Demand for fixed-line broadband in Australia*, Australian Government, Canberra, p7, available at: <https://www.communications.gov.au/publications/demand-fixed-line-broadband-australia>.
131. Bureau of Communications and Arts Research 2018, *Demand for fixed-line broadband in Australia*, Australian Government, Canberra, p7, available at: <https://www.communications.gov.au/publications/demand-fixed-line-broadband-australia>.
132. Australian Competition and Consumer Commission 2017, *Competition in the Australian telecommunications sector: Price changes for telecommunications services in Australia*, p. 108, available via: <https://www.accc.gov.au/publications/accc-telecommunications-report/accc-telecommunications-report-2015-16>.
133. Australian Bureau of Statistics 2018, *8153.0 – Internet Activity, June 2018*, Australian Government, Canberra, Tables 3 and 5, available at: https://www.abs.gov.au/ausstats/subscriber.nsf/log?openagent&81530do001_201806.xls&8153.0&Data%20Cubes&A1BD35CBCEf0BE42CA2583190077EE04&0&June%202018&02.10.2018&Latest.
134. JWS Research 2018, *Community perceptions of Australia's infrastructure*, JWS Research, Melbourne, p 64, available via: <https://www.infrastructureaustralia.gov.au/>.
135. JWS Research 2018, *Community perceptions of Australia's infrastructure*, JWS Research, Melbourne, p 64, available via: <https://www.infrastructureaustralia.gov.au/>.
136. JWS Research 2018, *Community perceptions of Australia's infrastructure*, JWS Research, Melbourne, p 64, available via: <https://www.infrastructureaustralia.gov.au/>.
137. JWS Research 2018, *Community perceptions of Australia's infrastructure*, JWS Research, Melbourne, p 64, available via: <https://www.infrastructureaustralia.gov.au/>.

138. JWS Research 2018, *Community perceptions of Australia's infrastructure*, JWS Research, Melbourne, p 64, available via: <https://www.infrastructureaustralia.gov.au/>.
139. Australian Communications Consumer Action Network 2017, *Telecommunications Expenditure in Australia*, ACCAN, Sydney, p 4, available via: <http://accan.org.au/our-work/research/1460-telecommunications-expenditure-in-australia>.
140. JWS Research 2018, *Community perceptions of Australia's infrastructure*, JWS Research, Melbourne, p 64, available via: <https://www.infrastructureaustralia.gov.au/>.
141. Australian Communications Consumer Action Network 2017, *Telecommunications Expenditure in Australia*, ACCAN, Sydney, p 4, available via: <http://accan.org.au/our-work/research/1460-telecommunications-expenditure-in-australia>.
142. Department of Human Services 2018, *Telephone Allowance*, Australian Government, viewed 22 May 2019, <https://www.humanservices.gov.au/individuals/services/centrelink/telephone-allowance>.
143. Australian Communications Consumer Action Network 2016, *Connectivity Costs – Telecommunications affordability for low income Australians*, ACCAN, Sydney, available at: http://accan.org.au/files/Reports/161011_Connectivity%20Costs_accessible-web.pdf.
144. Australian Competition & Consumer Commission 2018, *Regional Mobile Issues Forum - 28 February 2018 – Summary Report*, Australian Government, Canberra, p 3, available at: https://www.communications.gov.au/sites/g/files/net301f/submissions/australian_competition_and_consumer_commission_acc_1_of_2.pdf.
145. nbn 2019, *Corporate Plan 2019-22*, nbn, Sydney, p 41, available at: <https://www.nbnco.com.au/content/dam/NBNco2/2018/documents/media-centre/corporate-plan-report-2019-2022.pdf>.
146. Australian Competition & Consumer Commission 2018, *Communications Sector Market Study*, Australian Government, Canberra, p 84, available via <https://www.accc.gov.au/publications/communications-sector-market-study-final-report>.
147. Deloitte 2018, *5G mobile technology - Are businesses ready to seize the opportunity?*, Deloitte, Sydney, p 8, available via: <https://www2.deloitte.com/content/dam/Deloitte/au/Documents/Economics/deloitte-au-economics-5g-mobile-technology-170918.pdf>.

