# Measuring Broadband Australia

Report 11, December 2020

In 2017 the Australian Competition and Consumer Commission (ACCC) launched its project to measure internet performance. SamKnows was appointed to supply their Whiteboxes to internet users in Australia to measure the quality of experience for fixed-line internet.

The goal of the Measuring Broadband Australia is to increase transparency and encourage greater performance-based competition and better internet performance throughout the country.

# Overview

## 1 to 31 October 2020

This is the eleventh report issued as part of the Measuring Broadband Australia program. For this reporting period, measurements were collected over the month of October 2020, a 31 day period.

SamKnows prepares these reports each quarter for publication by the ACCC. The metrics are also presented by the ACCC in a public dashboard at:

https://www.accc.gov.au/consumers/internet-phone/broadband-performance-data

The program tests fixed-line services.
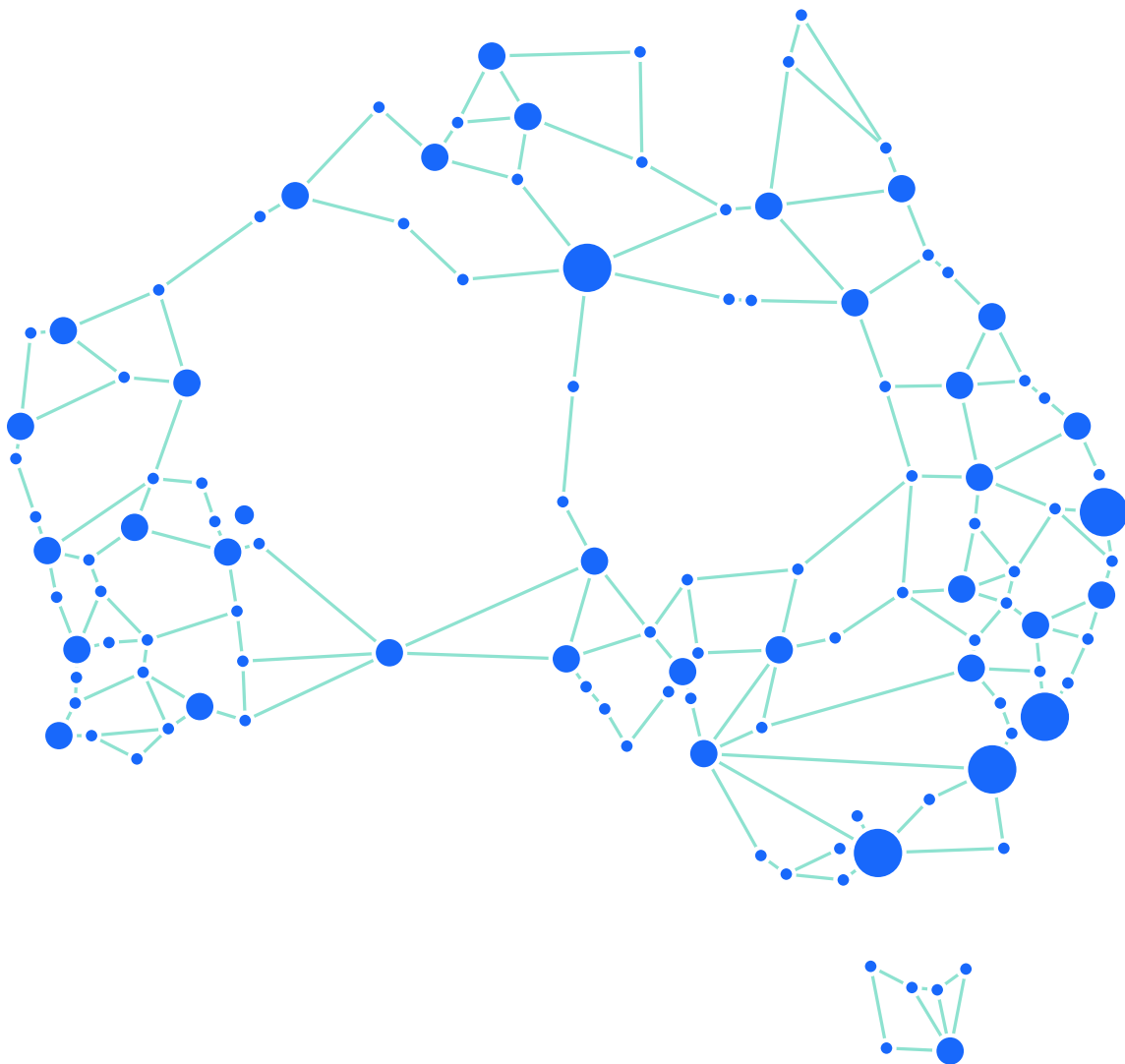
# COVID-19 and NBN performance

COVID-19 has led to a major switch in home internet usage patterns. More people are working and learning from home, increasing pressure on telecommunications networks.

In response, NBN Co has:

- provisioned more CVC (connectivity virtual circuit) capacity for retail service providers (RSPs)

- over-provisioned the download component of some NBN speed tiers by around 10 – 15 per cent where possible.

CVC is one of the essential elements of NBN performance. It is used to aggregate the traffic of an RSP's consumers. Where consumers are doing a lot of things on the internet at once, this will fill up a CVC and cause congestion. If CVC is under-provisioned relative to consumer requirements, then consumers will likely be impacted and speeds will slow, particularly during the busy hours. NBN Co implemented a 40 per cent CVC boost in late March 2020, and this capacity additional capacity was available to RSPs during the test period.

Over the period between June and August 2020, NBN Co started to implement over-provisioning of the download component of some speed tiers by around 10 – 15 per cent where possible. A certain proportion of a customer's plan speed is given over to protocol overhead, which is key to ensuring that communications are delivered to the right place. The over-provisioning of the download component now means that consumers can more reliably experience speeds that are closer to the maximum set download speed of their chosen retail plan speed.

Both of these measures introduced by NBN Co has caused an uplift in results in this report, particularly for download speeds and related metrics. The results presented in this report are reflective of performance during October 2020.

# Speed Test Results

Figures in this report relating to download and upload speed are generally expressed as a percentage of the service's plan speed. Plan speed is not always the same as the speed advertised for a plan by RSPs. Hence, where the report outlines speed measures below 100 percent of plan speed, this should not be interpreted as the RSP having failed to provide the speed that it advertised.

### Average download speed by RSP
*Including underperforming services. Error bars indicate 95% confidence intervals of the mean.*
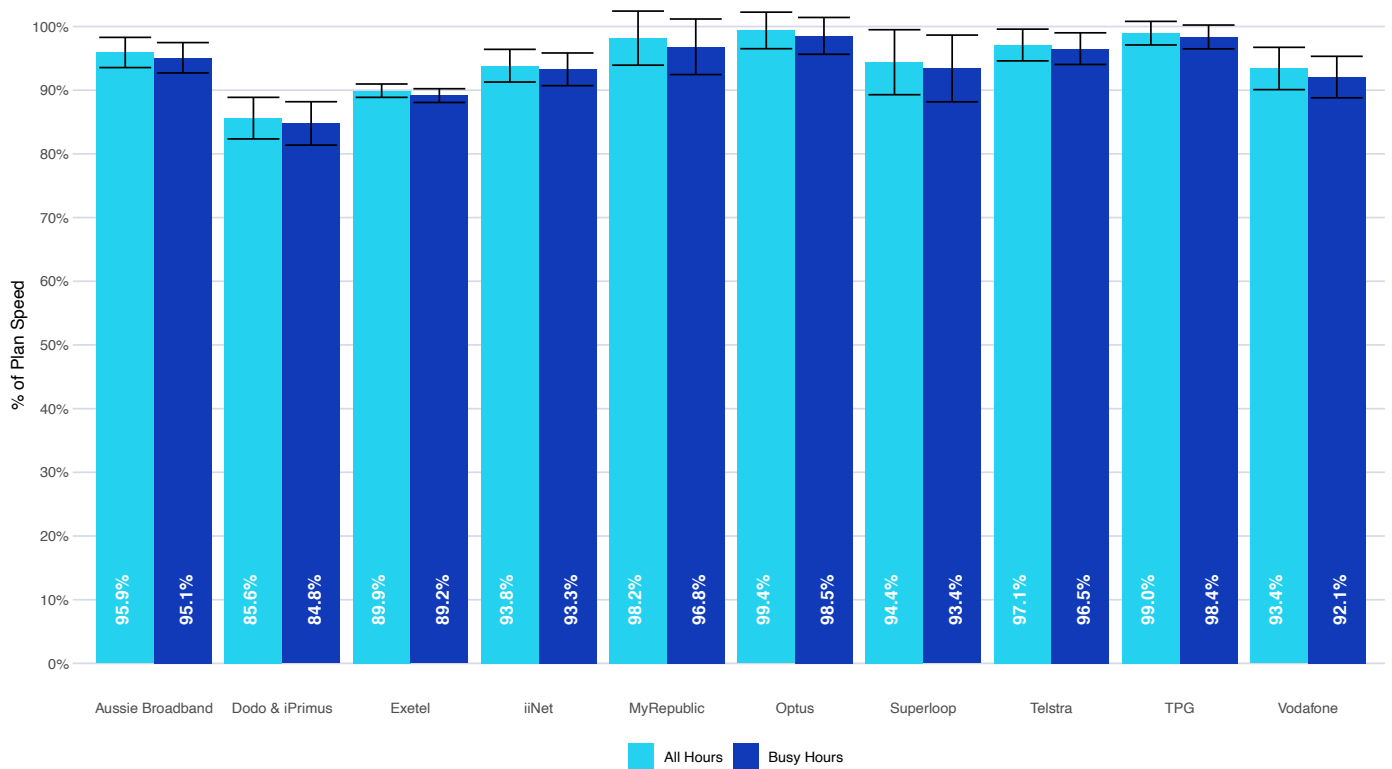


During this period, users on NBN connections attained an average download performance of 95.7% of plan speeds during all hours, decreasing to 94.9% during the busy hours (between 7pm and 11pm) which is when networks experience higher user activity.

This is a substantial increase on results collected previously by Measuring Broadband Australia. The main cause for this increase is that a larger proportion of NBN fixed line services are now over-provisioned to allow speeds closer to the maximum set download speed. For example: prior to this change, an nbn100 service would have been provisioned at slightly above 100 Mbps plan speed; after protocol overhead, the highest speed test result which we could have measured might have been around 94 Mbps. After the change, the same service might have been provisioned at above 100 Mbps plan speed, meaning that even after protocol overheads we might still measure speeds around or slightly above 100 Mbps. The increase in CVC has meant that there is sufficient capacity for RSPs to deliver speeds that are very close to the maximum set download speed.

This change is clearly evident in our results. Across October, 53.9% of NBN services we monitored had an average download speed higher than the plan speed.

To give an indication of the impact of this change in provisioning, the set of results in our previous report for May-June 2020 showed an all hours average download performance of 88.5% of plan speed, decreasing to 86.7% during busy hours. This implies that all-hours download performance has increased by 7.2 percentage points, and busy hour download performance by 8.2 percentage points, since the previous set of measurements.

As with previous reports, the 95% confidence intervals in the chart above are a measure of how certain we are that the true average download speed lies between the upper and lower boundary indicated by the thin black

lines. For example, Optus had an average download performance of 99.4% with a 95% confidence interval of ±2.9%. This means that if we were to repeat our sampling 100 times, we expect that average performance would fall between 96.5% and 102.3% in at least 95 cases.

## Average hourly download speed by plan

*Including underperforming services.*
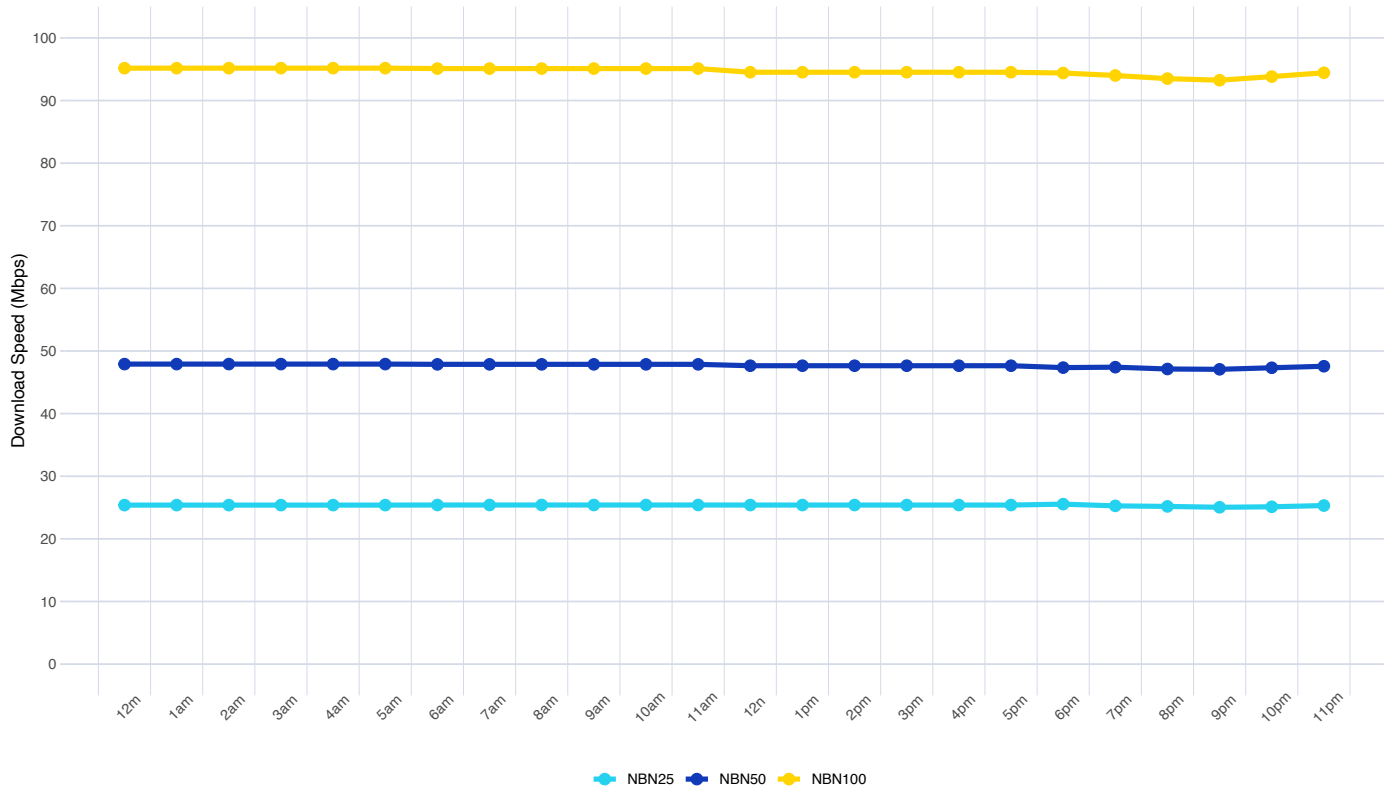


Average download speeds held steady throughout the day for users on most NBN speed tiers. The 100 Mbps NBN tiers remain the most affected by increased user activity in the evening hours: speeds typically started to decrease during the evening, dipping to 1.9 Mbps below the day's maximum by 9pm, and would recover to higher levels during the night.

## Frequency of download speeds attained during tests

*All hours. Including underperforming services.*
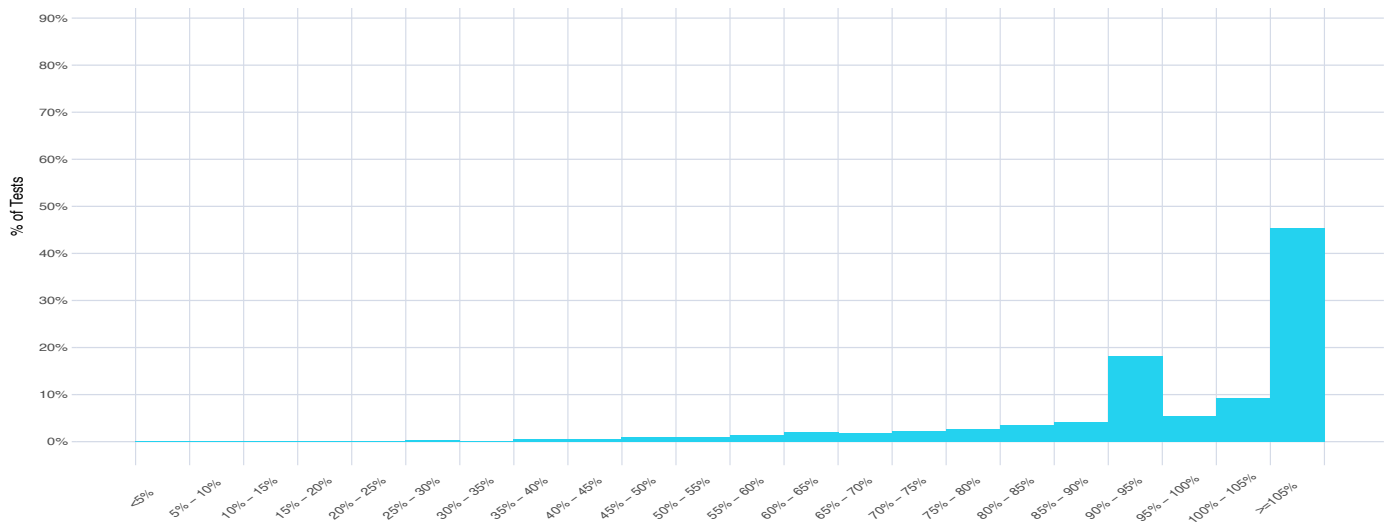
219,583 download speed tests were performed across 1,223 Whiteboxes connected to fixed-line NBN infrastructure during the period. 78.4% of tests conducted achieved a download speed of at least 90% of the plan's download speed – this is an increase from 74.8% in the previous report.

A much larger fraction of tests than in previous reports - around 54.7% - achieved speeds above 100% of their plan speed. This reflects the over-provisioning of NBN services and the increase in CVC capacity.
There is a spike at the 90%-95% level. Not all NBN services had been over-provisioned by the end of this measurement period, and some services switched over to the new provisioning during the measurement period.

3.1% of tests achieved less than 50% of plan speed; for reference, in the previous report 2.7% of tests had failed to meet the 50% mark.

## Average upload speed by RSP

*Including underperforming services. Error bars indicate 95% confidence intervals of the mean.*



Upload performance was similar when compared to the previous report: NBN services achieved an overall average upload performance of 85.1% during all hours, as against 86.1% in the previous report. By contrast to download speeds, the upstream side of NBN services has not been over-provisioned, and so these upload speed test results do not show a substantial change on previous reports.

Average upload performance ranged between 83.0% and 90.2% during all hours across RSPs.

## Average hourly upload speed by plan

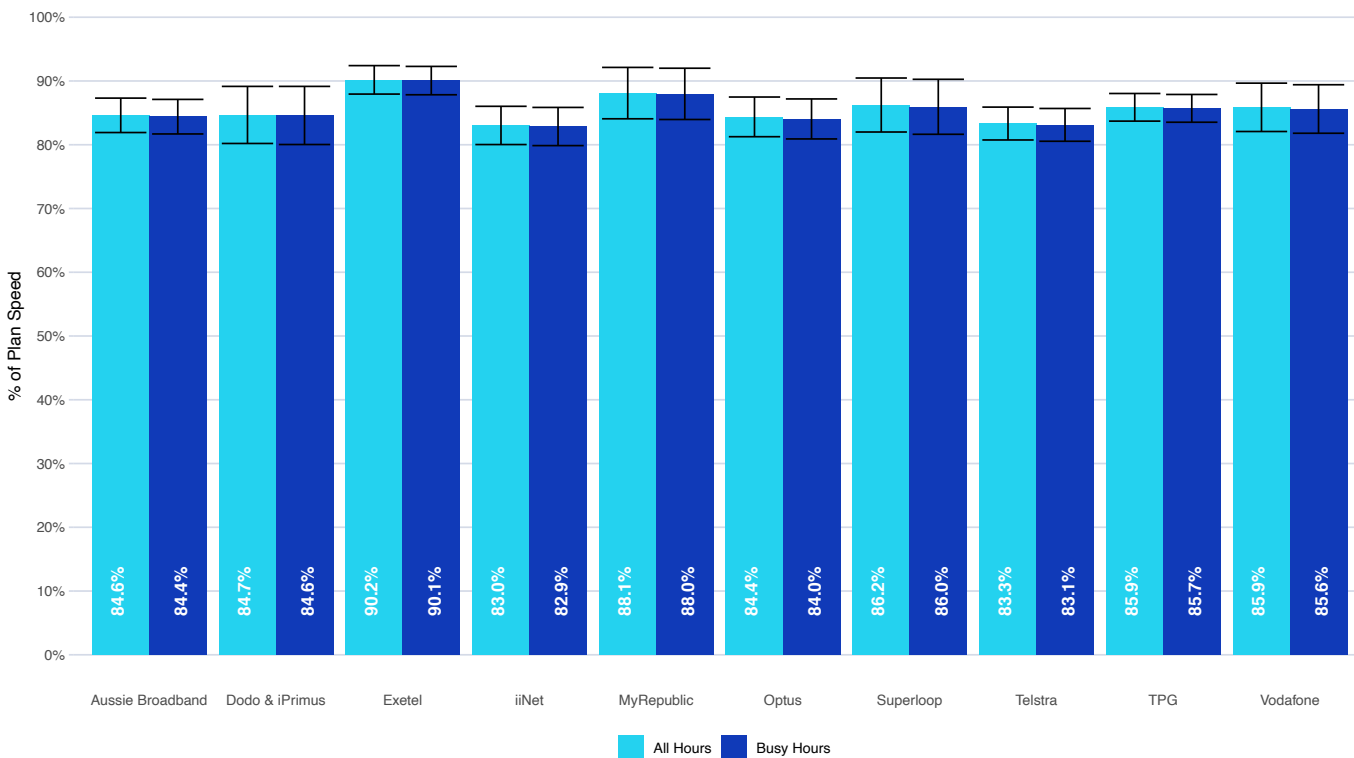*Including underperforming services.*
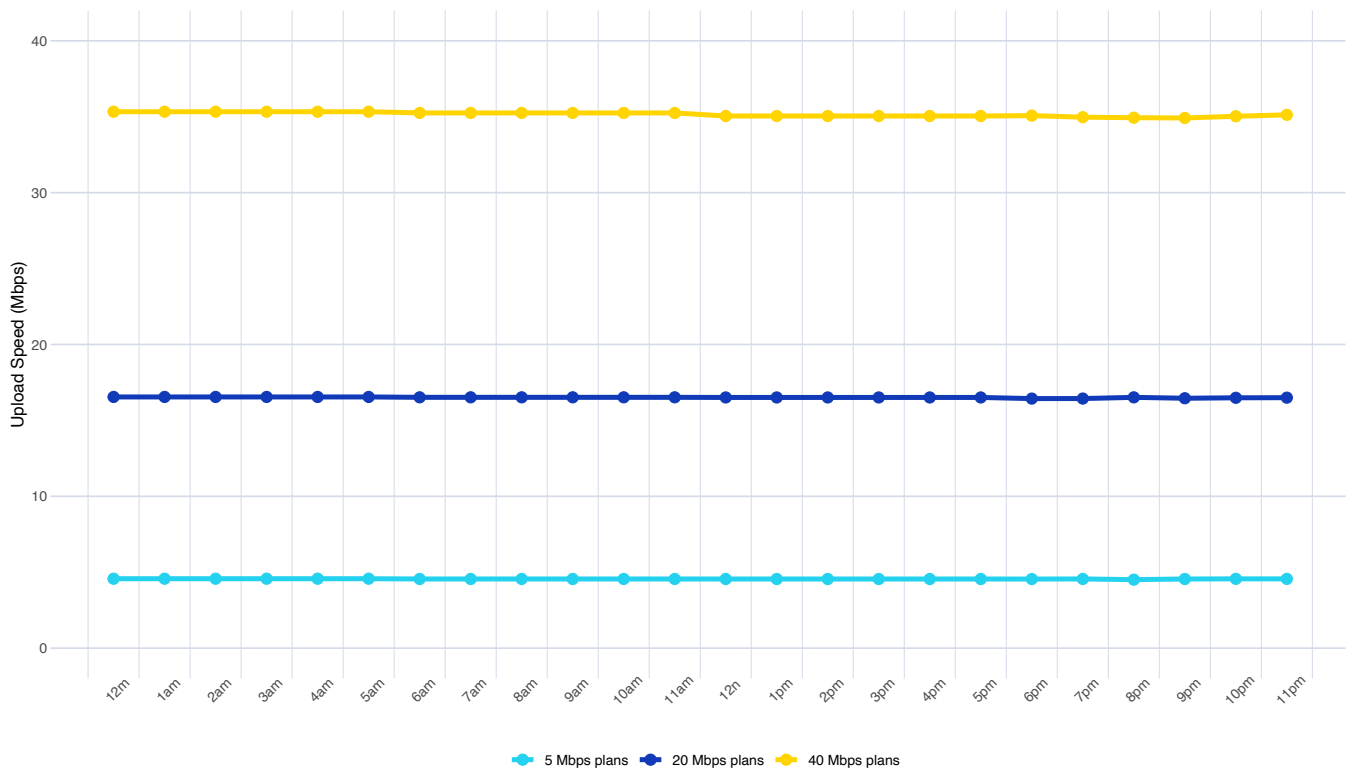


Average hourly upload speeds were steady throughout the day, with negligible change during busy evening hours.

# Video Streaming

The following chart shows the proportion of NBN services on the main NBN plans which would be able to reliably stream (without stopping and starting) a varying number of videos from Netflix simultaneously.

A High Definition video stream from Netflix would take up around 6 Mbps data rate on average. An Ultra High Definition (4K) video stream would take up 15.6 Mbps on average. The actual data rate will vary during video streaming: for example Netflix would use a higher data rate during a fast-paced action scene. It will also depend on Netflix's user traffic at a given time. The Whitebox measures the total downstream data rate available from Netflix's servers, and so using multiples of 6 Mbps (for High Definition) and 15.6 Mbps (for Ultra High Definition) allows us to infer whether a service would be able to handle different numbers of streams. This assumes no other use of the connection at the time i.e. that Netflix is the only application running.

**Netflix streaming by plan - busy hours**

*Excluding underperforming and impaired services.*
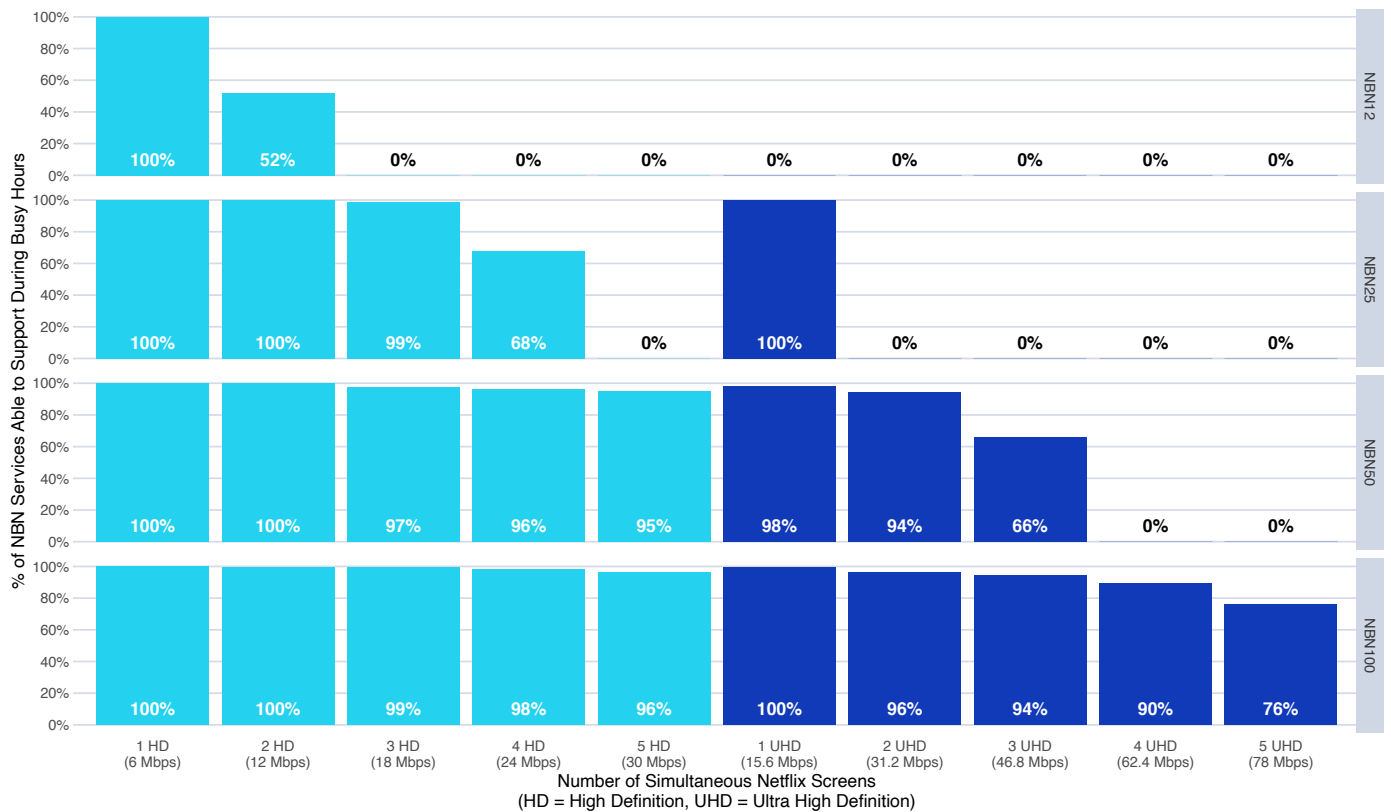


As a result of over-provisioning of download speeds and the increase in CVC capacity, many services are now able to deliver speeds that are very close to the maximum set download speed. In some cases this has increased the number of simultaneous screens which can theoretically be streamed.

- Around half[1] of NBN12 services would now be able to support simultaneous Netflix streams. In the previous report none were able to support multiple streams.

- Nearly all NBN25 services would support three simultaneous High Definitions streams, or a single Ultra High Definition stream. 68% of NBN25 services would support four simultaneous High Definition streams.

- NBN50 plans would further be able to handle four High Definition or two Ultra High Definition videos. 65% (up from 20% in the previous report) of NBN50 services can handle three Ultra High Definition streams.

- NBN100 plans will generally allow up to five Netflix videos to be watched with the highest quality settings available.

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1  Data was collected from 25 NBN12 services for this report, which is a lower number than for other plans; results for the NBN12 tier should be considered as indicative only.

Similar tests were run to YouTube. Since YouTube caps the data rate at which it serves video, test results could not be used to infer whether a service would be able to handle multiple concurrent streams. Nevertheless, nearly all tests from all NBN plans were able to stream YouTube reliably in Ultra High Definition.

Netflix content is served by 'Open Connect Appliance' CDN (content delivery network) caches embedded within RSPs' networks. Since the endpoints tested for each RSP are different, Netflix performance can vary across RSPs.

The following chart shows the proportion of NBN50 services which would be able to reliably stream two, three, or four simultaneous Netflix videos in High Definition, split by RSP.

**Netflix streaming by RSP - NBN50 services - busy hours**

*Excluding underperforming and impaired services.*
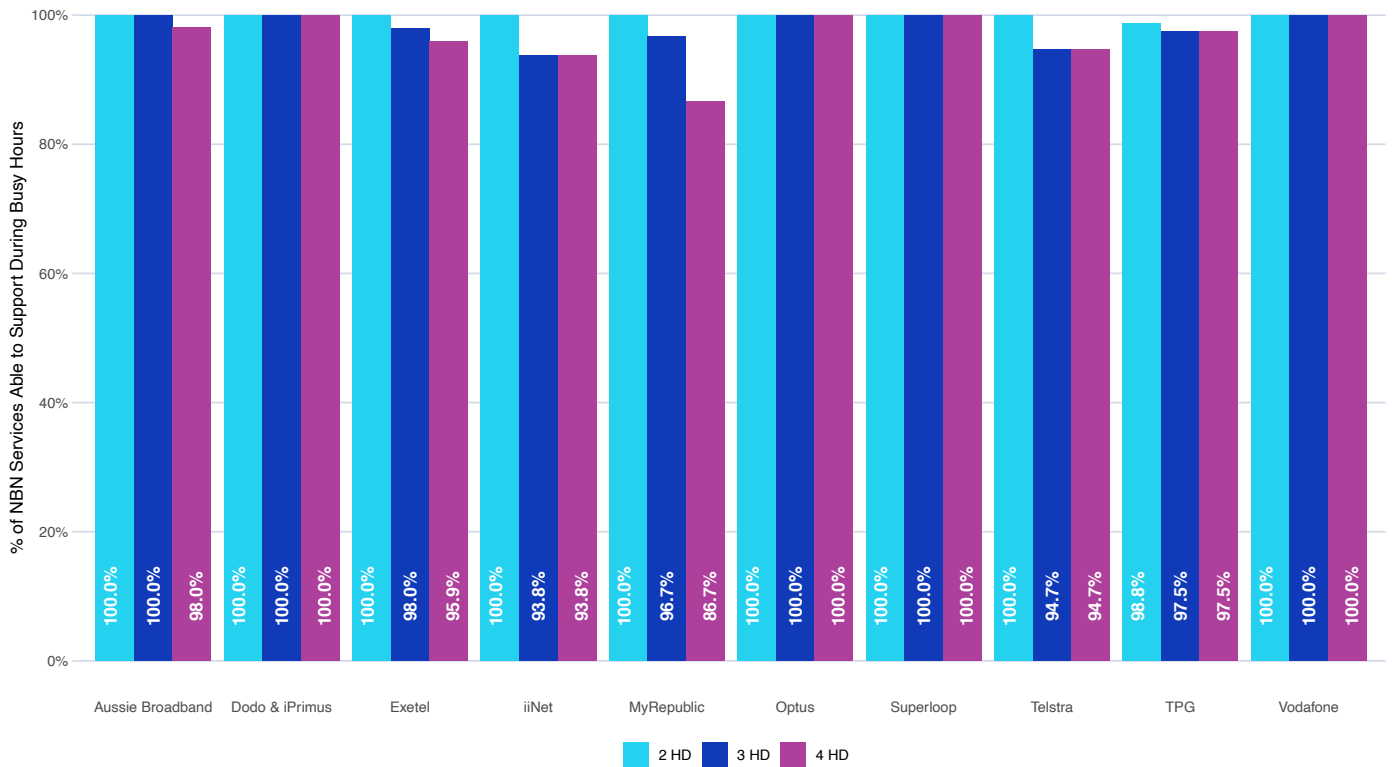


MyRepublic has shown an improvement in Netflix performance for its NBN50 services. In the previous report only 58% of MyRepublic's NBN50 services could handle four simultaneous HD streams; this proportion has now increased to 87%. It should be noted that the results for Dodo & iPrimus and MyRepublic are based on data from 23 and 30 Whiteboxes respectively, and so the results for those RSPs should be considered as indicative only.

# Impact of underperforming services[2] on download speed

As in previous reports, we present separate measures of download performance exclusive of underperforming services. These are services that do not achieve speeds that approach plan speeds at any time of the day. These are essentially services that the RSP supplies to a consumer with a plan speed that cannot be attained due to specific physical limitations affecting the service.
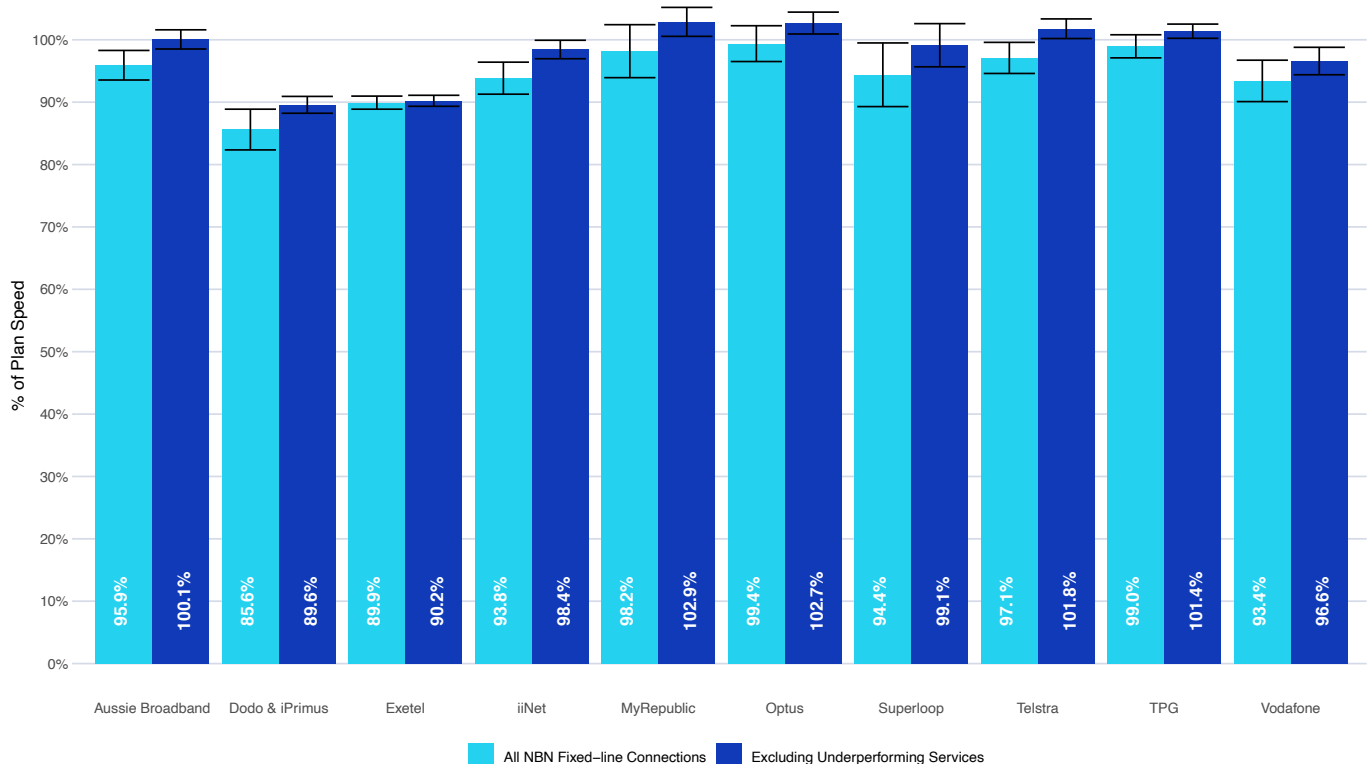
This information allows consumers to better understand the reported download and upload speed measures by removing the effect of services which, due to physical limitations, would be better assigned to another plan. At the same time, this comparison provides stronger incentives for service providers to improve service quality for customers on underperforming services; a small number of underperforming services can have an appreciable effect on an RSP's overall performance metrics.

Underperforming services represented 8.1% of the 1,223 NBN services that were tested for this report. 92% of underperforming NBN services are fibre to the node connections. 97% are on NBN50 and NBN100 plans. The average download performance once underperforming services are excluded is 99.3% as against the 95.7% figure quoted earlier for all services. This means that if underperforming services had been remediated before the measurements were collected then overall download performance would have been 3.6 percentage points higher than was actually observed during the period.

As in previous reports, all RSPs' performance were impacted to some extent by underperforming services during the period.

**Average download speed by RSP - all hours**

*Inclusive and exclusive of underperforming services. Error bars indicate 95% confidence intervals of the mean.*



Legend: All NBN Fixed–line Connections | Excluding Underperforming Services

Data values by RSP (All / Excluding):
- Aussie Broadband: 95.9% / 100.1%
- Dodo & iPrimus: 85.6% / 89.6%
- Exetel: 89.9% / 90.2%
- iiNet: 93.8% / 98.4%
- MyRepublic: 98.2% / 102.9%
- Optus: 99.4% / 102.7%
- Superloop: 94.4% / 99.1%
- Telstra: 97.1% / 101.8%
- TPG: 99.0% / 101.4%
- Vodafone: 93.4% / 96.6%

2   We classify a service as 'underperforming' if no more than 5 percent of speed tests that we conducted over the service achieved a speed that was above 75 percent of plan speed. This test effectively identifies those services with maximum attainable speeds that fall closer to the plan speed of a lower speed tier than to the plan speed of the consumer's current tier.

# Download Speed by NBN Plan and Access Technology

The following chart shows average download speed for different access technologies for different NBN speed tiers.

**Average Download speed by plan and technology.**

*Including underperforming services. Error bars indicate 95% confidence intervals of the mean.*
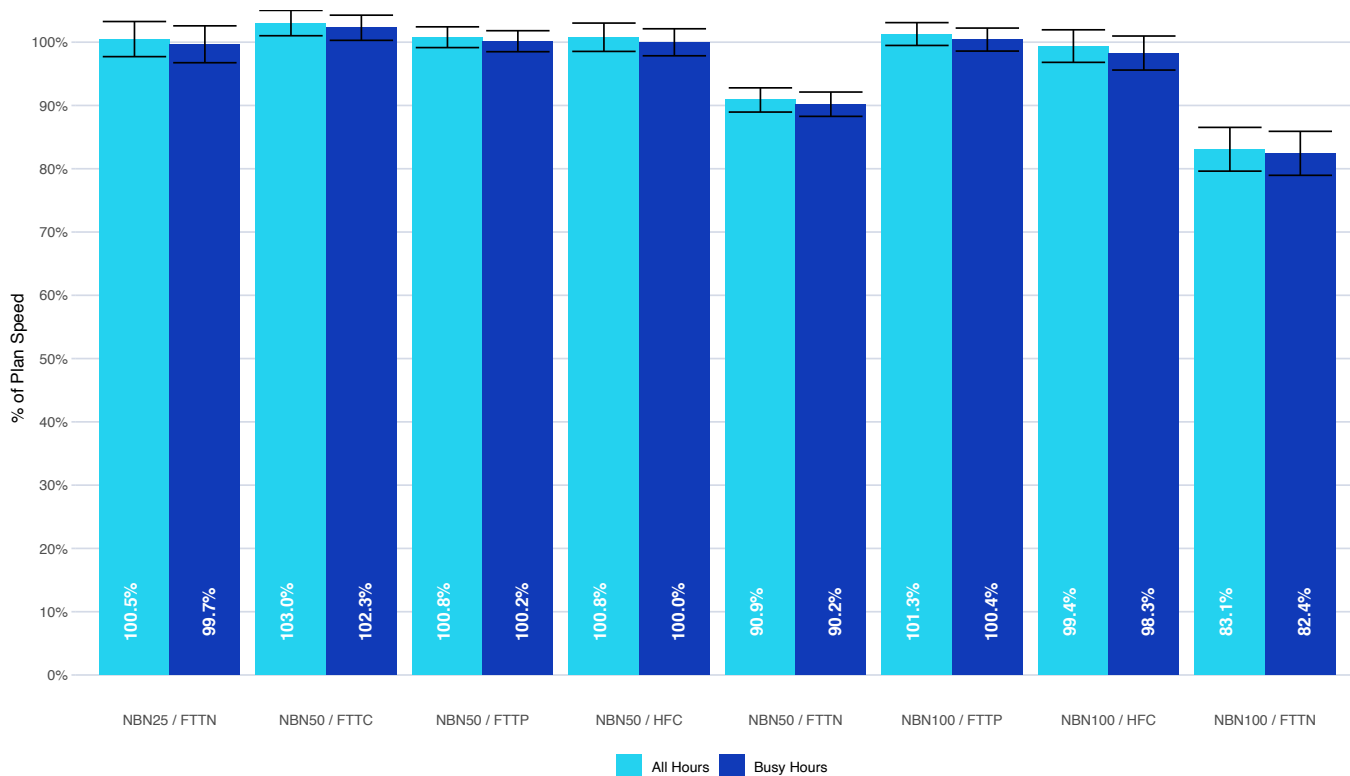


Within the 50/20 Mbps NBN speed tier, fibre to the node services had an average download speed around 5 Mbps lower than other technologies. Within the 100 Mbps NBN speed tiers, fibre to the node services had an average download speed around 17 Mbps lower than other technologies.

Following the higher incidence of over-provisioning, all technology/plan combinations have seen an increase in download performance. Fibre to the node services on the NBN100 plan saw a relatively modest 1.9 percentage point increase in download performance, whereas other technology/plan combinations saw increases ranging from 7.1 to 10.0 percentage points. We will continue to track the standing of fibre to the node relative to other technologies in future reports.

The following chart shows the impact of underperforming services on average download speed across different plans and technologies.

## Average download speed by plan and technology - all hours

*Inclusive and exclusive of underperforming services. Error bars indicate 95% confidence intervals of the mean.*



| | All NBN Fixed–line Connections | Excluding Underperforming Services |
|---|---|---|
| NBN25 / FTTN | 100.5% | 102.2% |
| NBN50 / FTTC | 103.0% | 103.0% |
| NBN50 / FTTP | 100.8% | 101.2% |
| NBN50 / HFC | 100.8% | 101.2% |
| NBN50 / FTTN | 90.9% | 97.6% |
| NBN100 / FTTP | 101.3% | 101.9% |
| NBN100 / HFC | 99.4% | 100.6% |
| NBN100 / FTTN | 83.1% | 90.2% |
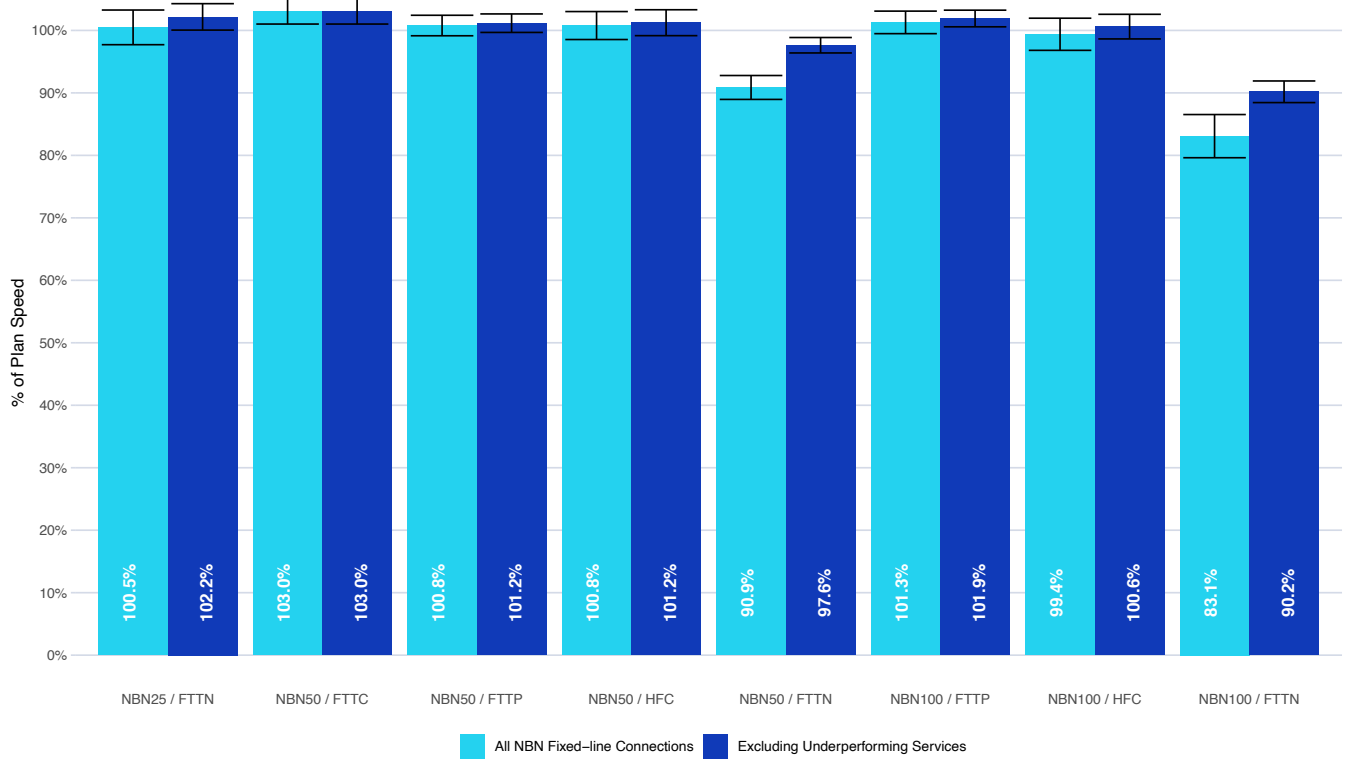
Fibre to the node continues to account for the bulk of the impact from underperforming services across both the NBN50 and NBN100 speed tiers.

# Latency, Webpage Loading Time, and Packet Loss by Plan

## Average latency by RSP

*Including underperforming services. Error bars indicate 95% confidence intervals of the mean.*



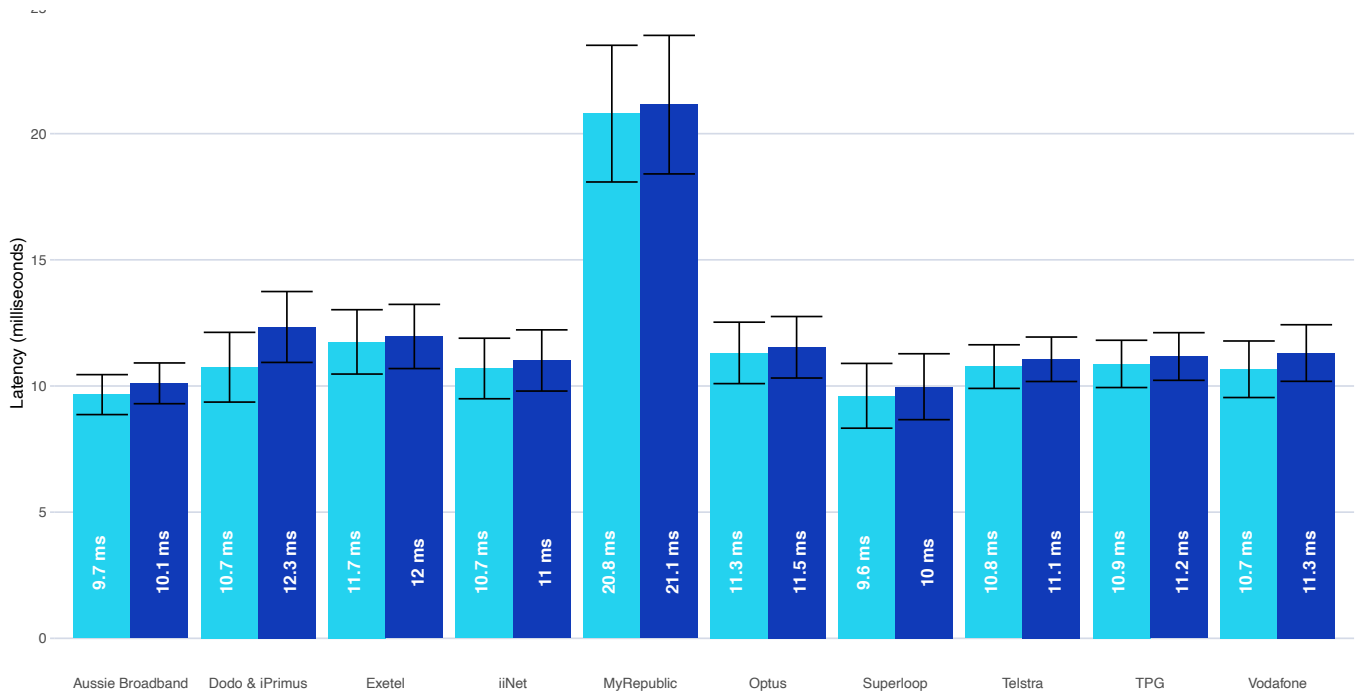Latency results from this period shown in the above chart are in line with the previous report: average latency was generally below 12ms during all hours across RSPs with the exception of MyRepublic.

MyRepublic services had higher average latency than connections served by other RSPs, although average latency did remain at around the same level during busy hours. It should be noted that latency at even 30ms would have a detrimental effect on only the most latency-sensitive applications and would be unlikely to be noticed by an end user.

Round trip latency is the time required to send a packet of data to the test server and back. Lower latency will result in more responsive behaviour from real-time applications such as video conferencing and online gaming.

The following chart shows the average time required to fully load eight popular webpages for Australian users across all NBN speed tiers, per RSP.

## Average webpage loading time by RSP

*Including underperforming services. Error bars indicate 95% confidence intervals of the mean.*
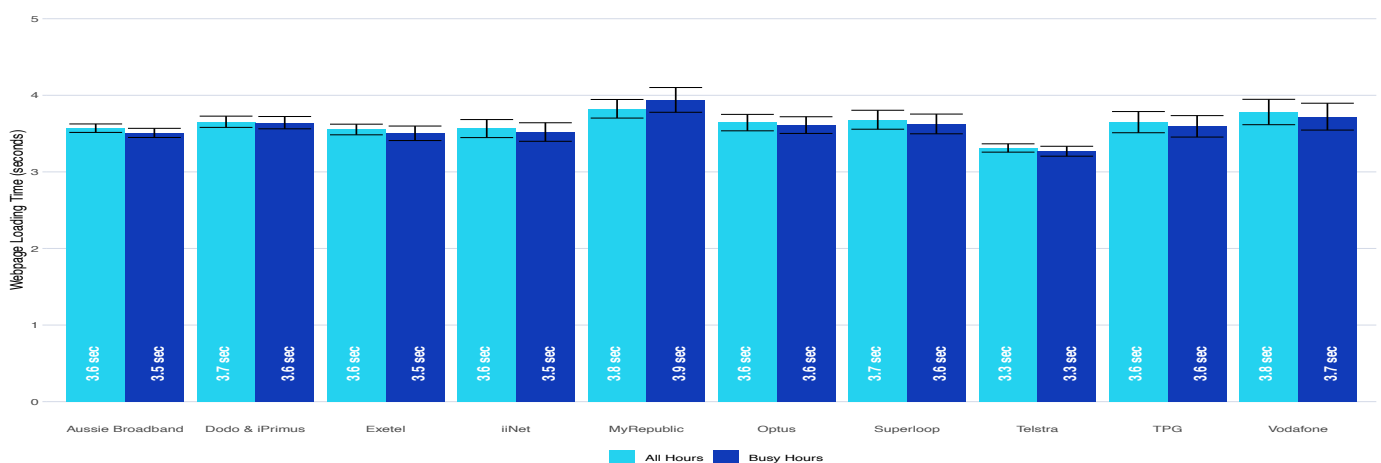
The average time needed to load a website increased since the previous reporting period by between 0.3 sec and 0.7 sec for each RSP. This is mainly due to the average time to load one monitored website increasing by 73% (to an average of around 8 sec) since the previous report. This increase affected the webpage loading time metric for all RSPs and so there are no material differences between RSPs by this metric. Even an increase of a few seconds may not have a huge visual impact to an end user: since websites are often designed so that the main elements of a page load first, the elements which come through in the final few seconds may not be needed immediately to get a general idea of the page's content.

The following chart shows the frequency at which different levels of packet loss occurred during tests.

**Frequency of packet loss rates observed during tests - all hours**

*Including underperforming services.*
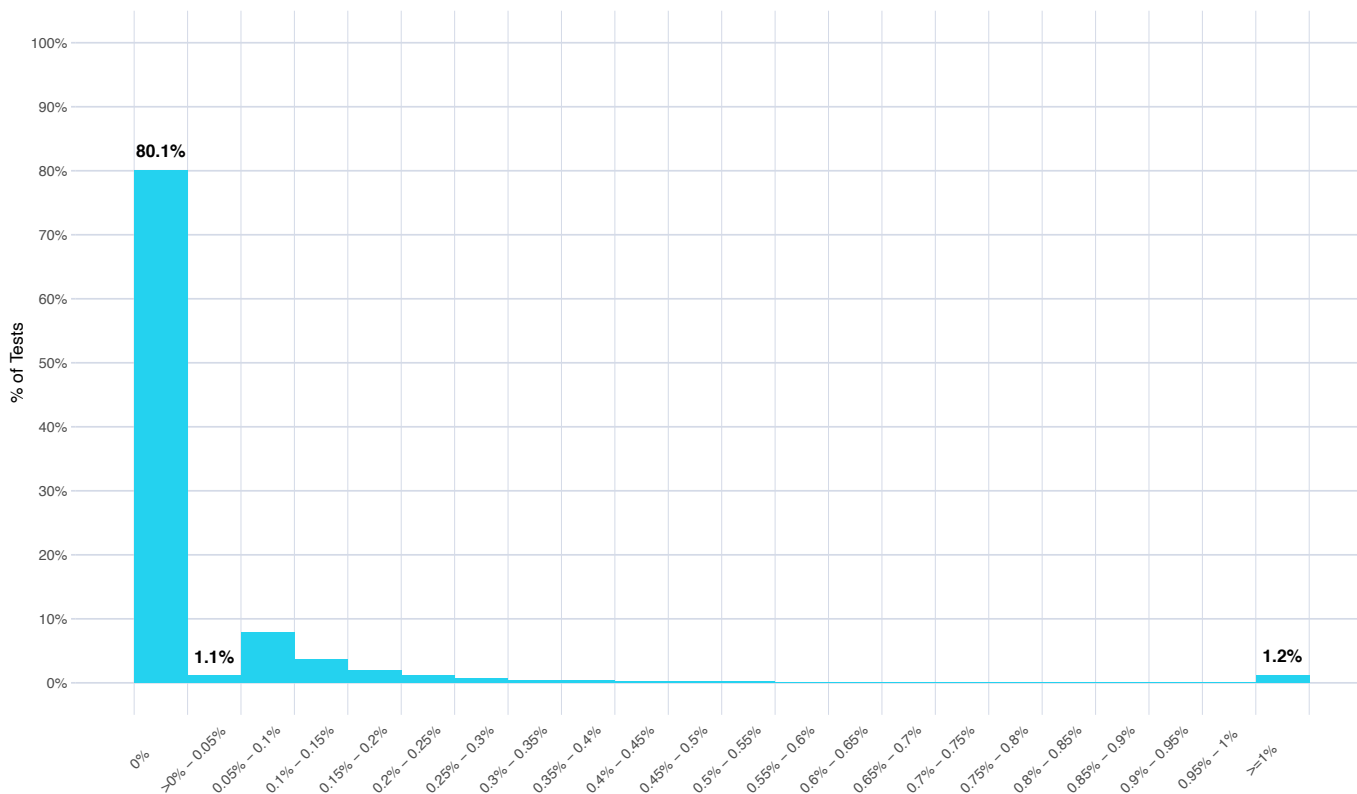


A total of nearly 744,303 packet loss tests were conducted over the measurement period. 81.2% of these tests had packet loss of either zero or less than 0.05%. For reference, in the previous report 77% of tests had packet loss below 0.05%.

At the other end of the scale, 1.2% of tests had packet loss greater than 1% as against 5.9% in the previous report. At levels above 1%, packet loss can cause issues which are detrimental to user experience, such as webpages failing to load.

# Outages

The following charts show, for each RSP:

- The average rate of daily outages for a service, indicating how often outages occurred

- The distribution of outage duration, indicating the severity of outages' impact on user experience.

## Average daily outages lasting over 30 seconds by RSP - all hours

*Including underperforming services.*
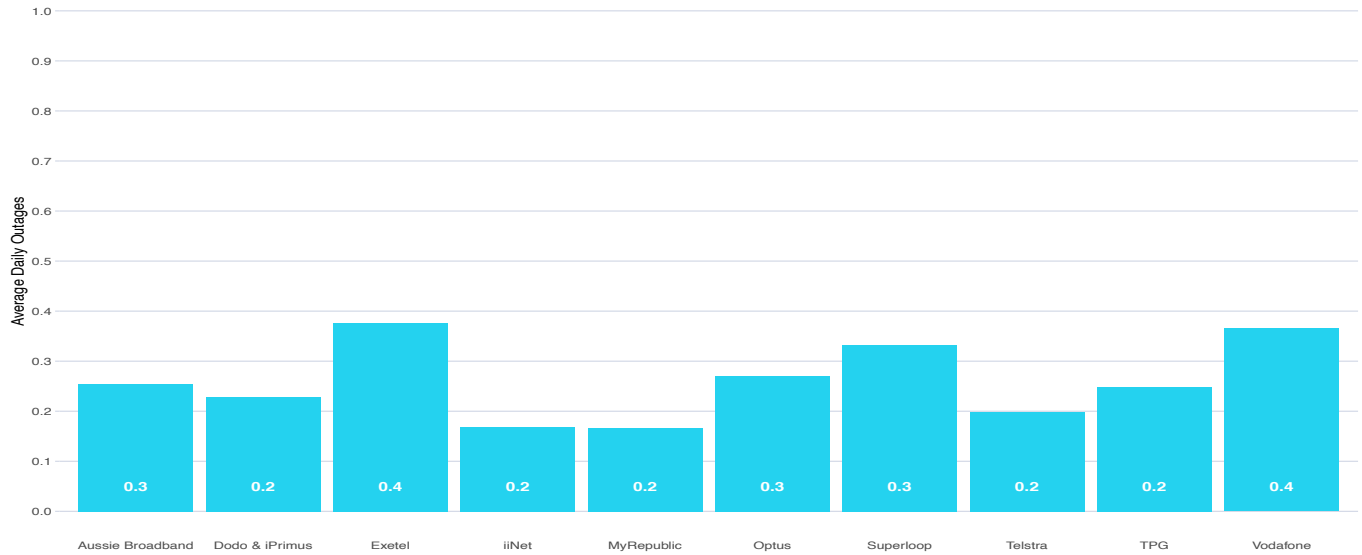


## Distribution of outage duration by RSP - all hours

*Including underperforming services.*
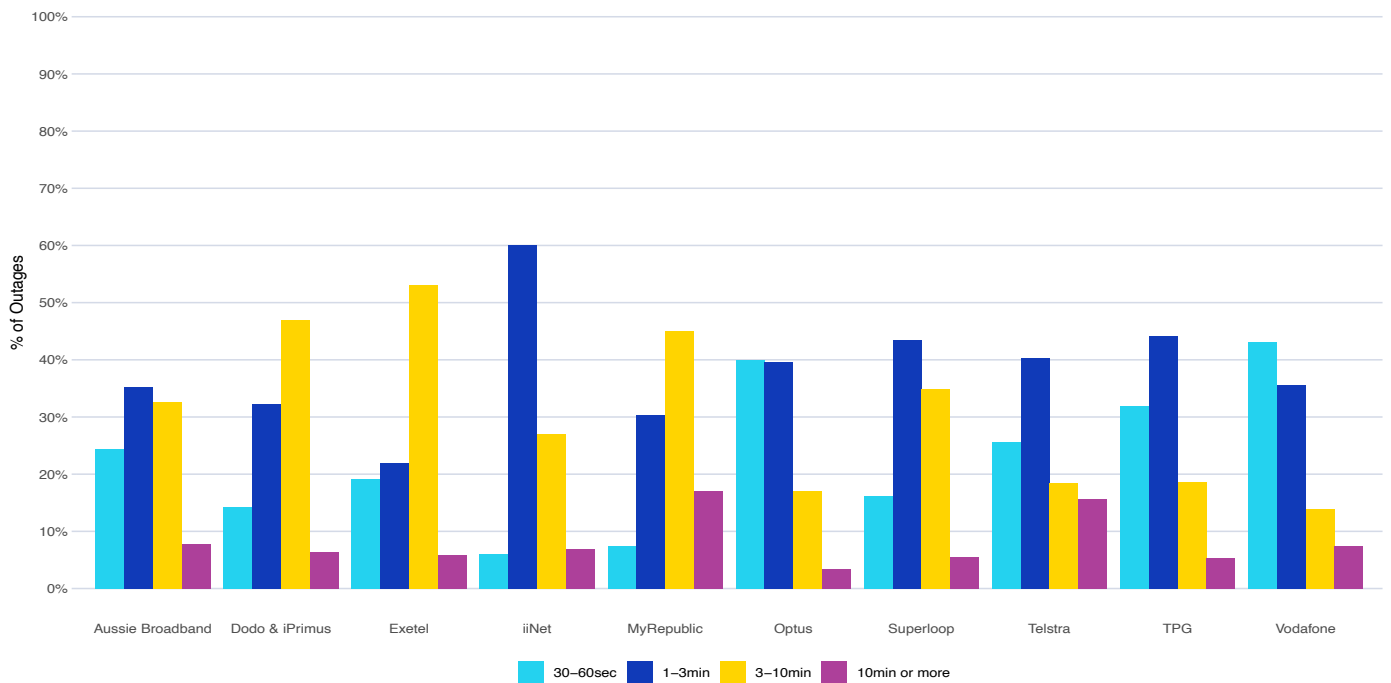


All RSPs' rates of outages were relatively low; no higher than the equivalent of one outage every two and a half days. This, combined with the information that the majority of outages last for no more than 3 minutes, means that outages have little material impact on end user experience.

# Download speed during the busiest hour[3]

The measurement period for this report had a total of 31 days with 4 busy hours each, totalling 124 busy hours in the month. For each busy hour, we calculate the average download performance (download speed as a percentage of plan speed) for each RSP. We take each RSP's fifth-lowest hourly download performance as an indicator of performance during the busiest hours when networks are under the highest levels of stress.

The chart below considers NBN50 and NBN100 plans and has three columns for each RSP:

- The first is a weighted average of the typical busy hour speeds advertised for these plans by each RSP at the end of the measurement period, expressed as a percentage of the maximum speed achievable by the plan. The weights used are the numbers of Whiteboxes online on the NBN50/NBN100 plans. See the 'NBN50 and NBN100 Advertised Speed Tables' section further in the report for full detail.

- The second column shows download performance during busy hours, expressed as a percentage of plan speed.

- The third column shows download performance during the busiest hour (i.e. the fifth-lowest hourly average as explained above), expressed as a percentage of plan speed.

A result in which the busiest hour speed is relatively close to average busy hour speed indicates that the plan is relatively unaffected by higher demand at especially busy times. Results in which busiest hour speeds are further below average busy hour speeds indicate that the plan is more affected by particularly high demand peaks.

At the end of the measurement period, RSPs advertised download speeds for their NBN50 and NBN100 products that were between 79% and 100% of the maximum achievable by the products, with Exetel advertising the lowest speeds, and Telstra the highest.

Any services which are underperforming (as defined above), or which have an acknowledged impairment which prevents the plan speed from being delivered, have been excluded.

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3   The busiest hour is the hour which had the fifth-lowest average download speed within the month, only considering busy hours (7pm-11pm), Monday-Sunday.

**Advertised speeds and average download speeds by RSP**

*50/20Mbps and 100/40Mbps NBN plans. Excluding underperforming and impaired services.*
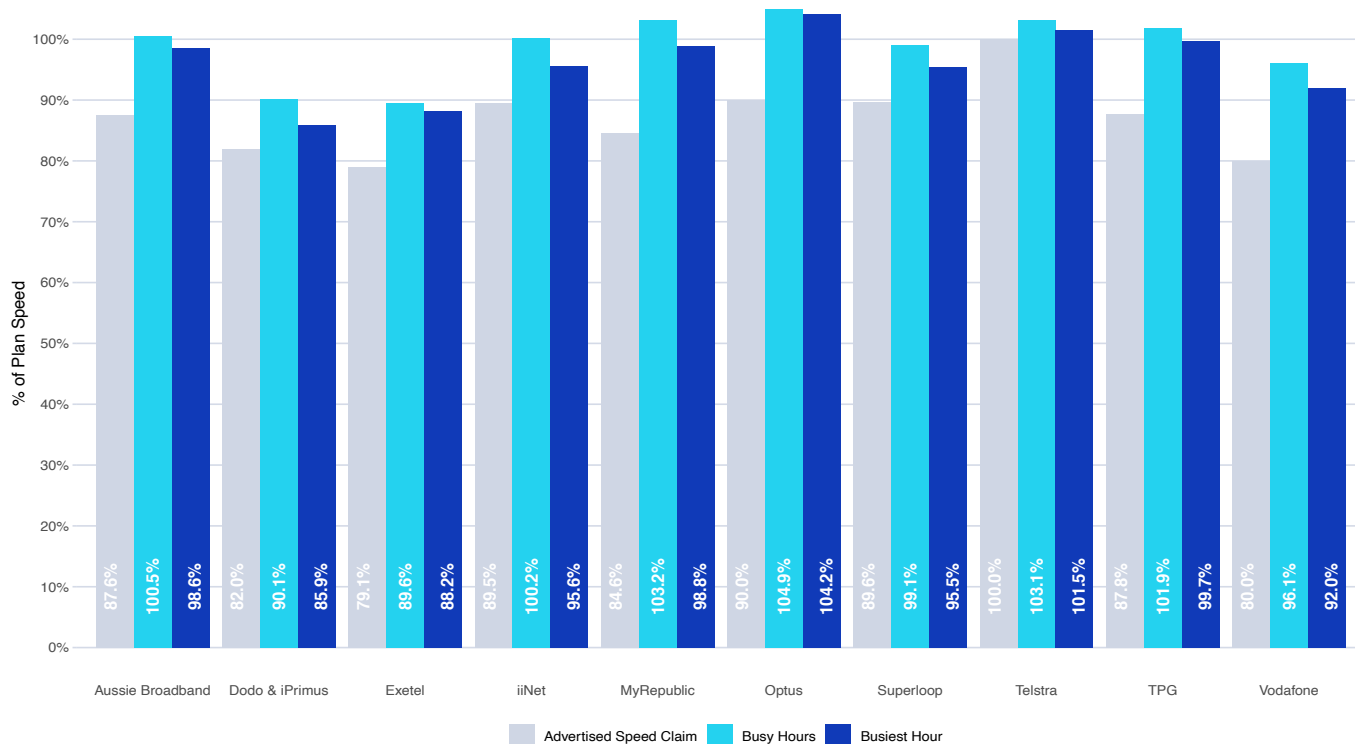


From these results we can see that if all underperforming services and impaired services had been remediated – or moved to a more appropriate plan - then all RSPs would have average speeds that exceeded advertised speed claims during their busiest hour.

The chart below shows the percentage of busy hours during the period in which test speeds for NBN 50/20Mbps and NBN 100/40Mbps products met or exceeded the speeds advertised by RSPs.

**Proportion of busy hours where advertised speed was achieved by RSP.**

*50/20Mbps and 100/40Mbps NBN plans. Excluding underperforming and impaired services.*
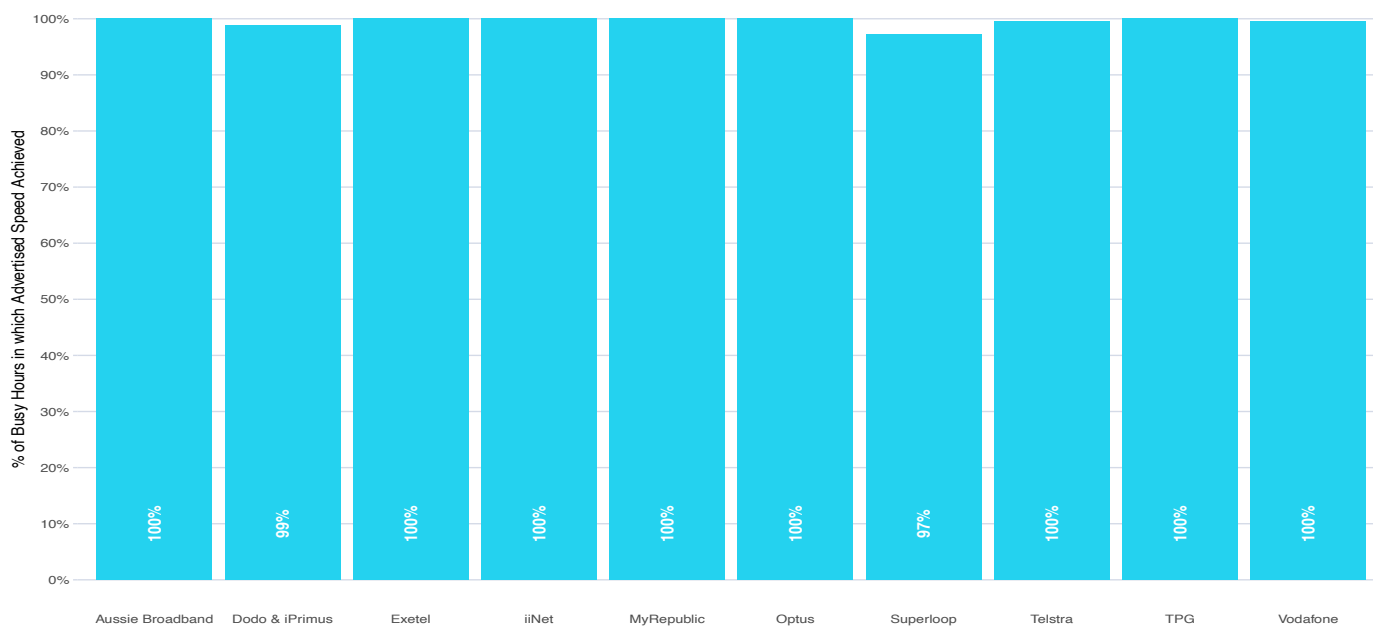


If all underperforming services and impaired services had been remediated – or moved to a more appropriate plan - then the proportion of busy hours when RSPs met their advertised speed claims would have been no lower than 97% for any tested provider.

# NBN RSP tables

The following tables show statistical information on download speeds, upload speeds, and outages for each RSP across all NBN speed tiers, and for individual NBN speed tiers in instances where at least 40 Whiteboxes reported successfully during the test period.

The overall speed is the average speed (download or upload) for the RSP, measured as a percentage of plan speed.

Standard deviation is a measure of how widely or narrowly test speeds are distributed in the data set.

The 95% confidence interval is a range in which the 'true' average value is estimated to lie and is a function of the sample size (i.e. number of Whiteboxes online) and standard deviation.

- If the standard deviation is larger then the confidence interval will be wider, reflecting greater variability in the underlying data. If the sample size is larger then the confidence interval will be narrower, reflecting more certainty in the underlying data.

- For example: during testing, we measured an average download performance of 85.6% of plan speed for Aussie Broadband across all NBN speed tiers with a 95% confidence interval of ±3.3%. If we were to repeat our sampling 100 times, we expect that this average would fall between 82.3% and 88.9% in at least 95 cases.

| Period | RSP | Download Average % of Plan Speed (all hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|
| All Hours | Aussie Broadband | 95.9% | 16.4% | 93.6% - 98.3% | 185 | 30,386 |
| All Hours | Dodo & iPrimus | 85.6% | 11.9% | 82.3% - 88.9% | 51 | 8,140 |
| All Hours | Exetel | 89.9% | 4.8% | 88.9% - 91.0% | 82 | 14,995 |
| All Hours | iiNet | 93.8% | 16.4% | 91.3% - 96.4% | 157 | 28,601 |
| All Hours | MyRepublic | 98.2% | 17.6% | 93.9% - 102.4% | 66 | 12,355 |
| All Hours | Optus | 99.4% | 17.0% | 96.5% - 102.3% | 135 | 25,198 |
| All Hours | Telstra | 97.1% | 18.2% | 94.6% - 99.6% | 206 | 40,206 |
| All Hours | TPG | 99.0% | 12.8% | 97.1% - 100.8% | 183 | 32,045 |
| All Hours | Superloop | 94.4% | 17.7% | 89.3% - 99.5% | 46 | 8,407 |
| All Hours | Vodafone | 93.4% | 15.9% | 90.1% - 96.7% | 88 | 15,142 |

| Period | RSP | Download Average % of Plan Speed (busy hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|
| Busy Hours | Aussie Broadband | 95.1% | 16.5% | 92.7% - 97.5% | 184 | 9,483 |
| Busy Hours | Dodo & iPrimus | 84.8% | 12.3% | 81.4% - 88.2% | 50 | 2,461 |
| Busy Hours | Exetel | 89.2% | 5.0% | 88.1% - 90.2% | 81 | 4,457 |
| Busy Hours | iiNet | 93.3% | 16.4% | 90.7% - 95.8% | 157 | 8,798 |

| Period | RSP | Download Average % of Plan Speed (busy hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|
| Busy Hours | MyRepublic | 96.8% | 18.1% | 92.5% - 101.2% | 66 | 3,445 |
| Busy Hours | Optus | 98.5% | 17.1% | 95.6% - 101.4% | 135 | 7,468 |
| Busy Hours | Telstra | 96.5% | 18.2% | 94.0% - 99.0% | 206 | 11,921 |
| Busy Hours | TPG | 98.4% | 12.9% | 96.5% - 100.2% | 182 | 9,534 |
| Busy Hours | Superloop | 93.4% | 18.1% | 88.2% - 98.7% | 46 | 2,605 |
| Busy Hours | Vodafone | 92.1% | 15.6% | 88.8% - 95.3% | 88 | 4,497 |

| Period | RSP | Upload Average % of Plan Speed (all hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|
| All Hours | Aussie Broadband | 84.6% | 18.7% | 81.9% - 87.3% | 185 | 30,309 |
| All Hours | Dodo & iPrimus | 84.7% | 16.3% | 80.2% - 89.2% | 51 | 8,169 |
| All Hours | Exetel | 90.2% | 10.3% | 87.9% - 92.4% | 81 | 14,794 |
| All Hours | iiNet | 83.0% | 19.2% | 80.0% - 86.0% | 157 | 28,580 |
| All Hours | MyRepublic | 88.1% | 16.7% | 84.1% - 92.1% | 66 | 12,416 |
| All Hours | Optus | 84.4% | 18.4% | 81.3% - 87.5% | 135 | 25,032 |
| All Hours | Telstra | 83.3% | 18.9% | 80.7% - 85.9% | 206 | 40,192 |
| All Hours | TPG | 85.9% | 15.0% | 83.7% - 88.0% | 183 | 31,974 |
| All Hours | Superloop | 86.2% | 14.7% | 82.0% - 90.5% | 46 | 8,383 |
| All Hours | Vodafone | 85.9% | 18.1% | 82.1% - 89.7% | 88 | 15,133 |

| Period | RSP | Upload Average % of Plan Speed (busy hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|
| Busy Hours | Aussie Broadband | 84.4% | 18.8% | 81.7% - 87.1% | 185 | 9,462 |
| Busy Hours | Dodo & iPrimus | 84.6% | 16.4% | 80.0% - 89.2% | 50 | 2,462 |
| Busy Hours | Exetel | 90.1% | 10.1% | 87.8% - 92.3% | 80 | 4,397 |
| Busy Hours | iiNet | 82.9% | 19.1% | 79.9% - 85.9% | 157 | 8,815 |
| Busy Hours | MyRepublic | 88.0% | 16.7% | 84.0% - 92.0% | 66 | 3,448 |
| Busy Hours | Optus | 84.0% | 18.6% | 80.9% - 87.2% | 135 | 7,402 |
| Busy Hours | Telstra | 83.1% | 18.8% | 80.5% - 85.7% | 206 | 11,913 |
| Busy Hours | TPG | 85.7% | 15.0% | 83.5% - 87.9% | 182 | 9,458 |
| Busy Hours | Superloop | 86.0% | 14.9% | 81.6% - 90.3% | 46 | 2,584 |
| Busy Hours | Vodafone | 85.6% | 18.2% | 81.8% - 89.4% | 88 | 4,500 |

| Period | RSP | Speed Tier | Download Average % of Plan Speed (all hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|---|
| All Hours | Aussie Broadband | 100/40 Mbps | 94.9% | 16.0% | 91.1% - 98.6% | 70 | 10,844 |
| All Hours | Aussie Broadband | 50/20 Mbps | 93.9% | 17.8% | 89.9% - 98.0% | 73 | 12,534 |
| All Hours | Exetel | 50/20 Mbps | 90.3% | 4.9% | 88.9% - 91.6% | 53 | 9,768 |
| All Hours | iiNet | 100/40 Mbps | 94.5% | 18.0% | 89.5% - 99.5% | 50 | 7,851 |
| All Hours | iiNet | 50/20 Mbps | 91.9% | 16.7% | 88.4% - 95.4% | 88 | 16,708 |
| All Hours | Optus | 100/40 Mbps | 95.0% | 20.4% | 89.4% - 100.6% | 51 | 8,908 |
| All Hours | Optus | 50/20 Mbps | 102.7% | 13.6% | 99.6% - 105.7% | 78 | 15,019 |
| All Hours | Telstra | 100/40 Mbps | 98.5% | 15.9% | 94.3% - 102.7% | 55 | 10,122 |
| All Hours | Telstra | 50/20 Mbps | 94.4% | 20.1% | 90.9% - 97.9% | 126 | 24,871 |
| All Hours | TPG | 100/40 Mbps | 96.6% | 16.7% | 91.9% - 101.2% | 50 | 8,565 |
| All Hours | TPG | 50/20 Mbps | 99.1% | 12.0% | 96.7% - 101.6% | 94 | 16,578 |
| All Hours | Vodafone | 50/20 Mbps | 94.8% | 19.0% | 89.2% - 100.4% | 44 | 7,440 |

| Period | RSP | Speed Tier | Download Average % of Plan Speed (busy hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|---|
| Busy Hours | Aussie Broadband | 100/40 Mbps | 93.9% | 16.2% | 90.1% - 97.7% | 69 | 3,373 |
| Busy Hours | Aussie Broadband | 50/20 Mbps | 93.3% | 17.8% | 89.3% - 97.4% | 73 | 3,905 |
| Busy Hours | Exetel | 50/20 Mbps | 89.5% | 5.3% | 88.0% - 90.9% | 52 | 2,886 |
| Busy Hours | iiNet | 100/40 Mbps | 93.9% | 17.9% | 88.9% - 98.9% | 50 | 2,475 |
| Busy Hours | iiNet | 50/20 Mbps | 91.5% | 16.8% | 87.9% - 95.0% | 88 | 5,113 |
| Busy Hours | Optus | 100/40 Mbps | 94.2% | 20.3% | 88.7% - 99.8% | 51 | 2,681 |
| Busy Hours | Optus | 50/20 Mbps | 101.9% | 13.8% | 98.8% - 104.9% | 78 | 4,400 |
| Busy Hours | Telstra | 100/40 Mbps | 98.0% | 15.8% | 93.9% - 102.2% | 55 | 3,057 |
| Busy Hours | Telstra | 50/20 Mbps | 93.7% | 20.1% | 90.2% - 97.2% | 126 | 7,307 |
| Busy Hours | TPG | 100/40 Mbps | 95.7% | 17.0% | 90.9% - 100.5% | 49 | 2,555 |
| Busy Hours | TPG | 50/20 Mbps | 98.7% | 11.9% | 96.3% - 101.1% | 94 | 4,906 |
| Busy Hours | Vodafone | 50/20 Mbps | 93.3% | 18.6% | 87.8% - 98.8% | 44 | 2,156 |

| Period | RSP | Speed Tier | Upload Average % of Plan Speed (all hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|---|
| All Hours | Aussie Broad-band | 100/40 Mbps | 86.0% | 14.9% | 82.5% - 89.4% | 70 | 10,837 |
| All Hours | Aussie Broad-band | 50/20 Mbps | 77.2% | 22.5% | 72.0% - 82.3% | 73 | 12,480 |
| All Hours | Exetel | 50/20 Mbps | 89.2% | 12.3% | 85.9% - 92.6% | 52 | 9,642 |
| All Hours | iiNet | 100/40 Mbps | 88.1% | 11.8% | 84.8% - 91.4% | 50 | 7,835 |
| All Hours | iiNet | 50/20 Mbps | 78.3% | 22.5% | 73.6% - 83.0% | 88 | 16,696 |
| All Hours | Optus | 100/40 Mbps | 84.8% | 18.2% | 79.8% - 89.8% | 51 | 8,849 |
| All Hours | Optus | 50/20 Mbps | 84.7% | 18.8% | 80.5% - 88.8% | 78 | 14,925 |
| All Hours | Telstra | 100/40 Mbps | 87.9% | 13.1% | 84.5% - 91.4% | 55 | 10,151 |
| All Hours | Telstra | 50/20 Mbps | 79.7% | 21.7% | 76.0% - 83.5% | 126 | 24,817 |
| All Hours | TPG | 100/40 Mbps | 87.1% | 13.6% | 83.4% - 90.9% | 50 | 8,508 |
| All Hours | TPG | 50/20 Mbps | 85.8% | 15.5% | 82.7% - 89.0% | 94 | 16,570 |
| All Hours | Vodafone | 50/20 Mbps | 81.1% | 23.3% | 74.2% - 88.0% | 44 | 7,456 |

| Period | RSP | Speed Tier | Upload Average % of Plan Speed (busy hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|---|
| Busy Hours | Aussie Broad-band | 100/40 Mbps | 85.6% | 14.9% | 82.1% - 89.1% | 70 | 3,386 |
| Busy Hours | Aussie Broad-band | 50/20 Mbps | 77.0% | 22.5% | 71.8% - 82.1% | 73 | 3,886 |
| Busy Hours | Exetel | 50/20 Mbps | 89.1% | 12.2% | 85.7% - 92.4% | 51 | 2,850 |
| Busy Hours | iiNet | 100/40 Mbps | 87.9% | 11.9% | 84.6% - 91.2% | 50 | 2,498 |
| Busy Hours | iiNet | 50/20 Mbps | 78.2% | 22.5% | 73.5% - 82.9% | 88 | 5,108 |
| Busy Hours | Optus | 100/40 Mbps | 84.2% | 18.4% | 79.2% - 89.3% | 51 | 2,656 |
| Busy Hours | Optus | 50/20 Mbps | 84.6% | 18.7% | 80.4% - 88.7% | 78 | 4,375 |
| Busy Hours | Telstra | 100/40 Mbps | 87.6% | 13.1% | 84.2% - 91.1% | 55 | 3,055 |
| Busy Hours | Telstra | 50/20 Mbps | 79.6% | 21.7% | 75.8% - 83.4% | 126 | 7,294 |
| Busy Hours | TPG | 100/40 Mbps | 86.9% | 13.8% | 83.1% - 90.8% | 49 | 2,521 |
| Busy Hours | TPG | 50/20 Mbps | 85.7% | 15.5% | 82.6% - 88.8% | 94 | 4,845 |
| Busy Hours | Vodafone | 50/20 Mbps | 80.7% | 23.4% | 73.7% - 87.6% | 44 | 2,167 |

| RSP | Average Daily Outages Lasting Longer than 30 Seconds | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size |
|---|---|---|---|---|
| Aussie Broadband | 0.25 | 0.71 | 0.15 - 0.36 | 185 |
| Dodo & iPrimus | 0.23 | 0.28 | 0.15 - 0.31 | 51 |
| Exetel | 0.38 | 1.12 | 0.13 - 0.62 | 82 |
| iiNet | 0.17 | 0.55 | 0.08 - 0.25 | 157 |
| MyRepublic | 0.17 | 0.21 | 0.12 - 0.22 | 66 |
| Optus | 0.27 | 0.61 | 0.17 - 0.37 | 135 |
| Telstra | 0.20 | 0.47 | 0.13 - 0.26 | 206 |
| TPG | 0.25 | 0.73 | 0.14 - 0.35 | 183 |
| Superloop | 0.33 | 0.56 | 0.17 - 0.49 | 46 |
| Vodafone | 0.37 | 1.07 | 0.14 - 0.59 | 88 |

| RSP | Percentage of Outages Lasting 30-60sec | Percentage of Outages Lasting 1-3min | Percentage of Outages Lasting 3-10min | Percentage of Outages Lasting 10min or more |
|---|---|---|---|---|
| Aussie Broadband | 24.3% | 35.2% | 32.7% | 7.8% |
| Dodo & iPrimus | 14.3% | 32.3% | 46.9% | 6.5% |
| Exetel | 19.1% | 21.9% | 53.1% | 5.8% |
| iiNet | 6.0% | 60.1% | 27.0% | 6.9% |
| MyRepublic | 7.5% | 30.3% | 45.0% | 17.1% |
| Optus | 40.0% | 39.7% | 17.0% | 3.4% |
| Superloop | 16.1% | 43.5% | 34.9% | 5.5% |
| Telstra | 25.6% | 40.3% | 18.5% | 15.6% |
| TPG | 31.8% | 44.1% | 18.6% | 5.4% |
| Vodafone | 43.0% | 35.6% | 13.9% | 7.4% |

# NBN speed tier tables

The following tables show statistical information on download and upload speeds for each NBN speed tier, including all tested RSPs.

The overall speed is the average speed (download or upload) for the particular NBN speed tier, measured as a percentage of plan speed.

Standard deviation is a measure of how widely or narrowly test speeds are distributed in the data set.

The 95% confidence interval is a range in which the 'true' average value is estimated to lie.

- For example: during testing, we measured an average download performance of 95.0% of plan speed for users subscribed to 100/40 Mbps NBN fixed-line plans with a 95% confidence interval of ±1.6%. If we were to repeat our sampling 100 times, we expect that this average would fall between 93.4% and 96.6% in at least 95 cases.

For the 12/1Mbps tier, the sample size is considered low and results are indicative only.

The dataset used for this report includes data from 11 services on 250 Mbps NBN speed tiers (two on 250/100 Mbps and nine on 250/25 Mbps). These services are implicitly included in the overall, by-RSP, and by-technology results, but the sample size is too low for us to report on results for 250 Mbps tiers separately.

| Period | Speed Tier | Download Average % of Plan Speed (all hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|
| All Hours | 100/40 Mbps | 95.0% | 16.2% | 93.4% - 96.6% | 394 | 65,656 |
| All Hours | 50/20 Mbps | 95.2% | 16.5% | 94.0% - 96.5% | 647 | 119,609 |
| All Hours | 25/5 Mbps | 101.4% | 10.1% | 99.4% - 103.3% | 103 | 19,857 |
| All Hours | 12/1 Mbps | 101.2% | 4.5% | 99.4% - 102.9% | 25 | 5,142 |

| Period | Speed Tier | Download Average % of Plan Speed (busy hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|
| Busy Hours | 100/40 Mbps | 94.1% | 16.3% | 92.5% - 95.8% | 392 | 19,884 |
| Busy Hours | 50/20 Mbps | 94.5% | 16.5% | 93.3% - 95.8% | 645 | 35,702 |
| Busy Hours | 25/5 Mbps | 100.6% | 10.6% | 98.5% - 102.6% | 103 | 5,986 |
| Busy Hours | 12/1 Mbps | 100.3% | 5.1% | 98.3% - 102.3% | 25 | 1,567 |

| Period | Speed Tier | Upload Average % of Plan Speed (all hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|
| All Hours | 100/40 Mbps | 87.8% | 12.9% | 86.6% - 89.1% | 394 | 65,574 |
| All Hours | 50/20 Mbps | 82.2% | 20.3% | 80.7% - 83.8% | 646 | 119,246 |
| All Hours | 25/5 Mbps | 91.2% | 12.1% | 88.9% - 93.6% | 103 | 19,804 |
| All Hours | 12/1 Mbps | 83.5% | 15.4% | 77.5% - 89.5% | 25 | 5,138 |

| Period | Speed Tier | Upload Average % of Plan Speed (busy hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|
| Busy Hours | 100/40 Mbps | 87.5% | 13.0% | 86.2% - 88.8% | 393 | 19,852 |
| Busy Hours | 50/20 Mbps | 82.1% | 20.3% | 80.5% - 83.6% | 644 | 35,526 |
| Busy Hours | 25/5 Mbps | 91.2% | 12.5% | 88.8% - 93.6% | 103 | 5,967 |
| Busy Hours | 12/1 Mbps | 83.4% | 15.1% | 77.5% - 89.3% | 25 | 1,565 |

## NBN technology tables

The following tables show statistical information on download speeds, upload speeds, and outages on a per-technology basis.

The overall speed is the average speed (download or upload) for the technology type, measured as a percentage of the plan speed for each subscriber.

Standard deviation is a measure of how widely or narrowly test speeds are distributed in the data set.

The 95% confidence interval is a range in which the 'true' average value is estimated to lie.

• For example: during testing, we measured an average download performance of 92.6% of plan speed for fibre to the premises NBN fixed-line connections with a 95% confidence interval of ±0.4%. If we were to repeat our sampling 100 times, we expect that this average would fall between 92.2% and 93.1% (rounded to 1 decimal place) in at least 95 cases.

| Period | Technology | Download Average % of Plan Speed (all hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|
| All Hours | Fibre to the premises - FTTP | 101.3% | 9.9% | 100.2% - 102.4% | 316 | 55,739 |
| All Hours | Fibre to the curb - FTTC | 98.4% | 11.3% | 96.1% - 100.8% | 87 | 15,205 |
| All Hours | Hybrid fibre-coaxial - HFC | 100.4% | 11.9% | 98.9% - 101.9% | 240 | 40,557 |
| All Hours | Fibre to the node - FTTN | 90.2% | 18.9% | 88.7% - 91.8% | 580 | 108,082 |

| Period | Technology | Download Average % of Plan Speed (busy hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|
| Busy Hours | Fibre to the premises - FTTP | 100.4% | 10.2% | 99.3% - 101.6% | 314 | 16,840 |
| Busy Hours | Fibre to the curb - FTTC | 97.8% | 11.4% | 95.4% - 100.2% | 87 | 4,512 |
| Busy Hours | Hybrid fibre-co-axial - HFC | 99.3% | 12.0% | 97.8% - 100.9% | 240 | 12,338 |
| Busy Hours | Fibre to the node - FTTN | 89.6% | 19.0% | 88.0% - 91.1% | 578 | 32,296 |

| Period | Technology | Upload Average % of Plan Speed (all hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|
| All Hours | Fibre to the premises - FTTP | 91.1% | 7.4% | 90.3% - 91.9% | 315 | 55,521 |
| All Hours | Fibre to the curb - FTTC | 91.9% | 3.5% | 91.2% - 92.7% | 87 | 15,161 |
| All Hours | Hybrid fibre-co-axial - HFC | 90.1% | 8.6% | 89.0% - 91.2% | 240 | 40,500 |
| All Hours | Fibre to the node - FTTN | 78.8% | 22.4% | 76.9% - 80.6% | 580 | 107,856 |

| Period | Technology | Upload Average % of Plan Speed (busy hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|
| Busy Hours | Fibre to the premises - FTTP | 91.0% | 7.3% | 90.2% - 91.8% | 313 | 16,724 |
| Busy Hours | Fibre to the curb - FTTC | 91.8% | 3.6% | 91.0% - 92.5% | 87 | 4,489 |
| Busy Hours | Hybrid fibre-co-axial - HFC | 89.6% | 8.9% | 88.4% - 90.7% | 240 | 12,293 |
| Busy Hours | Fibre to the node - FTTN | 78.6% | 22.4% | 76.8% - 80.5% | 579 | 32,229 |

| Technology | Average Daily Outages Lasting Longer than 30 Seconds | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size |
|---|---|---|---|---|
| Fibre to the premises - FTTP | 0.19 | 0.86 | 0.10 - 0.29 | 316 |
| Fibre to the curb - FTTC | 0.30 | 0.83 | 0.13 - 0.48 | 87 |
| Hybrid fibre-coaxial - HFC | 0.32 | 0.80 | 0.22 - 0.42 | 240 |
| Fibre to the node - FTTN | 0.26 | 0.69 | 0.20 - 0.32 | 580 |

| Technology | Percentage of Outages Lasting 30-60sec | Percentage of Outages Lasting 1-3min | Percentage of Outages Lasting 3-10min | Percentage of Outages Lasting 10min or more |
|---|---|---|---|---|
| Fibre to the curb - FTTC | 44.4% | 39.4% | 13.9% | 2.4% |
| Fibre to the node - FTTN | 19.0% | 33.0% | 39.6% | 8.4% |
| Fibre to the premises - FTTP | 34.3% | 45.9% | 13.7% | 6.1% |
| Hybrid fibre-coaxial - HFC | 30.2% | 45.1% | 15.3% | 9.4% |

# NBN state tables

This table shows statistical information on download speeds on a per-state basis. In this report, we have been able to draw upon all of the test results from a range of locations.

The overall speed is the average speed (download or upload) for the state, measured as a percentage of the plan speed for each panellist.

Standard deviation is a measure of how widely or narrowly test speeds are distributed in the data set.

The 95% confidence interval is a range in which the 'true' average value is estimated to lie.

- For example: during testing, we measured an average download performance of 93.2% of plan speed for NBN fixed-line services in QLD, with a 95% confidence interval of ±2.8%. If we were to repeat our sampling 100 times, we expect that this average would fall between 90.4% and 95.9% (rounded to 1 decimal place) in at least 95 cases.

| Period | State/Territory | Download Average % of Plan Speed (all hours) | Standard Deviation | 95% Confidence Interval of the Mean | Panel Size | Number of Tests |
|---|---|---|---|---|---|---|
| All Hours | NSW | 97.2% | 14.7% | 95.7% - 98.6% | 398 | 79,514 |
| All Hours | ACT | 92.6% | 16.6% | 88.4% - 96.9% | 59 | 11,095 |
| All Hours | VIC | 96.1% | 15.5% | 94.4% - 97.8% | 322 | 47,404 |
| All Hours | QLD | 93.2% | 20.0% | 90.4% - 95.9% | 199 | 37,874 |
| All Hours | WA | 96.1% | 14.7% | 93.4% - 98.8% | 115 | 23,145 |
| All Hours | TAS | 95.0% | 16.3% | 90.5% - 99.6% | 49 | 7,647 |
| All Hours | NT + SA | 94.8% | 14.5% | 91.7% - 98.0% | 81 | 12,904 |

# NBN50 and NBN100 Advertised Speed Tables

The figures in the following table are based on the typical evening hour speeds that were advertised by RSPs at the end of the measurement period. The single weighted average speed claim is calculated based on the number of Whiteboxes online for each RSP for each tier (excluding underperforming and impaired services).

| RSP | NBN50 Advertised % of Plan Speed | NBN100 Advertised % of Plan Speed | Number of NBN50 Whiteboxes (excluding underperforming and impaired services | Number of NBN100 Whiteboxes (excluding underperforming and impaired services | Weighted Advertised % of Plan Speed |
|---|---|---|---|---|---|
| Aussie Broadband | 86.0% | 89.0% | 51 | 58 | 87.6% |
| Dodo & iPrimus | 82.0% | 82.0% | 23 | 9 | 82.0% |
| Exetel | 80.0% | 77.0% | 50 | 23 | 79.1% |
| iiNet | 93.4% | 83.6% | 64 | 42 | 89.5% |
| MyRepublic | 86.0% | 83.0% | 30 | 26 | 84.6% |
| Optus | 90.0% | 90.0% | 66 | 40 | 90.0% |
| Telstra | 100.0% | 100.0% | 95 | 39 | 100.0% |
| TPG | 92.0% | 80.1% | 80 | 44 | 87.8% |
| Superloop | 88.8% | 90.0% | 9 | 19 | 89.6% |
| Vodafone | 80.0% | 80.0% | 37 | 30 | 80.0% |

Telstra's advertised speed claim of 100 Mbps for its NBN100 plan does not apply to fibre to the node or fibre to the curb services, and so these technologies are excluded from Telstra's counts.

There were 124 busy hours across the 31 day period from 1st October 2020 to 31st October 2020. The following table shows the proportion of busy hours in which each RSP's average speed for each tier met the advertised claims above.

| RSP | % of busy hours in which advertised download speed met or exceeded | % of busy hours in which advertised download speed met or exceeded (excluding underperforming and impaired services) |
|---|---|---|
| Aussie Broadband | 99% | 100% |
| Dodo & iPrimus | 88% | 99% |
| Exetel | 100% | 100% |
| iiNet | 68% | 100% |
| MyRepublic | 99% | 100% |
| Optus | 98% | 100% |
| Superloop | 93% | 97% |
| Telstra | 50% | 100% |
| TPG | 100% | 100% |
| Vodafone | 98% | 100% |

# NBN Whiteboxes connected to underperforming services

The following table shows the number of Whiteboxes on NBN connections for each RSP, alongside the number of Whiteboxes connected to underperforming services.

| RSP | NBN Whiteboxes | NBN Whiteboxes on underperforming services | % NBN Whiteboxes on underperforming services |
|---|---|---|---|
| Aussie Broadband | 185 | 18 | 10% |
| Dodo & iPrimus | 51 | 6 | 12% |
| Exetel | 82 | 1 | 1% |
| iiNet | 157 | 17 | 11% |
| MyRepublic | 66 | 6 | 9% |
| Optus | 135 | 8 | 6% |
| Other RSPs | 24 | 2 | 8% |
| Superloop | 46 | 5 | 11% |
| Telstra | 206 | 20 | 10% |
| TPG | 183 | 10 | 5% |
| Vodafone | 88 | 6 | 7% |
| Total | 1223 | 99 | 8% |

As highlighted earlier in the report, the majority of underperforming services are connected to fibre to the node infrastructure. The following table shows the number of Whiteboxes on fibre to the node services for each speed tier, alongside the number of underperforming services.

| Technology | Speed Tier | NBN Whiteboxes | NBN Whiteboxes on underperforming services | % NBN Whiteboxes on underperforming services |
|---|---|---|---|---|
| Fibre to the node - FTTN | 12/1 Mbps | 12 | 0 | 0% |
| Fibre to the node - FTTN | 25/5 Mbps | 67 | 3 | 4% |
| Fibre to the node - FTTN | 50/20 Mbps | 372 | 62 | 17% |
| Fibre to the node - FTTN | 100/40 Mbps | 114 | 20 | 18% |
| Fibre to the node - FTTN | Other NBN Speed Tiers | 15 | 6 | 40% |
| Fibre to the node - FTTN | All NBN Speed Tiers | 580 | 91 | 16% |

# How we test



## Measuring from homes across Australia

- The SamKnows Whitebox is a purpose-built testing agent that connects to your router.

- Measures every aspect of your internet service delivered to your home.

- Runs at regular intervals when you're not using the internet.

## SamKnows One analytics

- View all your data in one place.

- Create customised charts and save the results that mean the most to you.

- Track changes in your connection over time.
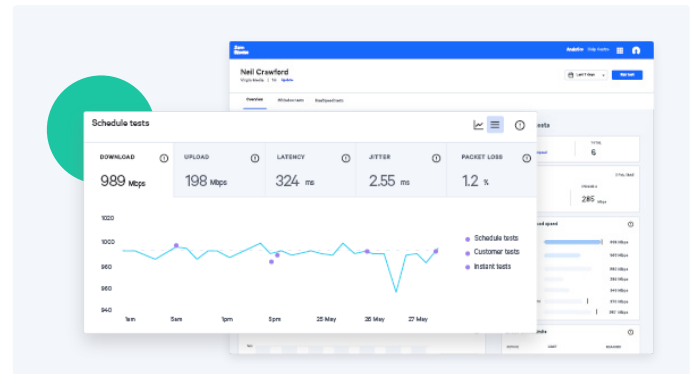


## Sign up

Please participate by volunteering to receive a Whitebox. The more volunteers we have, the more information we can provide to consumers in Australia in future reports: https://measuringbroadbandaustralia.com.au/signup

# Our Tests

| Metric | | Definition |
|---|---|---|
| 🔽 | Download | The speed data travels from our test server to your device, measured in bits per second. |
| ☁ | Upload | The speed data travels from your device to our test server, measured in bits per second. |
| ⏱ | Latency | How long it takes a data packet to go from your device to our test server and back to your device. |
| ⅠⅡ | Jitter | Measures the amount of difference between packet delays, or the stability of your latency. |
| ⋰ | Packet Loss | When a packet of data becomes lost (does not arrive for two seconds) measured as a percentage of packets lost out of packets sent. |
| ⏱ | Outage | The outages metric tracks how many times per day your broadband connection goes offline for at least 20 seconds. |
| 📹 | Video Conferencing | Measures round-trip latency and reachability of a selection of video conferencing services. |
| ▶ | Video streaming | Measures the highest bitrate you can reliably stream for the most popular video in your country. |
| 🖱 | Web browsing | Measures how long it takes to fetch the HTML and referenced resources of a popular website. |
| ⋏ | CDN Measurements | Measures download performance for the same (or very similar) object from a variety of popular Content Delivery Networks over HTTP. |
| 📞 | Voice over IP | Measures the suitability of a broadband connection for VoIP calls. |