Explore

Slow IPv6 migration and industry's short-sighted outlook represent problem for The Netherlands Inc.

IPv6 Inventory | September 2018

SIDN Your world. Our domain.

Contents

1 Management summary

- IPv4 has been stretched to the limit; migration to IPv6 is urgently required.

- The supply of IPv4 addresses ran out long ago; technical workarounds have since been used to keep the IPv4 network running. However, those workarounds are becoming less viable and have increasing implications for innovation, stability and security.

- IPv4 address blocks can still be purchased through specialist traders, but smaller market players and new entrants have little opportunity to obtain addresses.

- The implementation of IPv6 alongside IPv4 does still represent an additional operational burden, but in all other respects migration to IPv6 is advantageous.

- Adoption of IPv6 is going slowly: IPv4 is still used for the bulk of internet traffic.

- Established players have a commercial interest in maintaining the current situation for as long as possible.

- In terms of the adoption of (client-side) IPv6, the Netherlands lags well behind neighbouring countries. One of the main reasons is that the country's two biggest access providers do not offer internet users a proper IPv6 connection.
- This inventory shows that the average level of support by (server-side) DNS servers is much higher than the level of support by web and mail servers.

- When each domain's scores for the three elements of IPv6 support are combined, the resulting overall support scores remain very disappointing. Evidently, most registrants have no policy on IPv6.

- The level of adoption both amongst very large companies and amongst small businesses is above the national average, but the medium-sized lag behind. That effect is reflected in the adoption scores for different types of legal entity: public companies score much worse than private companies and partnerships, but partnerships lag behind private companies. A similarly divergent picture emerges when adoption in the three surveyed economic centres is mapped: the central zones score badly, while the surrounding industrial zones do better. Further out still, adoption rates drop again.

- Of the surveyed groups, universities had the highest level of IPv6 support for mail. That is because many higher education centres use a SURFnet mail filter for their incoming mail portals. With a high web support score as well, the universities secured the best overall score in the survey.

- Government-designated Essential Service Providers, who formed the starting point for our inventory, almost all registered strikingly low scores.

- Broadly speaking, the private sector has been migrating to IPv6 significantly more quickly than the public sector.

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- Most banks, telecom service providers and internet access providers are habitually cautious about implementing ‘new’ technology. Unsurprisingly, therefore, the inventory revealed low levels of IPv6 adoption in these groups. By contrast, new players in the financial sector – the cryptocurrencies and crypto-exchanges – have much higher scores than most other categories.

- The industry sees major issues for the implementation of IPv6.

- The central government is promoting the adoption of IPv6 via the internet.nl website and the ‘use-or-explain’ list.
  The Association of Netherlands Municipalities is actively encouraging members to use IPv6, and the National Government Internet Platform enables IPv6 support on websites as a matter of course.

- Six months ago, SIDN introduced a financial incentive to encourage registrars to support IPv6. That has led to a substantial increase in IPv6-enabled domains.

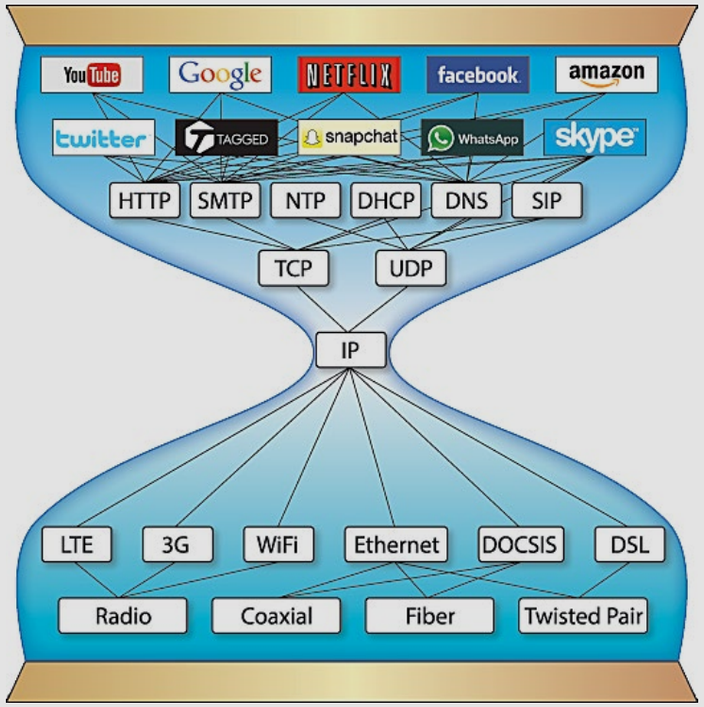
- The nation’s slow migration to IPv6 and the industry’s short-sighted outlook represent a problem for The Netherlands Inc. At the moment, startups and pilot programme organisers are unlikely to see the country as the most attractive place for IoT-related investment and innovation. Innovations in the field of mobile communication are similarly being held back.

- The low and patchy adoption scores and the lack of policy require action, possibly even in the form of regulation.

- Decision-makers in the internet access sector need to recognise that they are part of a market ecosystem, and that their own results depend to a significant extent on the health of that ecosystem.

2 The technology and the problems

The Internet Protocol forms the basis for all data traffic over the internet. One of its functions is to provide computer systems with unique addresses, so that they can find each other on the internet and exchange information. To that end, the Internet Protocol defines a format for network packages, in which the sender's address and the recipient's address are the key elements. The recipient's address is used by intermediate stations to pass the network packages on towards their final destination (routing).
The Internet Protocol underpins the TCP and UDP protocols, which in turn form the basis for better-known application protocols, such as DNS (domain names), HTTP (web), SMTP and IMAP (mail). The Internet Protocol (IP) is therefore the core of the internet.



IPv4
Version 4 of the Internet Protocol, known as IPv4 for short, is now nearly forty years old. Nevertheless, it is still used for the bulk of internet traffic. That is problematic, mainly because the number of unique addresses supported by IPv4 (2^32, more than 4 billion) has long since ceased to be sufficient for all the appliances and devices connected to the internet. IANA, the organisation with global responsibility for IP address management, allocated the last regular address blocks to the regional (i.e. continental) address management organisations back in 2011. Four of the five regional organisations have in turn subsequently issued their last regular address blocks to internet access providers in their regions. In the case of RIPE NCC, responsible for Europe, Russia and the Middle East, that was done back in 2012.

As a result of the shortage, blocks of IPv4 addresses have become very expensive and many service providers now charge their customers a monthly fee for each IP address they have. Furthermore, to the best of our knowledge, XS4ALL is the only Dutch access provider that assigns its customers static (i.e. fixed) IPv4 addresses.

Workrounds
The main reason why those problems have not brought the internet to a screeching halt is that various technical workarounds have been deployed. They include Network Address Translation (NAT, which allows numerous users to access the internet via a shared IP address), Classless Inter-Domain Routing (CIDR, which enables address blocks to be assigned and routed using any number of prefix bits) and Server Name Indication (SNI, which makes multiple websites accessible via a single shared IP address). NAT, which renders end users unreachable

from the internet, is a particular source of trouble, necessitating further workarounds, such as port forwarding and STUN servers.

Although the various workarounds are effective – subject to certain limitations – their use becomes ever more problematic as the internet grows. NAT at the household level becomes CGNAT at the neighbourhood level, introducing still further problems.

Status quo
It is worth noting that, although maintaining the status quo is increasingly difficult in a technical sense, the established players have a financial incentive for wanting things to continue as they are, in addition to the desire to recover what they have invested in the current set-up.

The chief drawback of a NAT address or a dynamic IP address is that it can't be used for services that need to be accessible from elsewhere on the internet. That isn't such a bad thing for internet access providers. NAT is also responsible for many problems with things such as VoIP and video conferencing: modern and often free competitors for the voice and video services of traditional telecom service providers, which customers generally still pay for by the second.

Economically speaking, IPv4 is the key that locks the market. Whereas the big players control blocks of IPv4 addresses assigned to them free of charge, new market players have to pay for addresses. In other words, there is an increasingly high investment threshold for entering the existing market. New initiatives and innovations that require large numbers of IPv4 addresses are simply impossible at the moment.

IPv6
IPv6 is the direct successor to IPv4 (IPv5 having been a short-lived experimental protocol), which amply resolves the problem of inadequate address space. IPv6 addresses are 128 bits long, enabling the creation of 2^128 = 3.4x10^38 (340 undecillion) unique addresses. That is so many – 34 followed by 37 zeros – that it can be expressed only in astronomic terms. Consider: the routable part of an IPv6 address is a prefix of 32 bits (/32). That is the level on which address blocks are assigned to access providers. Of the remaining 96 bits, a provider typically uses sixteen to define subnets for customers. Each end user is then given a unique /48 prefix, which they can use to define up to 66 thousand networks of their own. A further 64 bits remain for addressing within each of those networks, enabling each device to be given a unique IP address (via SLAAC) based on its MAC hardware address.

Each individual internet user with a /48 prefix (address block) therefore has 2^80 = 1200 sextillion addresses available for personal use. In other words, each user's personal address space is 2^48 = 281 trillion times bigger than the space that IPv4 provides for the entire internet (2^32).

As well as a dizzyingly large address space, IPv6 has various technical advantages in terms of multicasting (to supersede broadcasting), autoconfiguration (SLAAC, as well as DHCPv6), faster routing and larger network packages. However, the vastly enlarged address space is the overriding argument for migration to IPv6.

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Disadvantages of IPv4 and its workarounds:

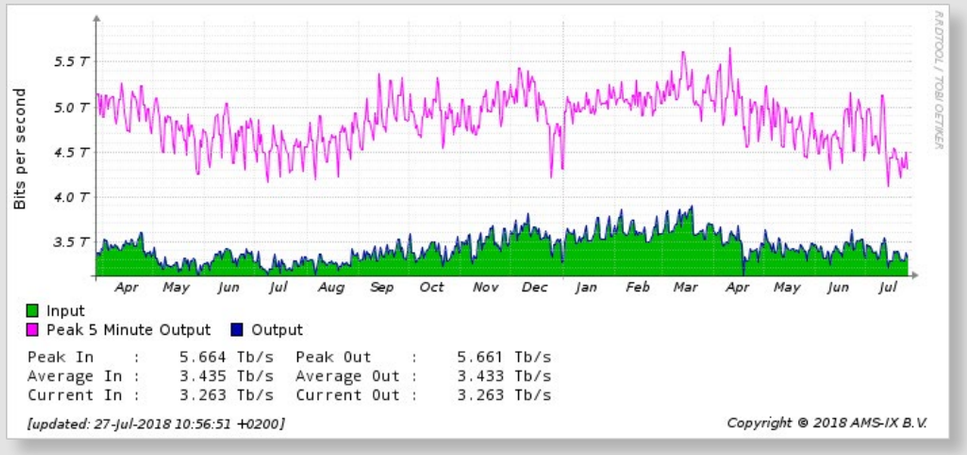
- There are no IP addresses left!
- The only way to get IP addresses is to buy them off someone else. That puts smaller market players and entrants at a disadvantage, inhibits innovation and makes the Netherlands unattractive to foreign investors and pilot organisers.
- With NAT, end users can't be reached from elsewhere on the internet. In principle, therefore, end users can only act as clients. End-user services can be made available only on an individual level by means of port forwarding (a workaround).
- In addition, NAT causes problems with other protocols:
  - Old protocols such as FTP don't work well with NAT.
  - Newer protocols, such as SIP and WebRTC (internet telephony, video calling and collaboration), don't work with NAT. Issues can often be resolved by using STUN servers (a workaround), but not always.
- Address space sharing is potentially problematic on a VPN (overlaps and clashes).
- CGNAT exploits the last remaining elasticity in the IPv4 address space, but involves a two-level NAT cascade enabling an entire street or neighbourhood to share a single IP address. That has various implications:
  - End-user services cannot be accessed even by means of port forwarding
  - Banks, government agencies and others cannot use IP addresses to assure security, or as a basis for filtering or blocking
- Classless routing (CIDR) enables much more efficient address block utilisation, but requires the deployment of additional hardware to handle the enlarged route tables. Advances in processing power and prefix aggregation (supernetting, like reallocation for address blocks) have made the technology viable and affordable.

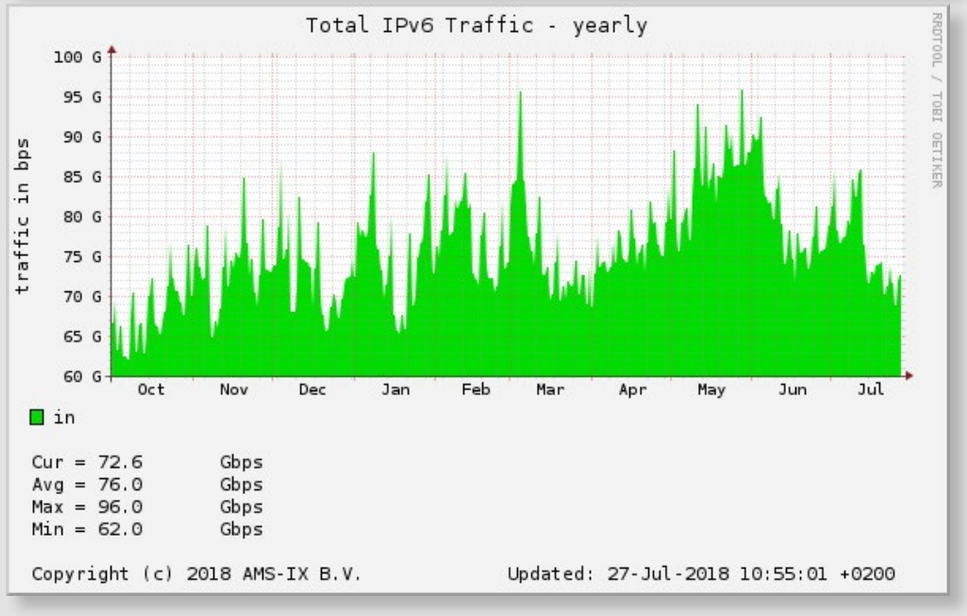
Advantages of IPv6:

- Enough IP addresses for everything and everyone.
- Semi-functional workarounds, such as (CG)NAT, port forwarding and STUN servers are no longer needed. No impediments to the development and rollout of new protocols and applications.
- No more address space overlaps or clashes.
- Each end user doesn't merely have their own IP address, but their own vast address space.
- Although NAT is (incorrectly) seen as a privacy/security feature, IPv6's SLAAC Privacy Extensions combined with good firewall settings provide greater protection without any reachability penalty.
- New and improved functionality: autoconfiguration, faster routing and larger network packages.

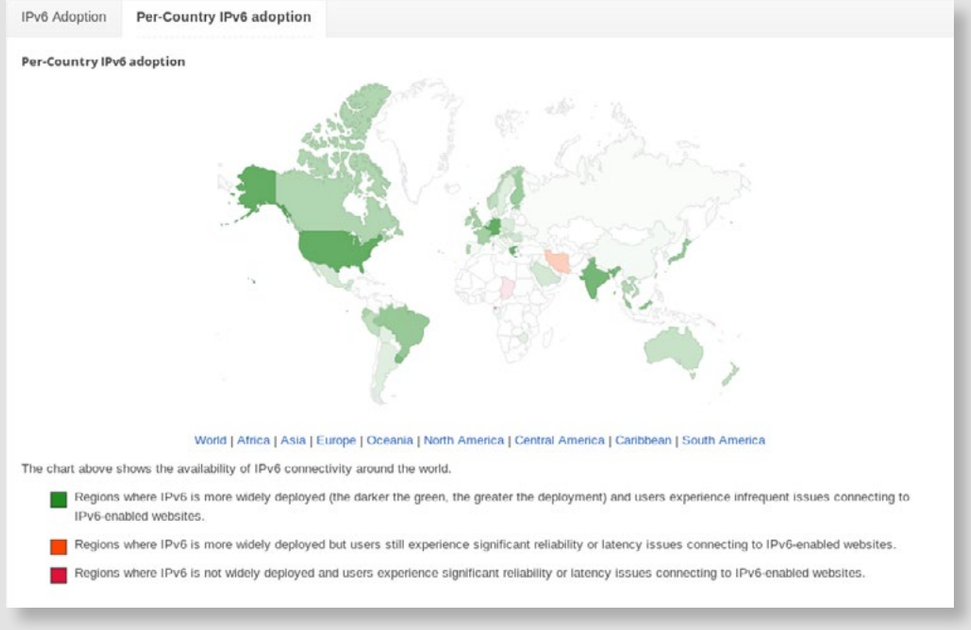
3 Adoption

Although IPv6 has been around for twenty years and is now supported by almost all equipment and operating systems, its use has started to pick up only in recent years.
The AMS-IX reports that an average of 75 Gbps of IPv6 traffic is handled by its hub daily. Out of a total traffic volume of 3.4 Tbps, that represents just 2.2 per cent.





Google publishes a continually updated graph, from which it is apparent that the number of users accessing the company's services using IPv6 has increased sharply in recent years. Globally, the figure is now more than 20 per cent, although there is considerable variance either side of that mean. Leading the migration are Western countries, Brazil, India and Japan.



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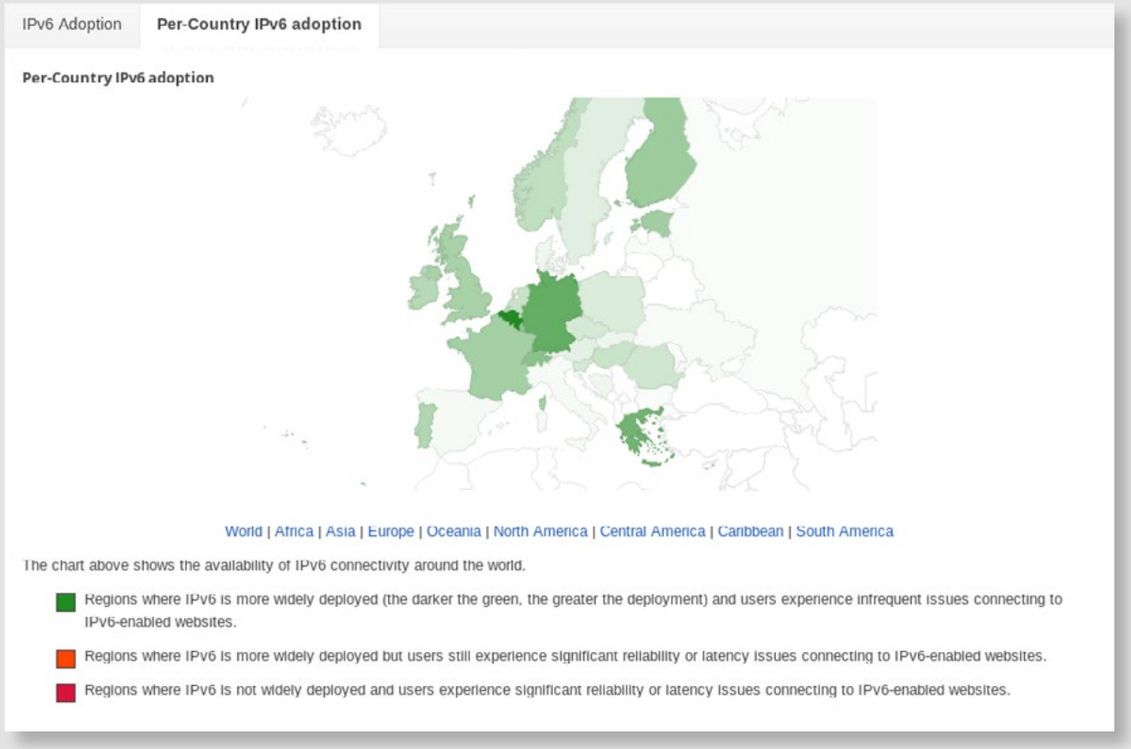
Within Europe, it is unfortunately the case that the Netherlands lags well behind neighbouring countries. The Netherlands' adoption rate of just 13.2 per cent is much lower that Germany's (38.0 per cent) and Belgium's (54.3 per cent!). Dutch IPv6 use is more on a par with countries on the periphery of Europe. One of the main reasons is that neither of the country's two biggest access providers (KPN and Ziggo) offers internet users a proper dual-stack IPv6 connection, despite telling their clients for years that a large-scale rollout was soon to start.

Country	Percentage
Belgium	54.3
Germany	38.0
Greece	34.5
Switzerland	28.6
Luxembourg	26.3
Finland	23.7
Estonia	22.8
France	22.0
United Kingdom	21.1
Portugal	18.9
Ireland	17.3
Norway	15.1
Netherlands	13.2

Tabel 1: Europe's top IPv6-adopting countries [source: Google]



4 IPv6 Inventory 2018

With a view to building a more detailed picture of the (server-side) IPv6 adoption landscape in the industry, we have analysed support for the protocol within various economic sectors. We focused particularly on organisations that play a critical role in the infrastructure, economy and security of the Netherlands. That focus reflects the fact that the reachability of the organisations in question is vital for keeping the country running.

The selection was based on the list of Essential Service Providers referred to in the Cybersecurity Notification Obligation Decree, a general administrative order associated with the Data Processing and Cybersecurity Notification Obligation Act. The organisations in question include the drinking water supply companies, national and regional electricity and gas network operators, nuclear plants, banks and stock exchanges, telecom and the internet access providers, the internet hubs, the Port of Rotterdam, Schiphol Airport Authority and the flood defence operators. Because of their importance to the nation, such organisations are classed as Essential Service Providers (ESPs) and, as such, obliged to notify the National Cyber Security Centre (NCSC) of any serious security breaches or other major ICT problems.

Domain names

We supplemented the ESP list with our own list of critical entities, covering the Brainport Region around Eindhoven, the road network and inland waterway management authorities, and various non-governmental entities of great importance to the community, such as care providers, scientific research centres, public order and security agencies, news providers and on-line media.

The resulting ESP/critical entity list was used to compile eighty lists of domain names, partly by hand and partly imported from open data files and information published by organisations representing the sectors in question.

One would hope that organisations whose online reachability is vital to Dutch society would be more likely than most to provide IPv6-enabled services from their primary domains. If the integrity (security) and continuity (availability) of the organisations in question are of national importance, so is their reachability.

Test, test, test

The domains' name servers (DNS), web servers (HTTP) and mail servers (SMTP) were tested for IPv6 support. A domain was considered to support the protocol if at least two name servers, one website (with or without 'www') and one mail gateway (MX gateway) were reachable using IPv6. Naturally, mail gateway support was considered only if the domain was actually used for mail. The thinking behind that definition of IPv6 support was that it implies a viable infrastructure would remain in place if IPv4 were removed from the picture.

Element	IPv6 support
DNS	2+ servers reachable
Web	1+ server reachable (with or without 'www' prefix)
Mail	1+ gateway reachable (applies to mail domains only)
Overall	All three support elements

Tabel 2: IPv6 support test criteria

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The test itself was carried out using the Dmap crawler & classifier: a tool developed at SIDN Labs, which yields 150 to 200 columns of raw and enriched information for each scanned domain. SIDN is considering the possibility of publishing it as open-source software in due course. SIDN uses the tool itself for monitoring IPv6 support in connection with its registrar incentive scheme. Further details are provided later in this report.

Internet.nl batch processor
All the domain name lists were then put through Internet.nl portal batch processor. That provided us with a data set for validation and cross-comparison of our own findings.

Broadly speaking, the batch processor results were consistent with our own test results. However, Internet.nl applies stricter criteria than we used: the batch processor classes a domain as IPv6-enabled only if all web and mail servers are reachable using IPv6. That is possible only because Internet.nl maintains a strict separation between web tests and mail tests. If we had applied similarly strict criteria, and had combined the DNS, web and mail results, the difference between our findings and the batch processor results would have been negligible.

Element	IPv6 support
Web	2+ name servers reachable and all webservers reachable and consistent (with and without www considered separately)
Mail	2+ name servers reachable and all gateways reachable

Tabel 3: Internet.nl's IPv6 support test criteria

5 Findings

Our findings are presented in the table on the next page, grouped under ten sector headings. After the table, the findings for each sector are presented in a diagram. In each case, the first three columns detail the separate elements of IPv6 support: DNS, web and mail (dark grey, white and light grey, respectively). The next diagram states the level of overall support (all three elements of support combined).

The most striking characteristic is the relatively high DNS scores. In the discussion later in this report, we highlight the influence of SIDN's IPv6 incentive scheme in that context. The web and mail support scores are generally quite similar to one another. However, when each domain's scores for the three elements of IPv6 support are combined, the resulting overall support scores remain very disappointing.

No policy

The discrepancies between the elements corroborate the general observation that DNS, web and mail services are usually obtained from different providers. For example, DNS management is normally undertaken by an external operator who is also the domain's registrar. Websites are often managed by a hosting service provider. And mail services are typically obtained from a major provider, such as Google or Microsoft.

Furthermore, the much lower overall scores registered across the board by all sectors indicate that few registrants have a policy on IPv6. If a registrant has a policy on IPv6, one would expect that to result in a consistent support status across the various support elements, due to supplier selection in line with that policy.

The levels of overall IPv6 support can only be described as disappointing. In all surveyed sectors, only a small proportion of domains tested positive for all three IPv6 support elements.

> Tabel 4: IPv6 test results for different sectors and categories
> Graphs 1 to 20: IPv6 test results per sector

Differences between organisations of different types

Generally speaking, the level of adoption both amongst very large companies and amongst small entities is above the national average, but the medium-sized lag behind. A similar observation was made in ISOC's 'State of IPv6 Deployment 2018', which highlighted enterprise networks as reluctant adopters.

The explanation may be as follows. 'Big Internet' corporations tend to set up and maintain their own infrastructures. For example, Google even lays its own undersea cables. Such organisations will generally be inclined to adopt modern, scalable internet standards.

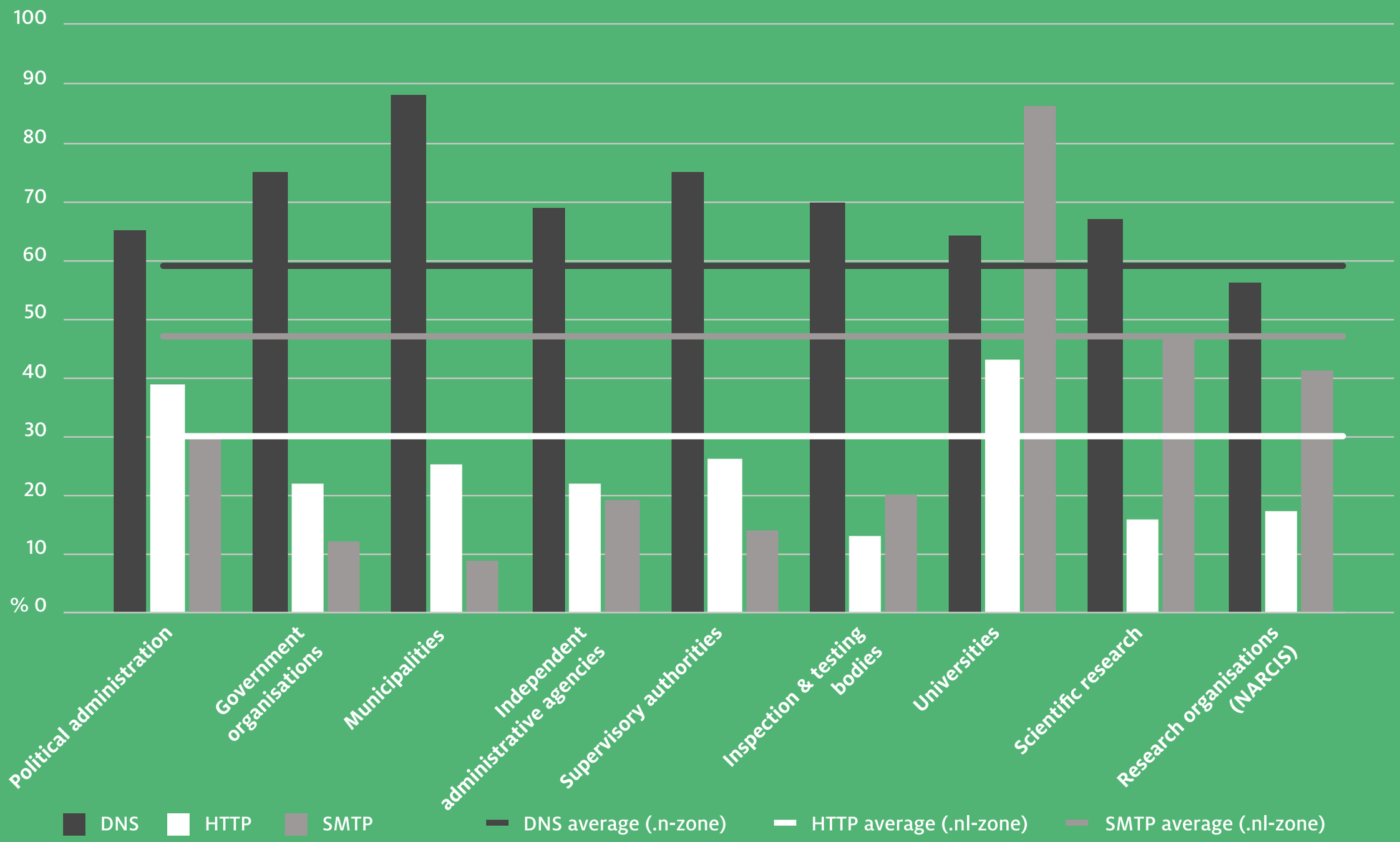
According to the ISOC publication mentioned above, some multinationals repeatedly re-use the same private IPv4 address series – mutually separated using NAT – in different parts of their organisations, with all the associated headaches. Consequently, companies such as Google, Facebook, Microsoft, LinkedIn and Akamai are currently converting their internal networks to IPv6-only, or have already done so.

Below such organisations in the pyramid are organisations that are large enough to set up and maintain at least part of their own infrastructures, but do not prioritise the implementation of modern standards, since infrastructure management is not a core activity.

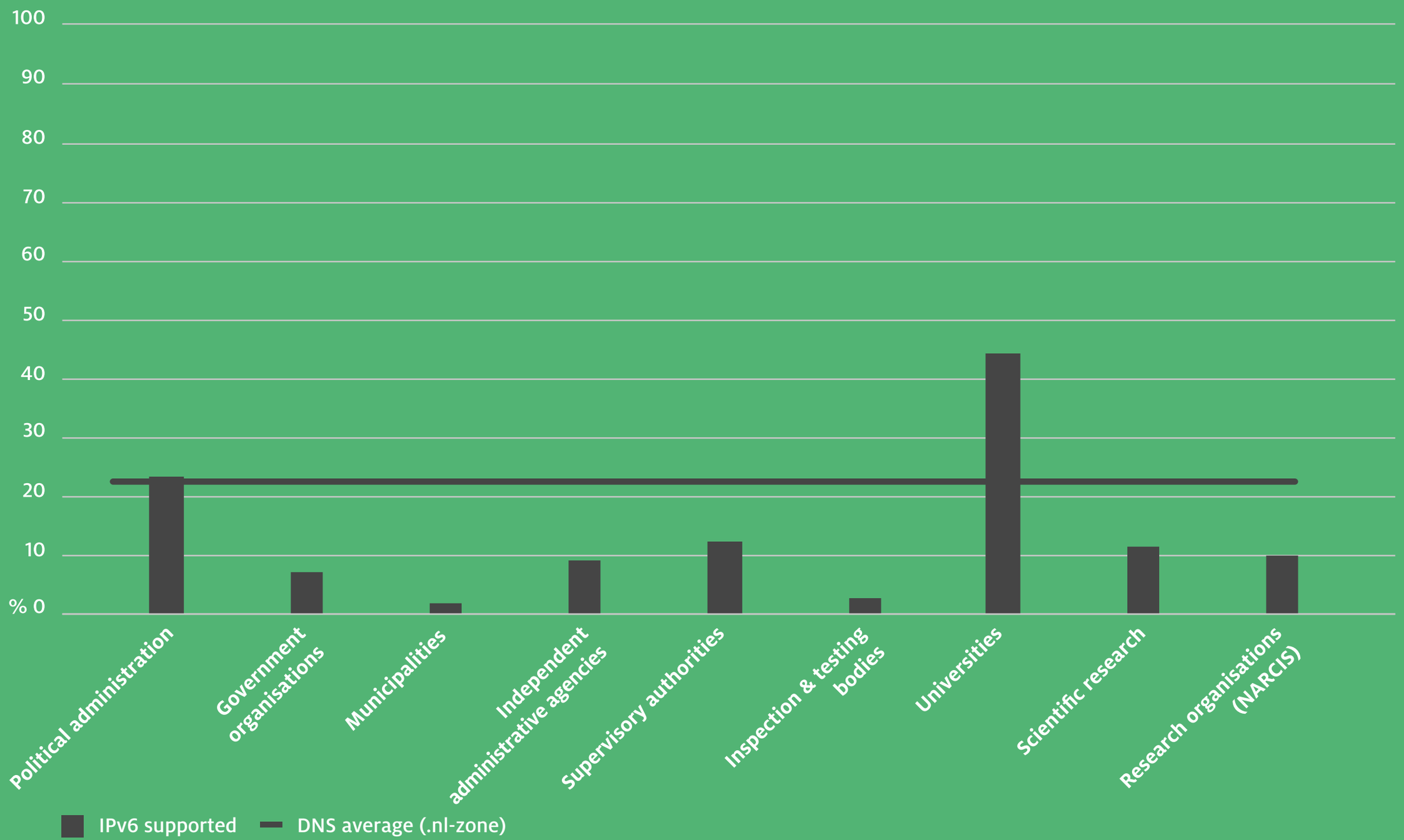
Sectors	Groups	DNS	Web	E-mail	IPv6 supported
Public sector	Political administration	65%	39%	30%	23%
	Government organisations	75%	22%	12%	7%
	Municipalities	88%	25%	9%	2%
	Independent administrative agencies	69%	22%	19%	9%
	Supervisory authorities	75%	26%	14%	12%
	Inspection & testing bodies	70%	13%	20%	3%
	Universities	64%	43%	86%	43%
	Scientific research	67%	16%	47%	11%
	Research organisations (NARCIS)	56%	17%	41%	10%
Transport & water	Water boards	62%	19%	14%	10%
	Public Works & Water Management Directorate	100%	0%	25%	0%
	Pumping station (historical)	74%	21%	23%	13%
	Fairway Information Service	53%	5%	0%	0%
	Transport	60%	12%	11%	3%
Utility companies	Energy supply	74%	17%	4%	4%
	Dutch Energy Association	69%	11%	16%	5%
	Electricity/gas suppliers	67%	11%	16%	5%
	Drinking water suppliers	68%	0%	0%	0%
Public order & security	Emergency services	65%	11%	7%	3%
	Regional security authorities	68%	12%	4%	0%
	National security service	90%	30%	40%	10%
	Defence	100%	100%	0%	0%
Health care	Hospitals	66%	6%	14%	0%
	GP surgeries	49%	7%	12%	4%
	Pharmacists	47%	3%	11%	2%

Sectors	Groups	DNS	WebE	-mail	IPv6 supported
Commerce	Listed companies	46%	6%	7%	0%
	MT 500 top 50	67%	16%	14%	6%
	MT 500	57%	9%	7%	1%
	Fortune Global 500	35%	10%	4%	1%
	NL Groeit top 10	90%	30%	30%	0%
	NL Groeit top 250	71%	12%	35%	5%
	Fortune Future 50	66%	23%	22%	8%
Financial service providers	Financials	62%	8%	5%	1%
	Banks	50%	6%	2%	0%
	Financial/mortgage advisors	60%	17%	20%	8%
	Payment processors	50%	6%	6%	2%
	On-line payment processors	65%	19%	32%	6%
	Cryptocurrencies	75%	32%	33%	19%
	Cryptocurrency exchanges	92%	44%	51%	25%
Internet and telecom	AMS-IX members	50%	29%	24%	11%
	NL-ix members	59%	25%	27%	13%
	Social media	71%	21%	46%	8%
	Most-visited .nl sites (Alexa)	60%	43%	43%	24%
	Most-visited sites from NL (Alexa)	78%	48%	47%	24%
	Most-visited sites from NL (SimilarWeb)	76%	37%	38%	16%
	Most-visited sites worldwide (Alexa)	50%	15%	20%	
	Most-visited sites worldwide (SimilarWeb)	70%	57%	56%	36%
On-line media	Newspapers	84%	31%	43%	27%
	Radio and TV	93%	23%	30%	10%

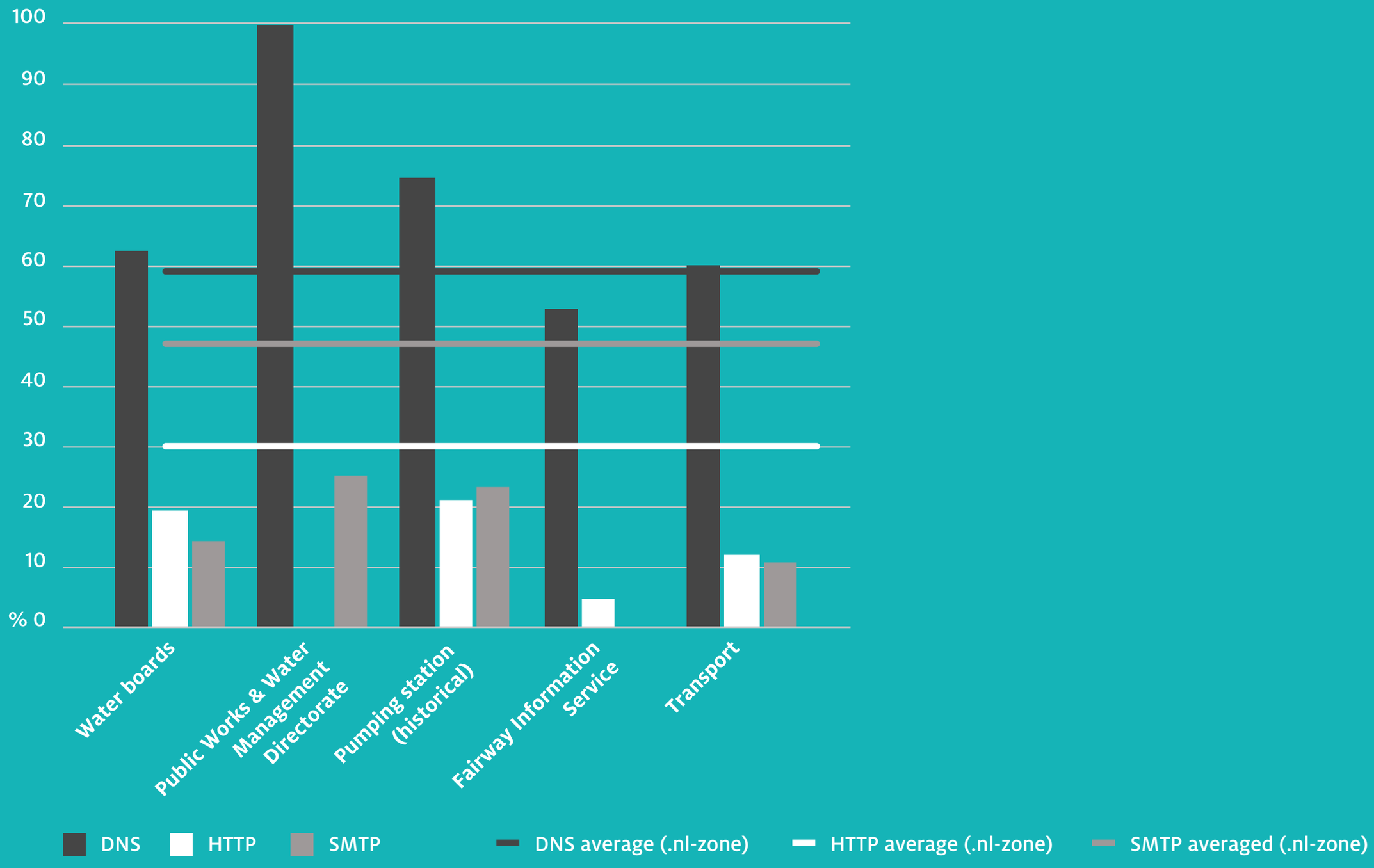
Sectors	Groups	DNS	Web	E-mail	IPv6 supported
Industry	Nuclear	70%	20%	20%	10%
	Energy production/transmission/trading	62%	10%	6%	3%
	Schiphol businesses	58%	9%	10%	3%
	Businesses in Schiphol industrial areas	64%	26%	32%	15%
	Schiphol region	42%	9%	8%	7%
	Brainport businesses	60%	9%	9%	0%
	Businesses in Eindhoven industrial areas	61%	25%	29%	14%
	Brainport region	59%	16%	15%	9%
	Port of Rotterdam businesses	55%	12%	12%	3%
	Port of Rotterdam chemicals firms	47%	9%	0%	0%
	Rotterdam Transport	57%	13%	12%	3%
	Rotterdam port area businesses	61%	28%	31%	17%
	Main port region	61%	23%	20%	16%
	Three main port regions collectively	58%	16%	16%	10%



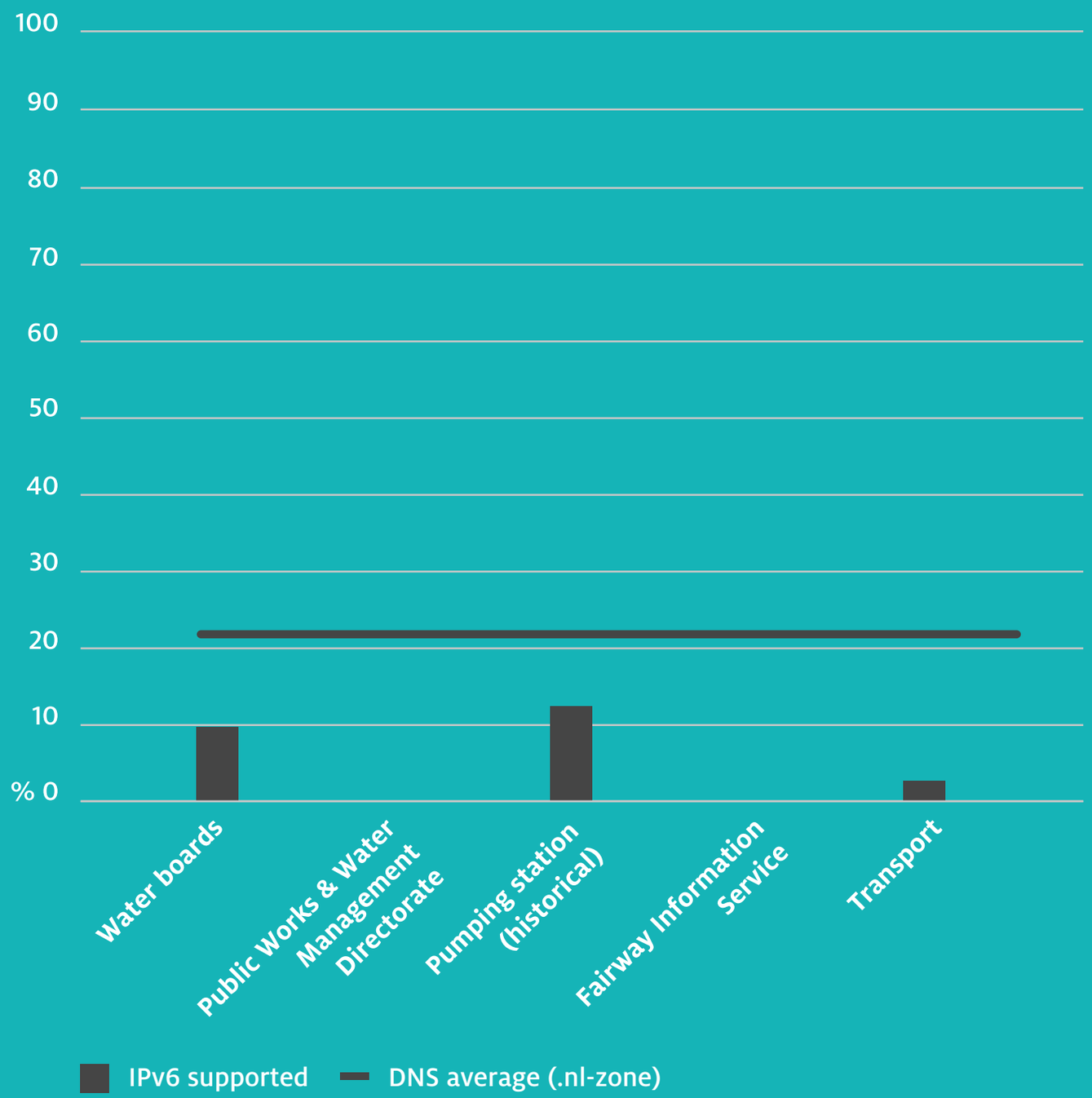
Graph 1: IPv6 test results for the public sector



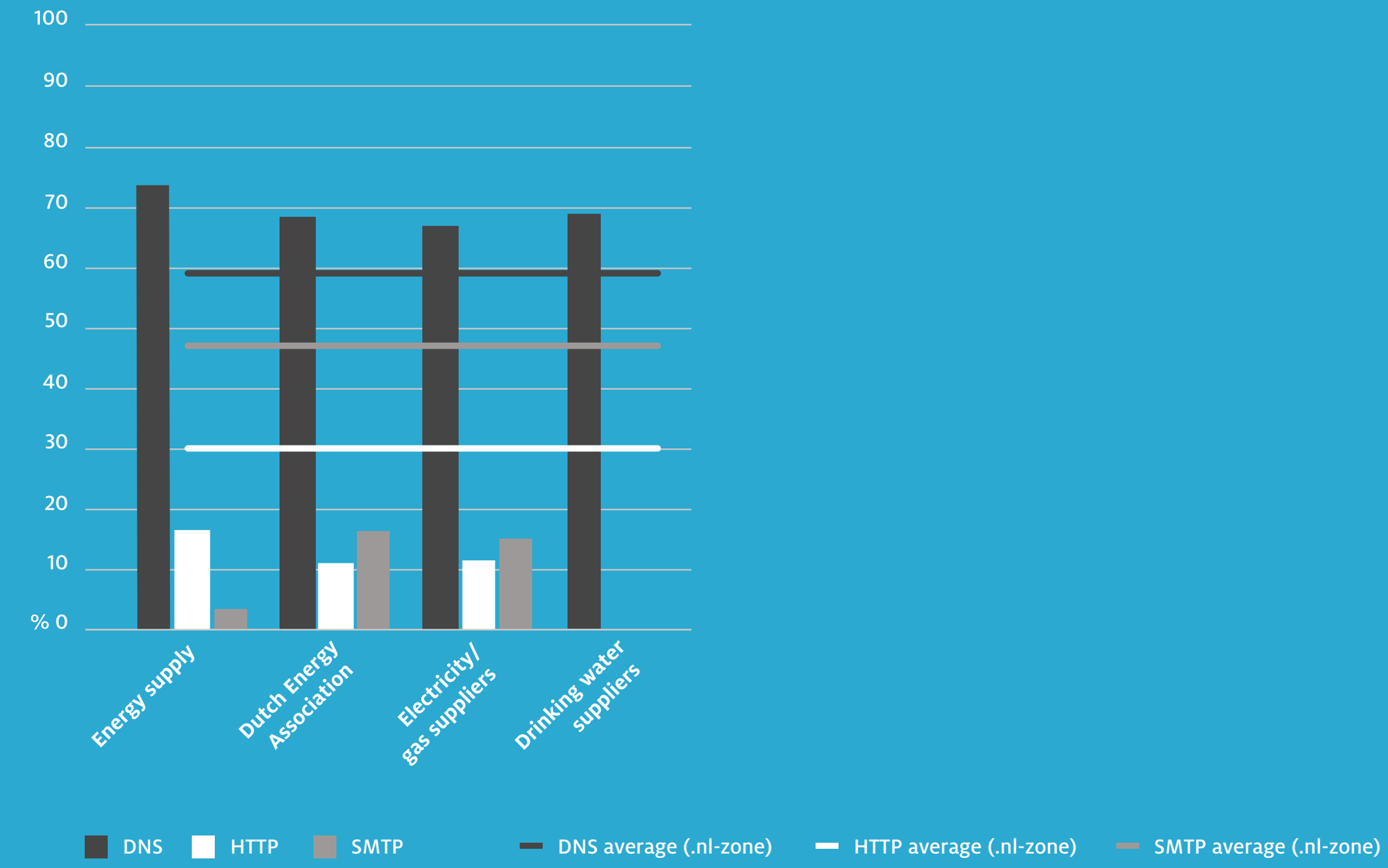
Graph 2: overall IPv6 test results for the public sector



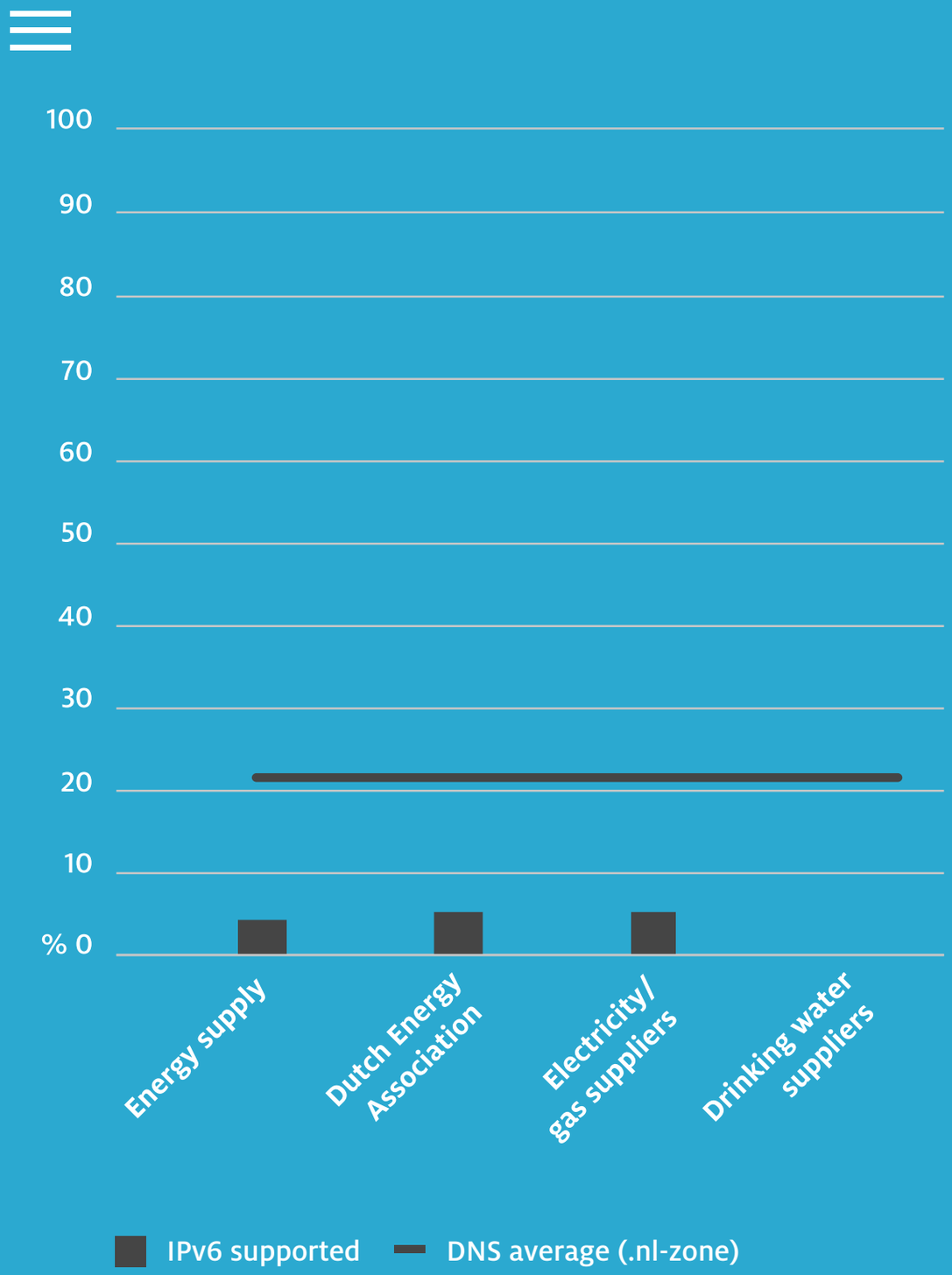
Graph 3: IPv6 test results for the transport & water sector



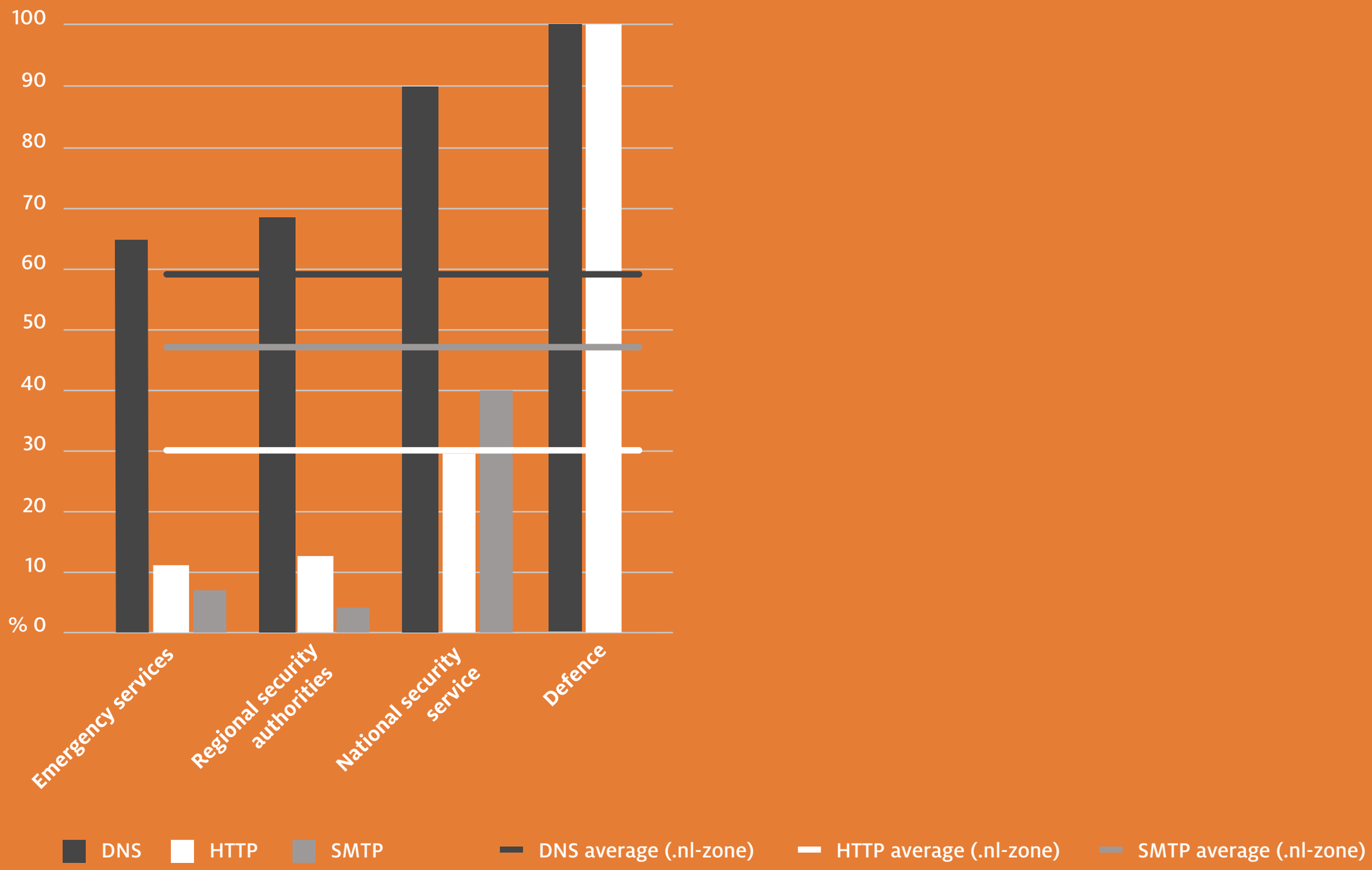
Graph 4: overall IPv6 test results for the transport & water sector



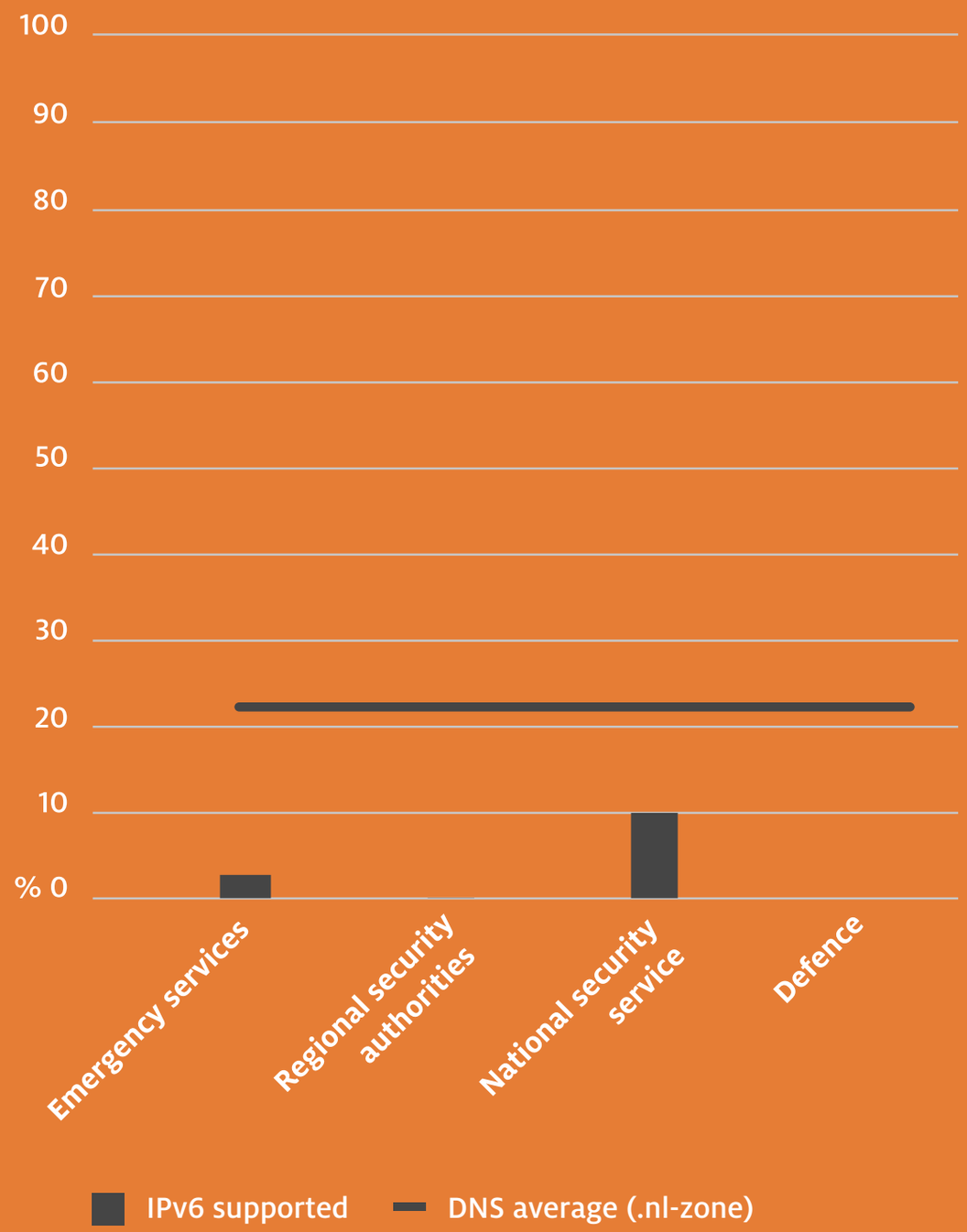
Graph 5: IPv6 test results for the utilities sector



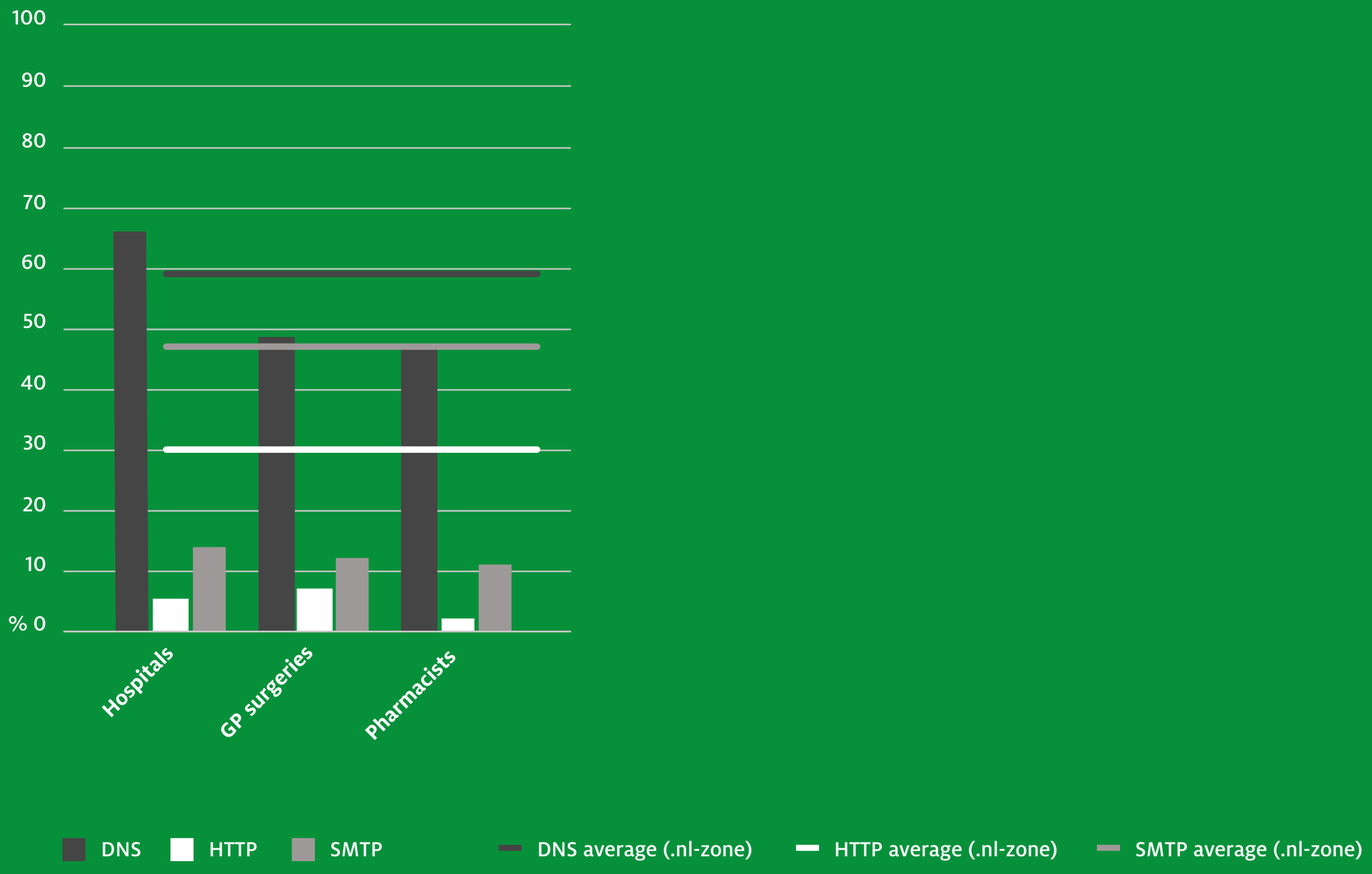
Graph 6: overall IPv6 test results for the utilities sector



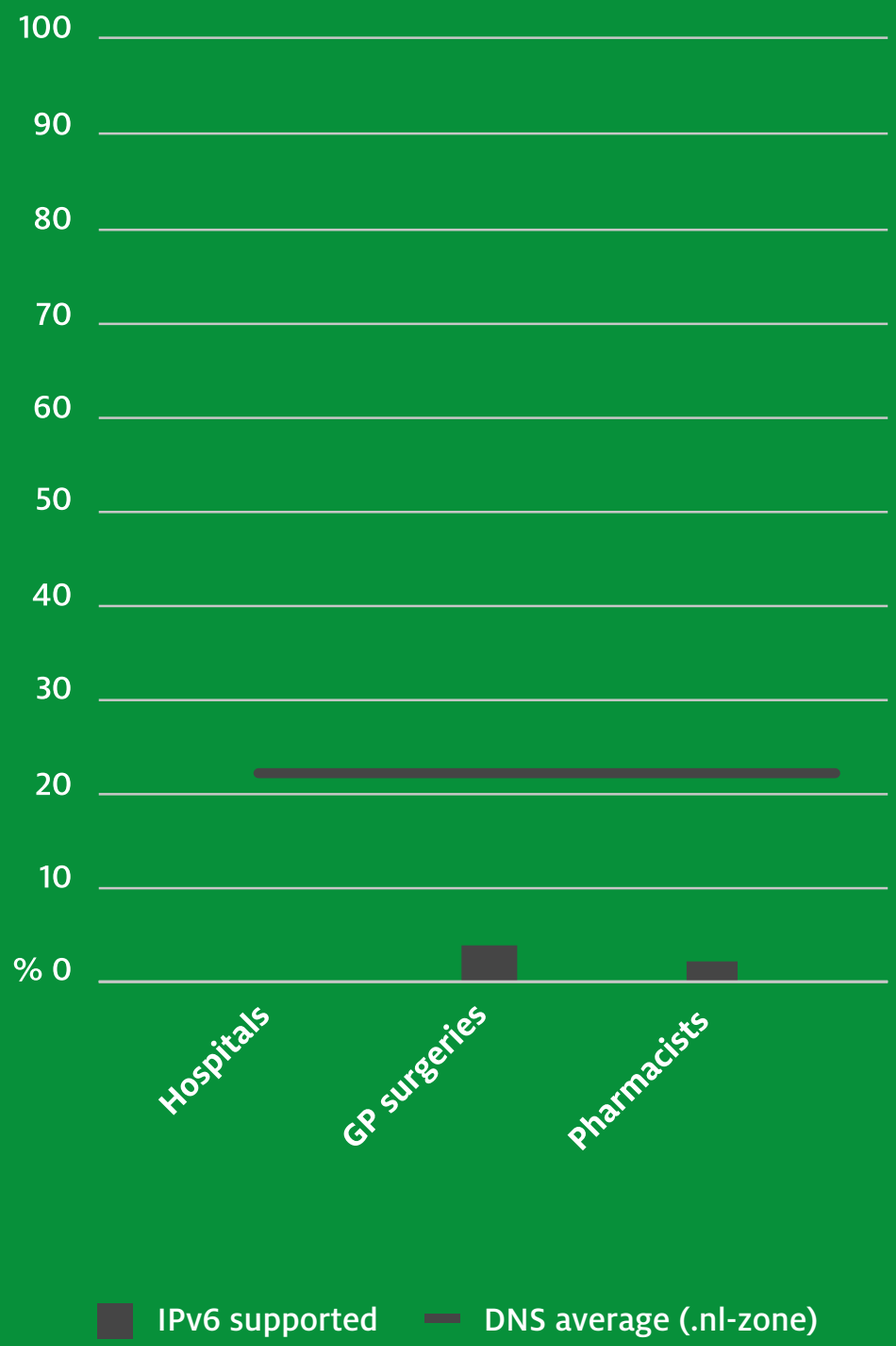
Graph 7: IPv6 test results for the public order & security sector



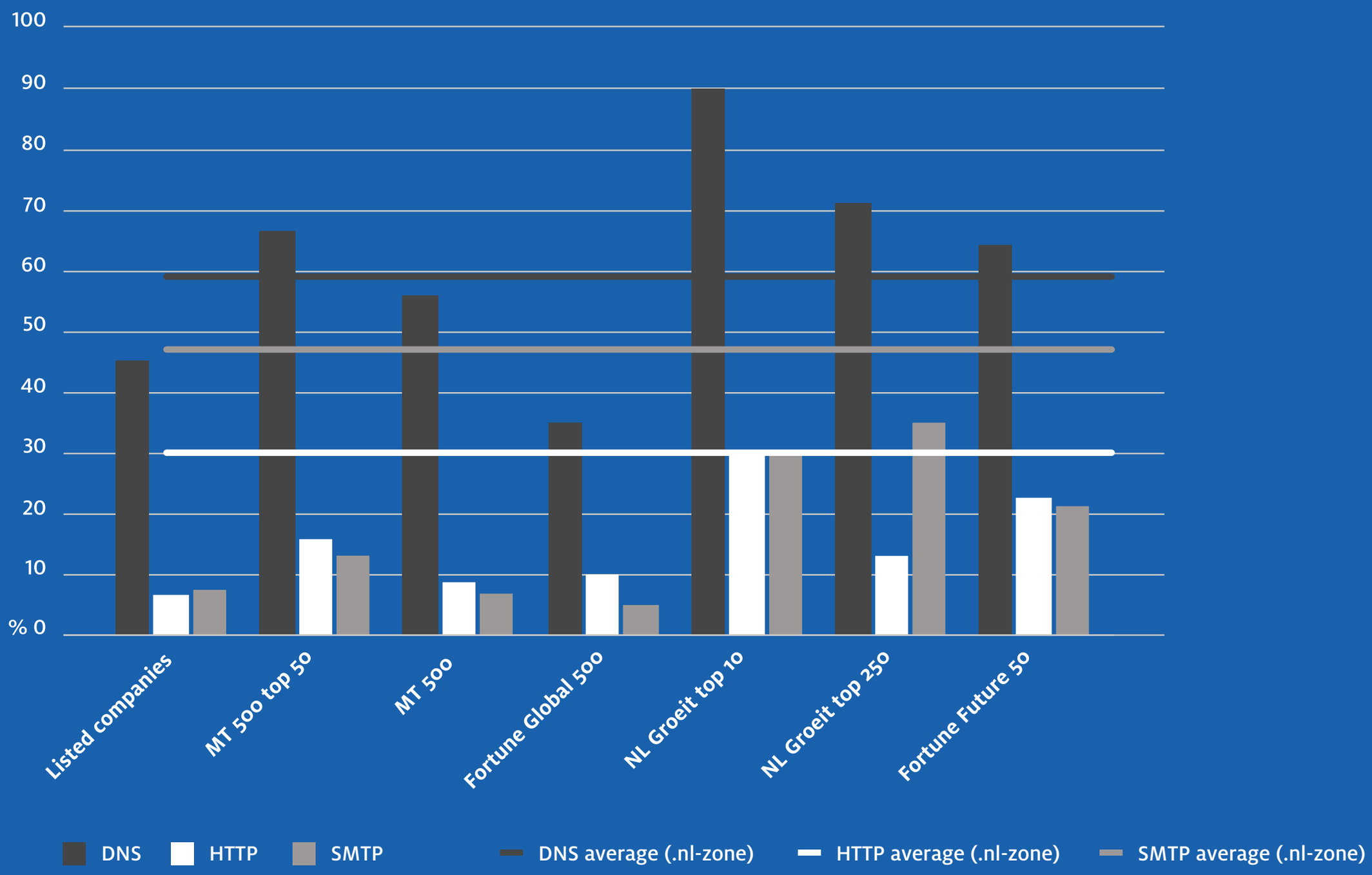
Graph 8: overall IPv6 test results for the public order & security sector



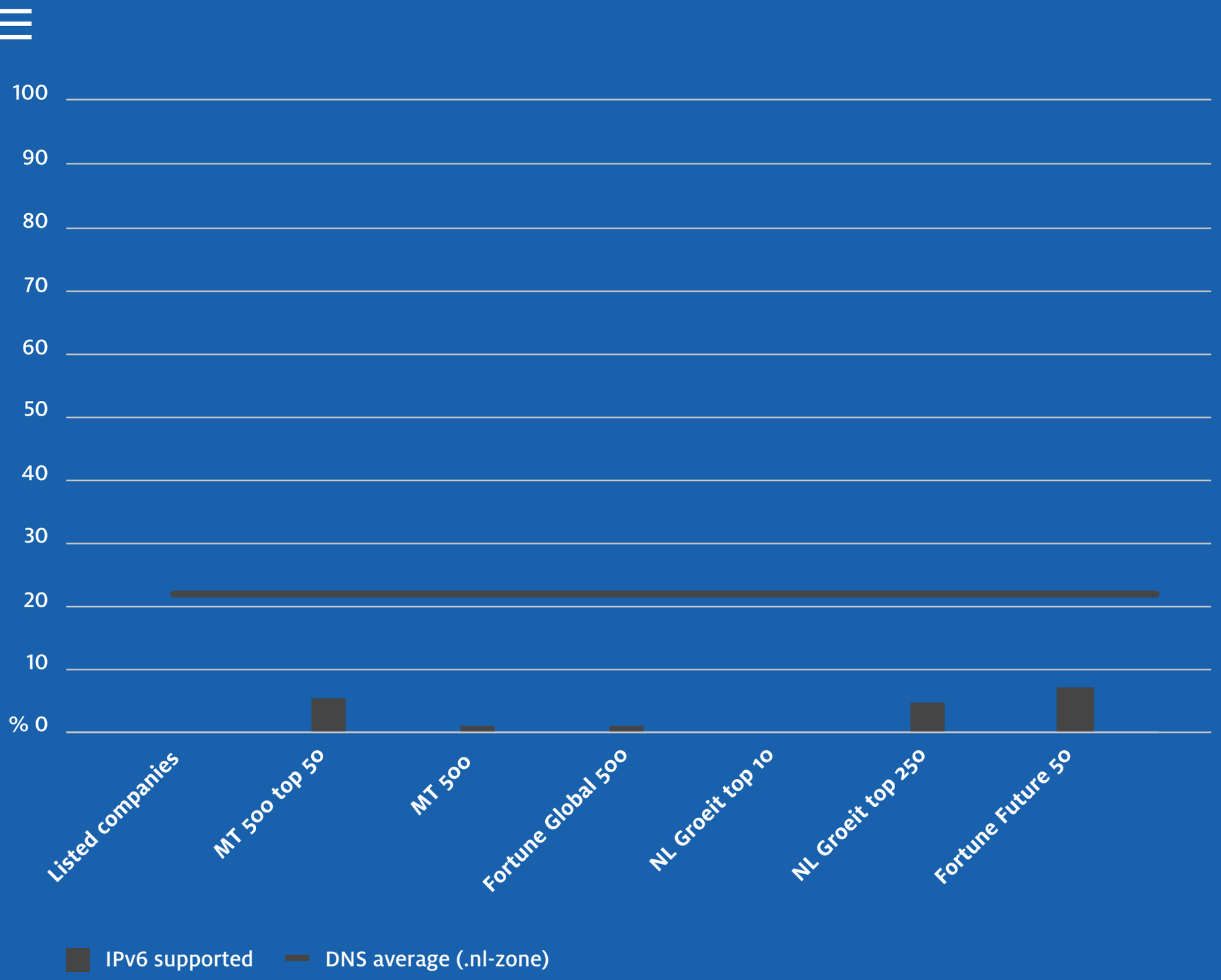
Graph 9: IPv6 test results for the care sector



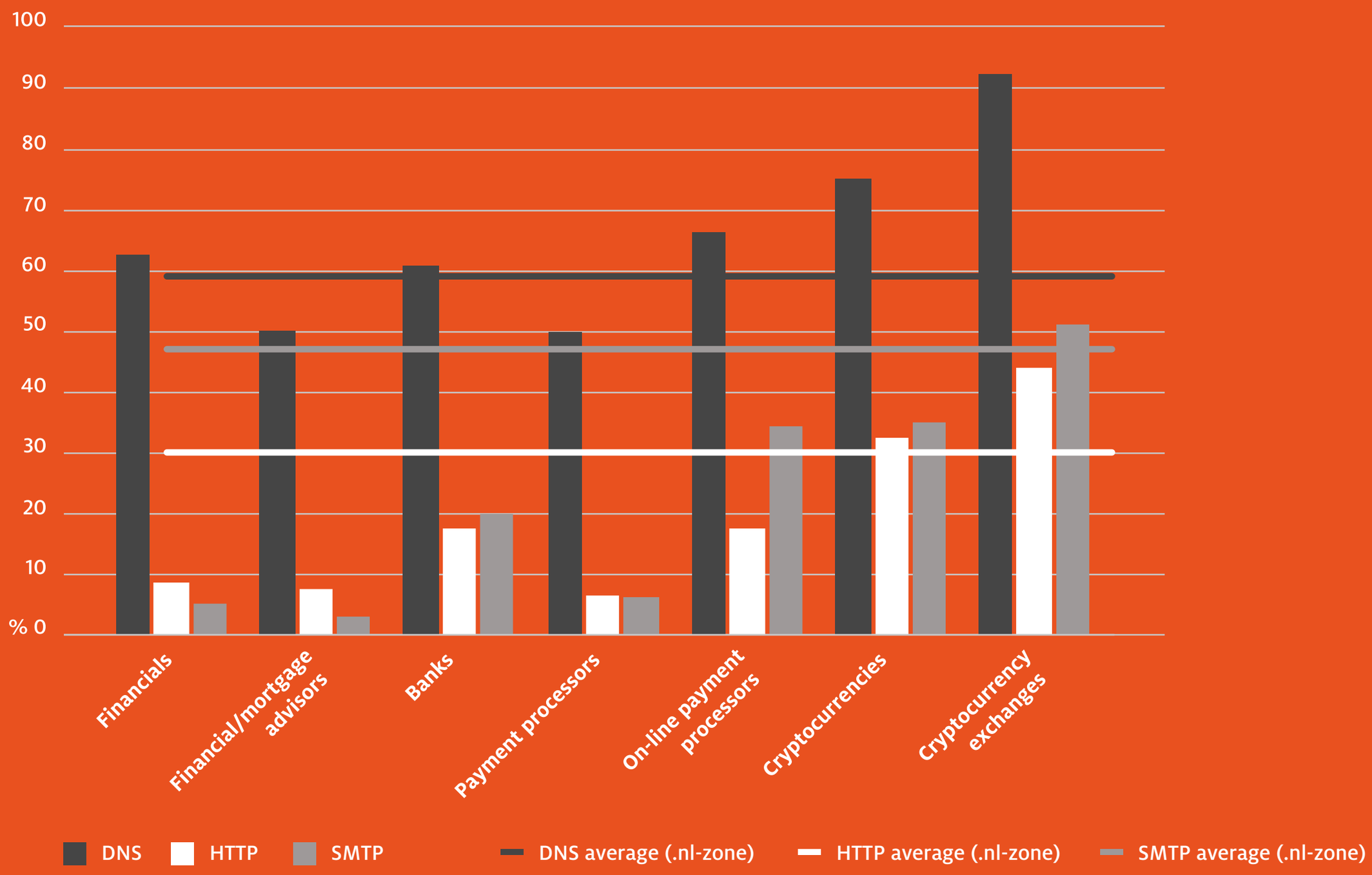
Graph 10: overall IPv6 test results for the care sector



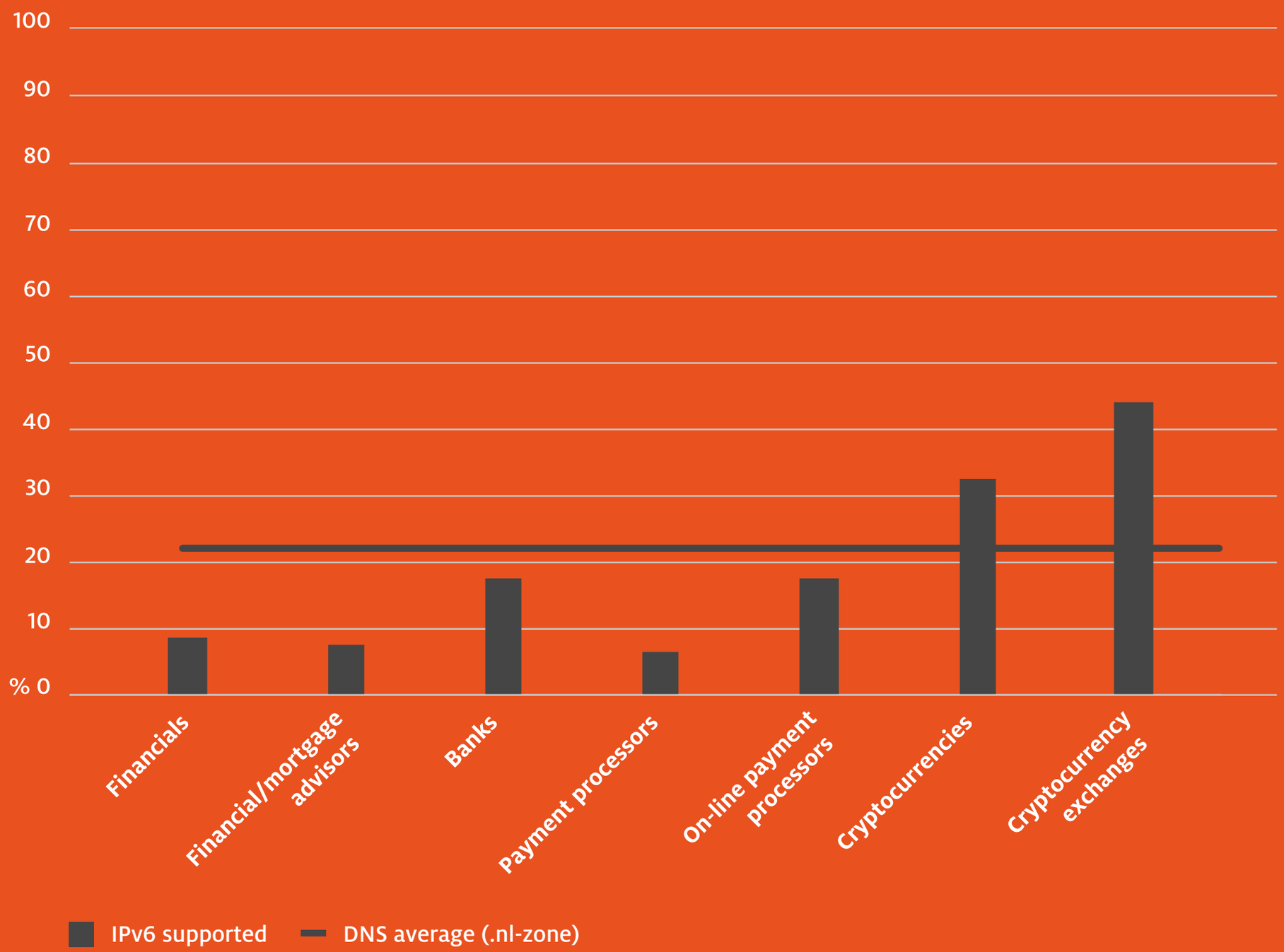
Graph 11: IPv6 test results for the commerce sector



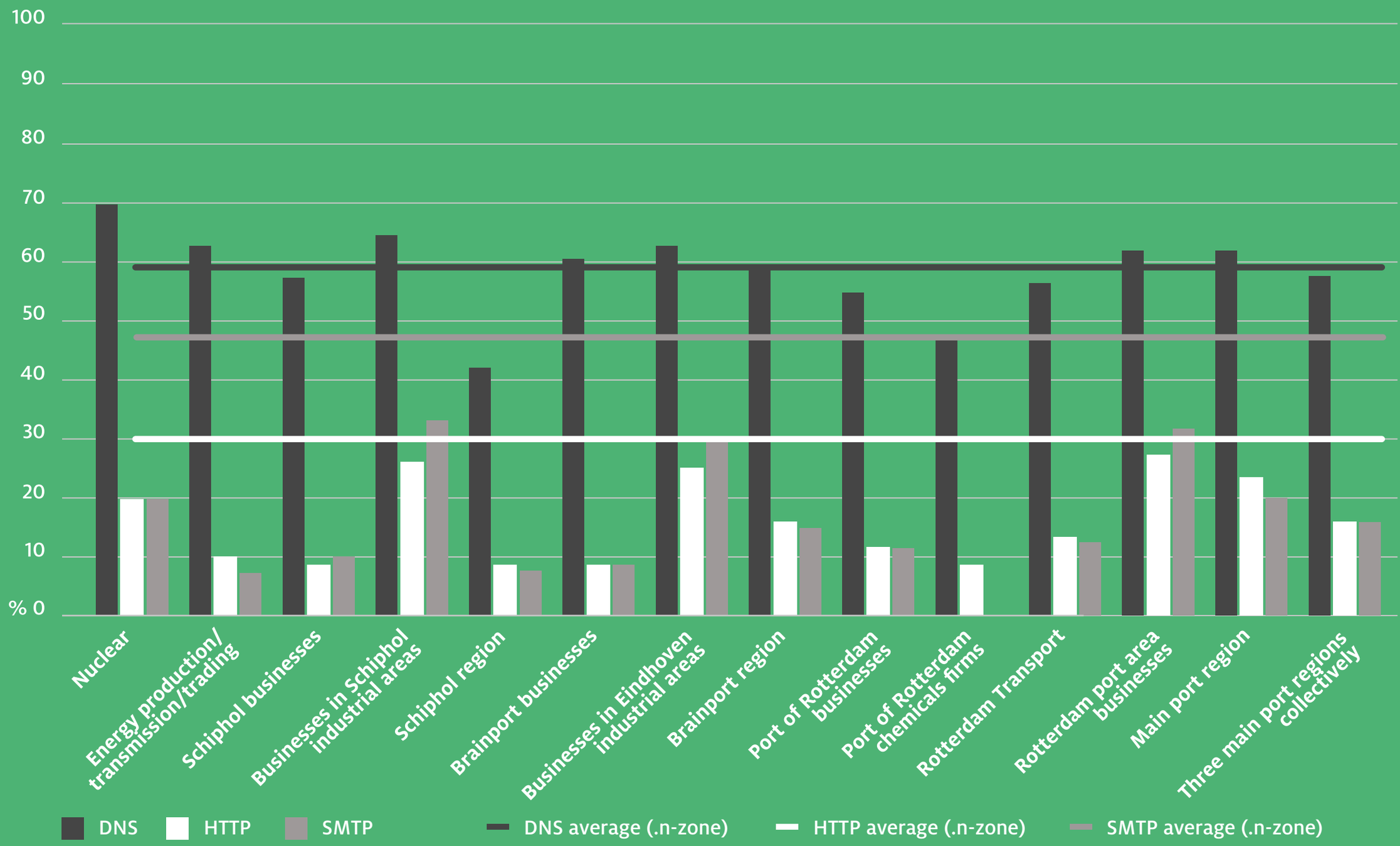
Graph 12: overall IPv6 test results for the commerce sector



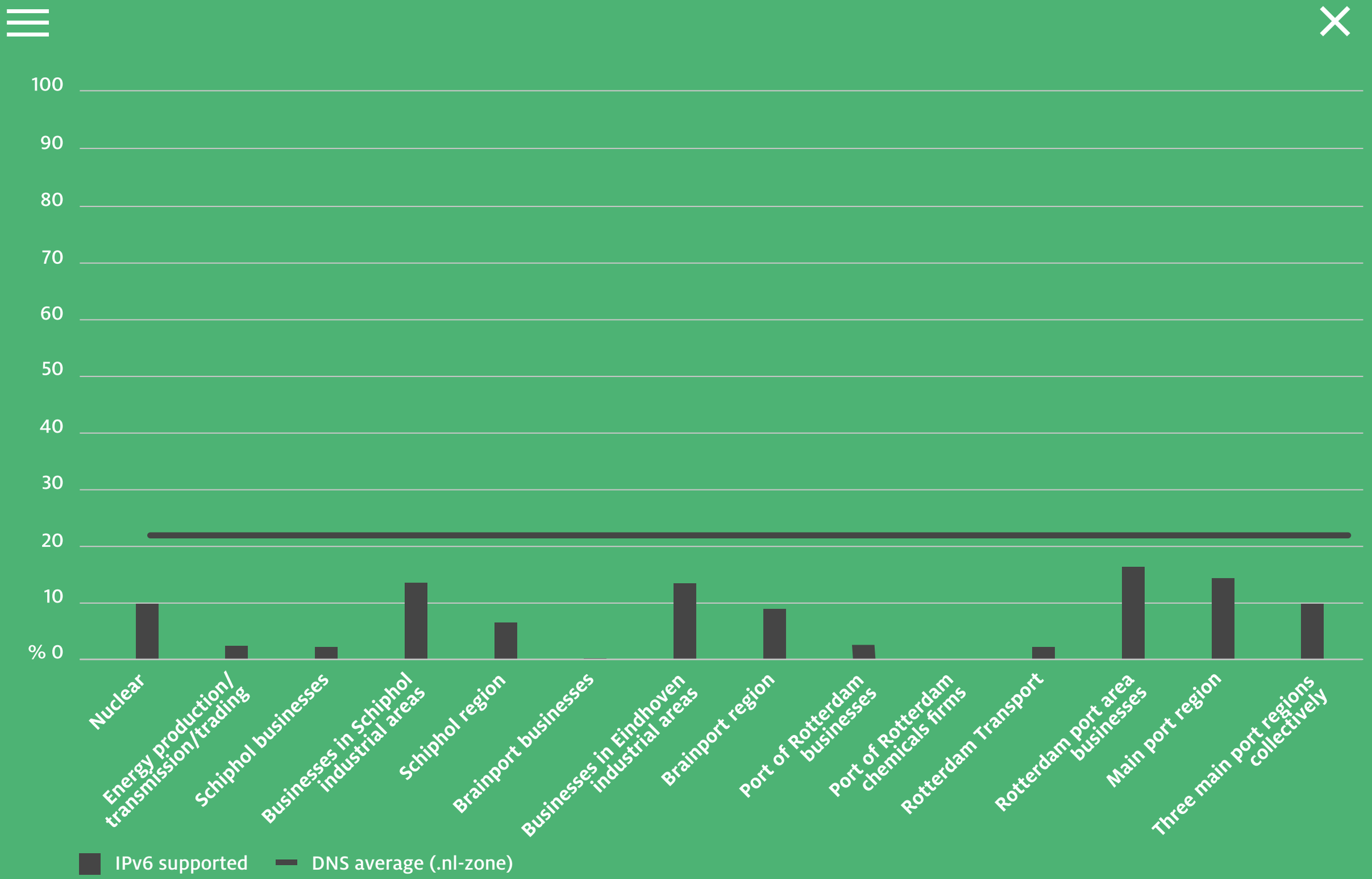
Graph 13: IPv6 test results for the financial services sector



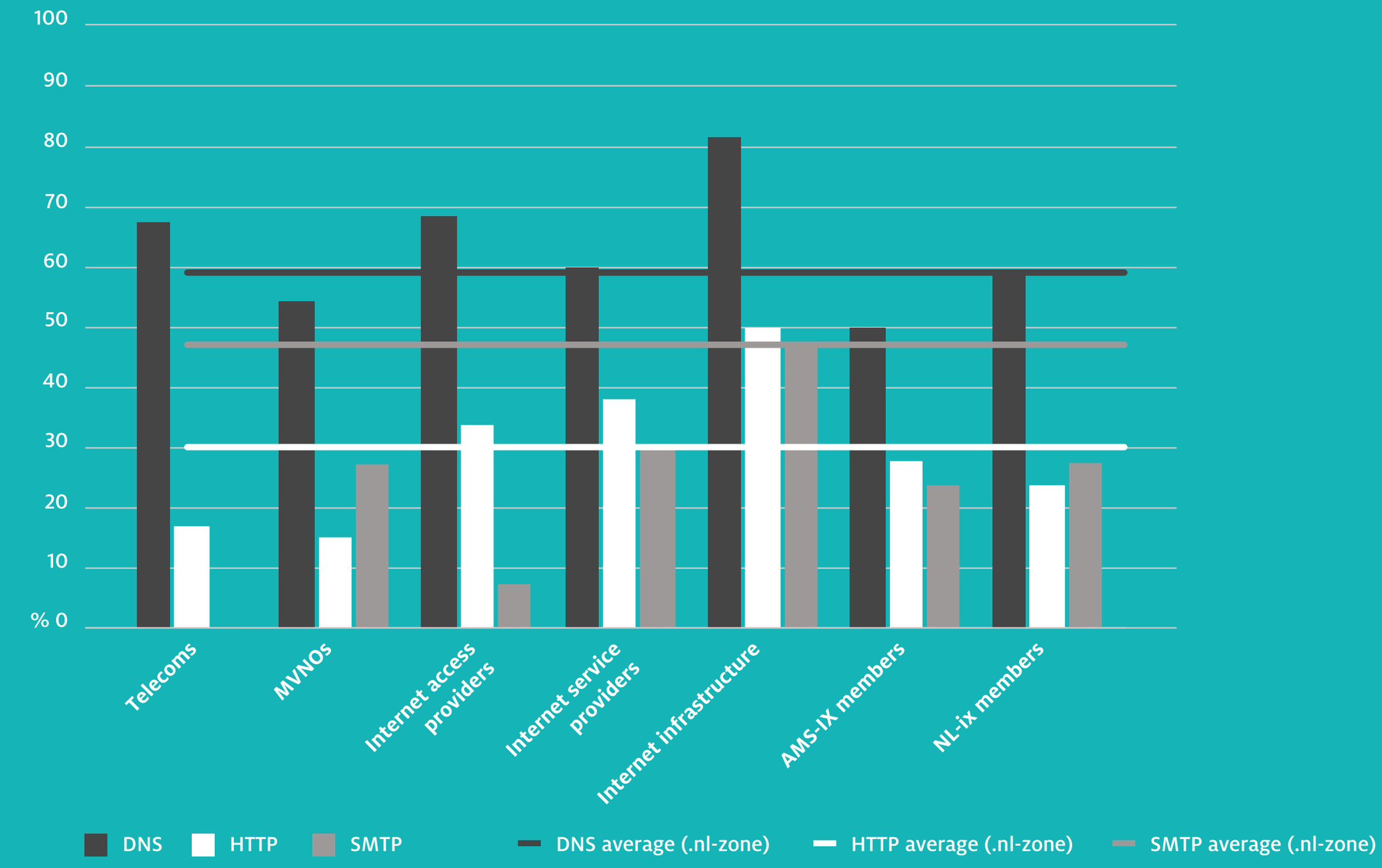
Graph 14: overall IPv6 test results for the financial services sector



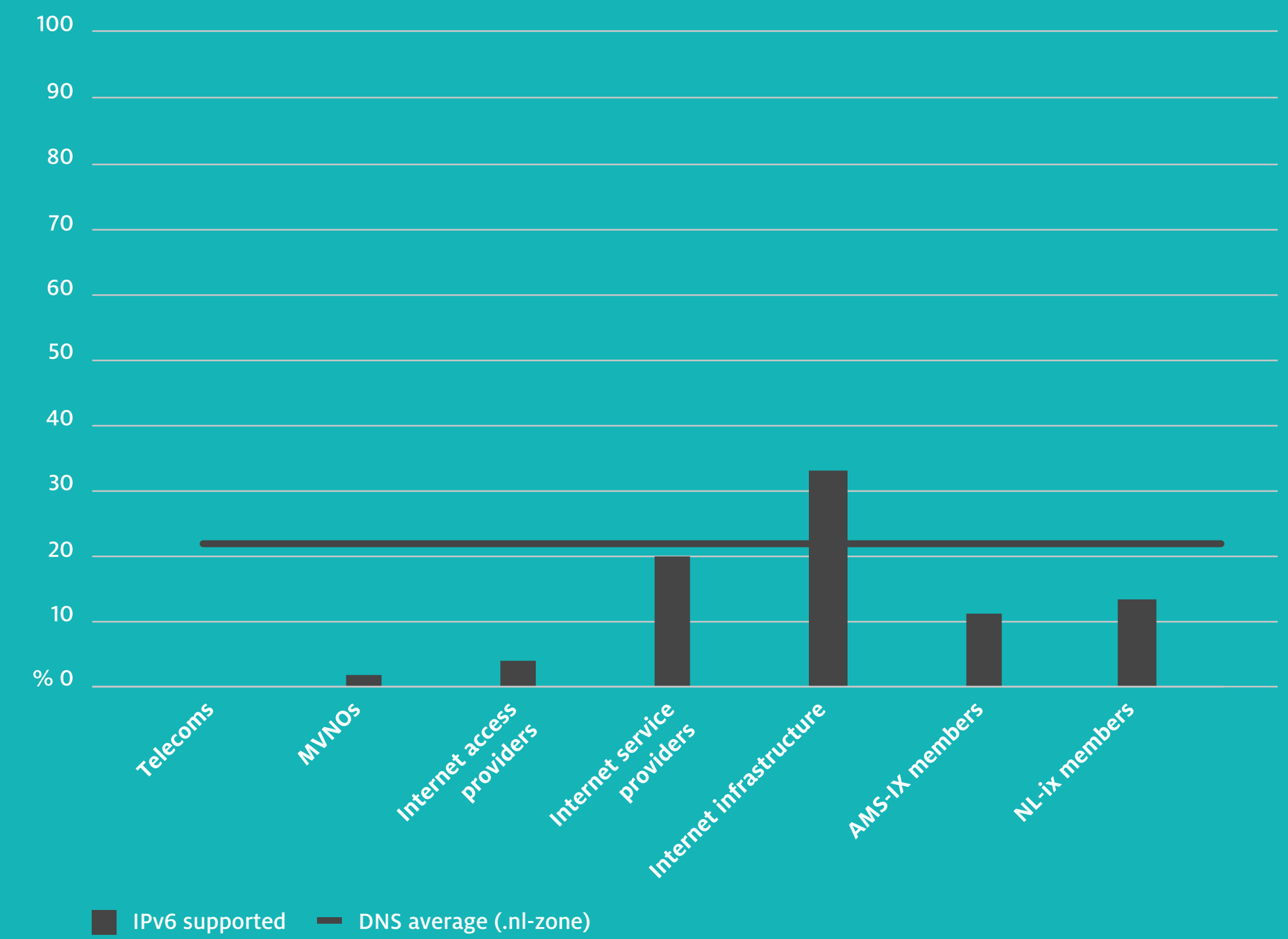
Graph 15: IPv6 test results for the industrial sector



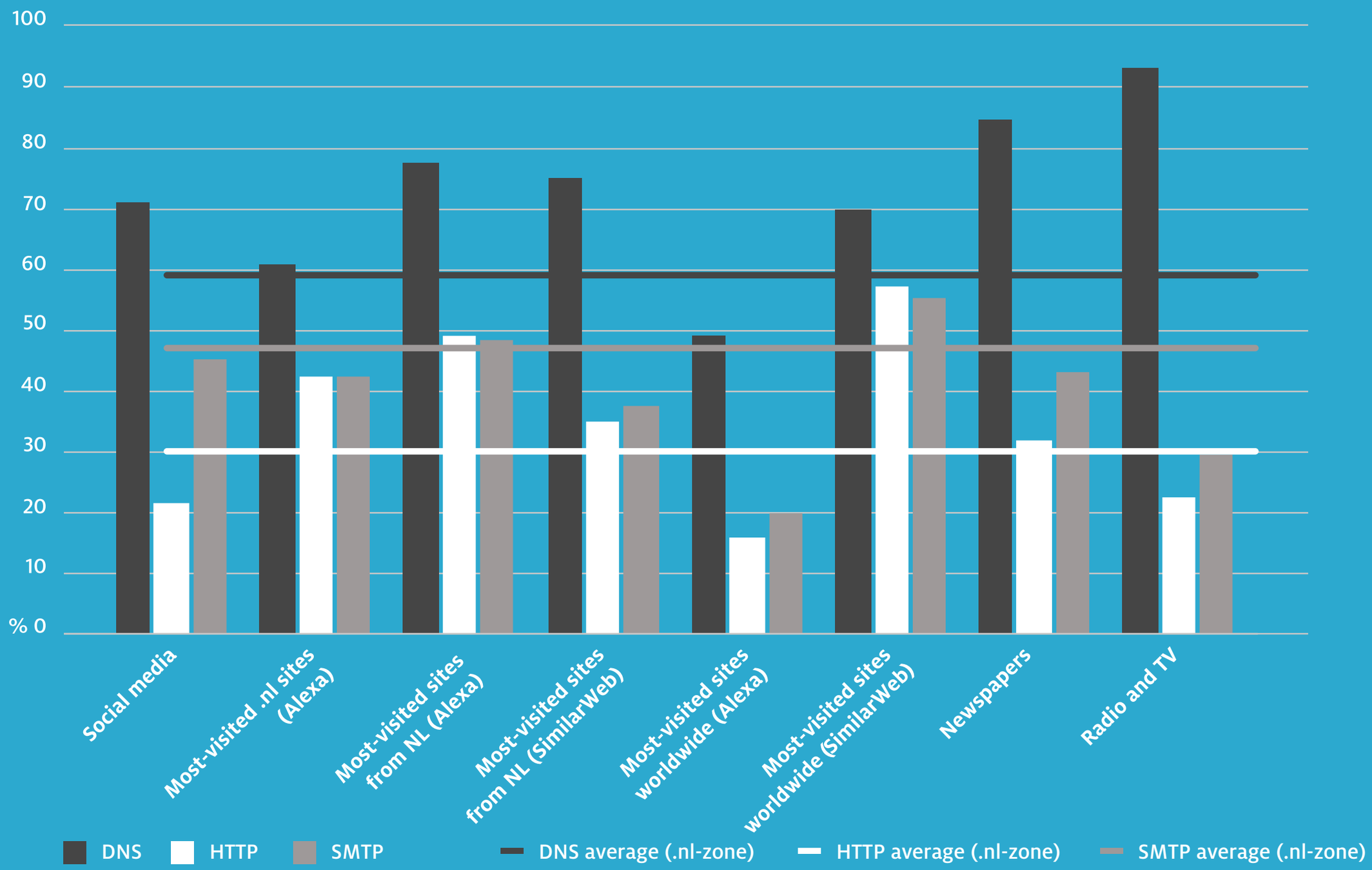
Graph 16: overall IPv6 test results for the industrial sector



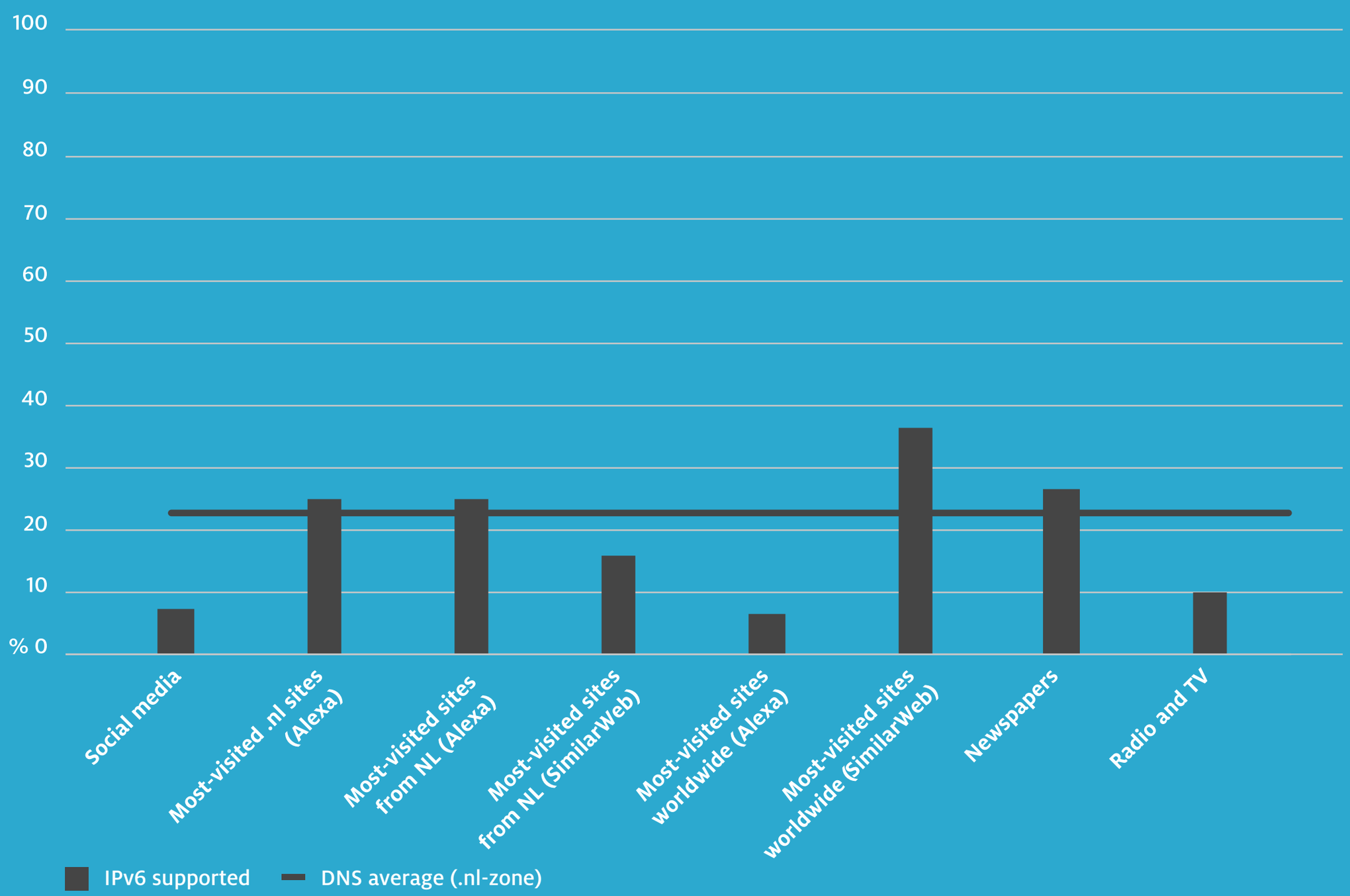
Graph 17: IPv6 test results for the internet & telecoms sector



Graph 18: overall IPv6 test results for the internet & telecoms sector



Graph 19: IPv6 test results for the on-line media sector



Graph 20: overall IPv6 test results for the on-line media sector

Finally, small organisations buy in commodity services from large external providers and have little or no knowledge of the protocols they are using. Amongst the public sector groups, for example, it is political parties that score best. Similarly, the historical water pumping stations stand out in the traffic and water sector, and GP clinics and pharmacists in the care sector.

Long tail or bathtub

To test that theory, we plotted the scores for Alexa's global million most visited domains in a graph. The top organisations did indeed prove to support IPv6 more than the rest. However, a million was not enough to enable us to study the bottom end of the rankings. A national political party or a GP clinic will not appear in the world's top million. The shape of the graph trace is therefore less of a bathtub and more of a longtail.

› Graph 21: Top million most-visited websites worldwide [source: Alexa]

To build a picture of the situation amongst smaller organisations, we grouped all enterprises in the Netherlands' three main port regions on the basis of legal entity type (public limited company, private limited company or partnership). The public companies do indeed score much worse than the other two entity types, but the partnerships lag well behind the private companies.

"It may be that public companies do indeed do more for themselves, but don't know much about IPv6," says Marco Davids, Research Engineer at SIDN. "Private companies are more likely to be using hosting services provided by the likes of Cloudflare and TransIP, meaning that their domains are IPv6-enabled without them necessarily being aware of it. For their part, partnerships will often be using smaller hosting service providers and resellers who don't work with IPv6."

One can deduce that the graph's plot line must turn back up at the bottom end, at least where the web scores, mail scores and overall scores are concerned, because the averages for the .nl zone as a whole are significantly higher than the figures measured for the particular sectors featured here.

› Graph 22: IPV6 test results for businesses in the three main port regions, grouped by legal entity type

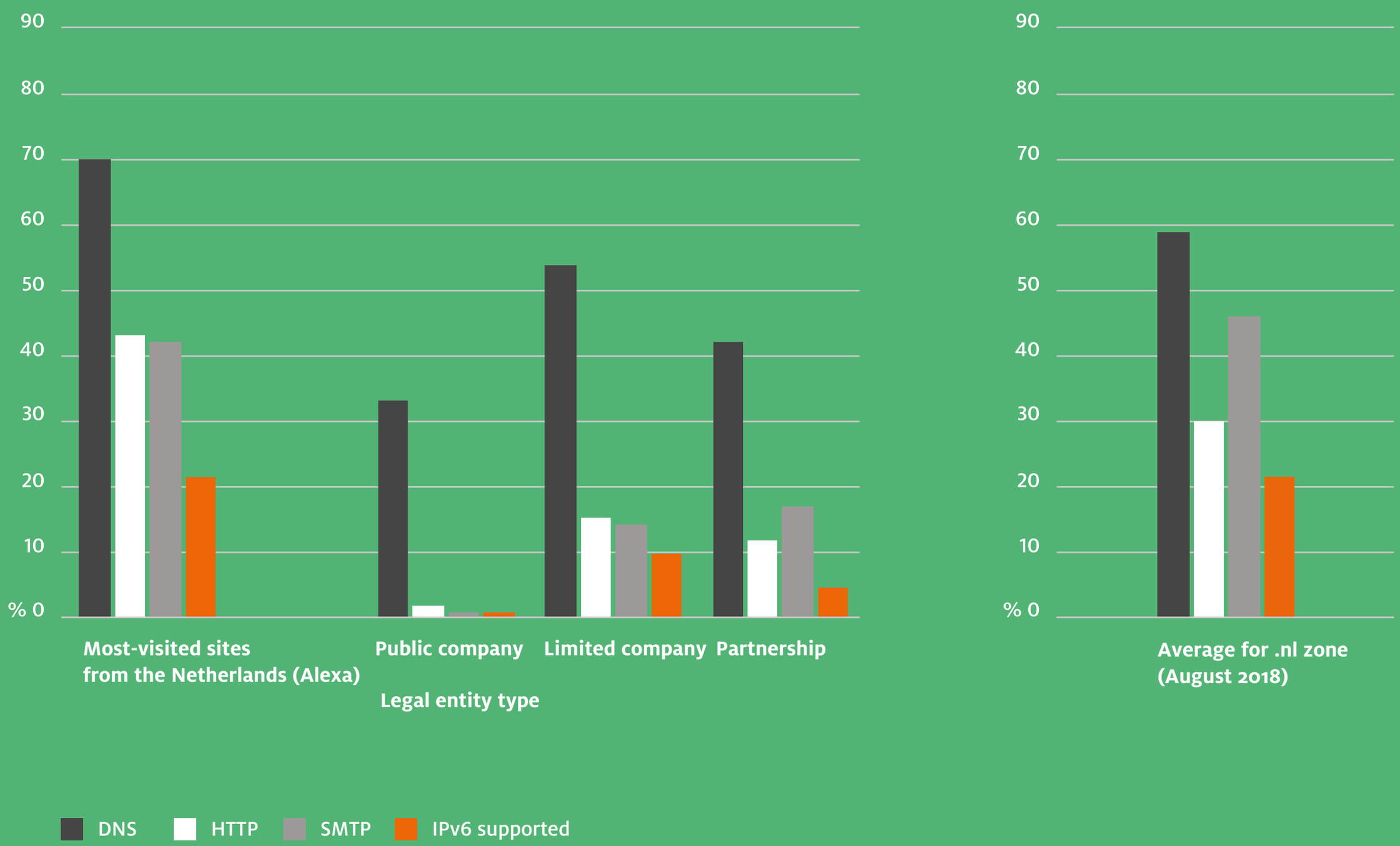
Public sector groups

Amongst the public sector groups that we surveyed, universities stand out as having the highest level of IPv6 support for mail (86 per cent). The reason being that many higher education centres use a SURFnet mail filter for their incoming mail portals. With a high web support score as well, the universities secured the best overall score in the survey (43 per cent).

Government-designated Essential Service Providers, who formed the starting point for our inventory, almost all registered strikingly low scores. The overall scores for the relevant groups are presented below. The only groups that don't lag too far behind are the nuclear plants and internet hubs. Nevertheless, given that IPv6 is directly relevant to the internet hubs' core activities, the levels of support are equally disappointing.

› Graph 23: Overall scores for the essential service providers

Graph 21: Top million most-visited websites worldwide [source: Alexa]



Graph 22: IPV6 test results for businesses in the three main port regions, grouped by legal entity type

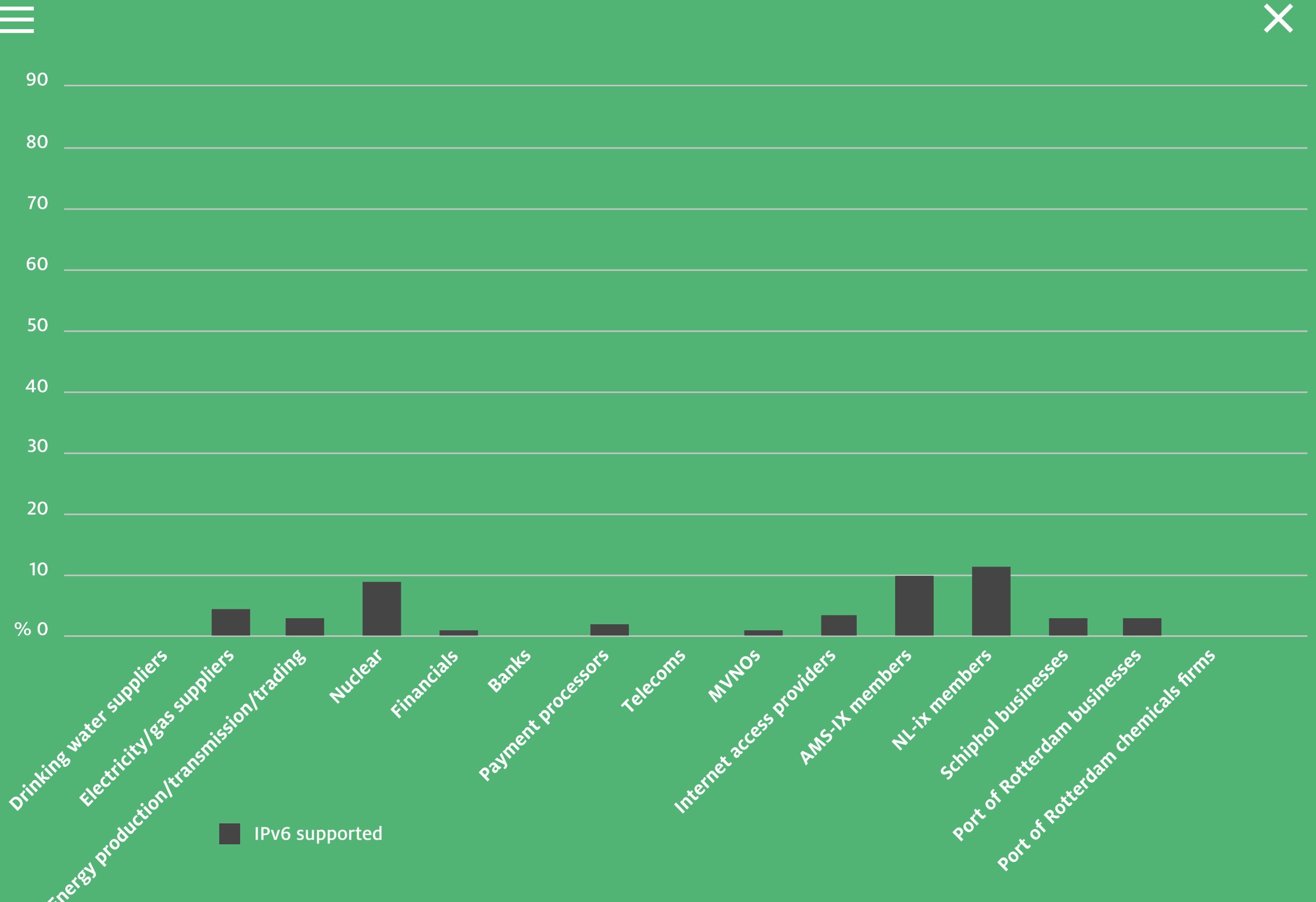
5

Private sector groups
Broadly speaking, private sector groups have been migrating to IPv6 significantly more quickly than public sector groups. As indicated above, reasonably large, traditional companies tend to score significantly worse than both very big companies and medium-sized businesses. That is reflected, for example, in the low overall scores of companies listed on the stock market. Similarly, the MT 500 companies scored badly, but within that group the top fifty were better than the rest. Internationally, the picture is not very different, judging by the results for the Fortune Global 500.

A similar pattern emerges if one maps adoption in the three surveyed economic centres (Schiphol Airport, Eindhoven Brainport and Rotterdam Seaport). The central zones score badly, while the surrounding industrial zones do better. Further out still, adoption rates drop again. Although we have not investigated the phenomenon in detail, it is consistent with the observations relating to legal entity type.

The low scores of the banks and the telecom and internet access providers are also unsurprising. Such organisations frequently prove to have a very conservative approach to the implementation of ‘new’ technology. However, it doesn’t have to be that way: new players in the financial sector – the cryptocurrencies and crypto-exchanges – have much higher scores than most other groups.

Finally, the newspapers deserve an honourable mention for scoring much better than the rest.



Graph 23: overall scores for the essential service providers

6 The industry and the government

“No economic incentive”
Michiel Steltman, CEO of Digitale Infrastructuur Nederland (DINL), sees major issues for the implementation of IPv6. “There is currently no business case for the rollout of IPv6,” he said. “Here in the Netherlands, we’ve still got plenty of IPv4 addresses available. Because we built up a strong internet industry early on, there is relatively little new construction happening in the field of hosting and infrastructure. The telecom companies use NAT on a large scale. And, if you do need more IPv4 addresses, you can by a block of 256 from a specialist trader.”

“If you host in the Netherlands and you’re reachable only via IPv4, you won’t lose any trade. So there’s no economic incentive to switch. After all, there are no clients out there who only use IPv6. An access provider that rolls out IPv6 has a whole additional network infrastructure, which needs to be managed, monitored and secured. Often, access providers only implement IPv6 when obliged to by the requirements of a handful of key customers. And then they roll it out for everyone at the same time.”

Risks for the future
“What makes IPv6 so important?” asks Steltman. “There’s no shortage of addresses and nothing is coming to any harm. I just can’t see the economic benefit.” One might even argue that a push for IPv6 would unnecessarily make hosting in the Netherlands more expensive. “IPv6 was devised because people were worried about the possibility of not being reachable on the internet. However, that problem hasn’t materialised.”

“Nevertheless, we should try to establish what risks slow adoption might entail. Does the fact that consumers don’t have IPv6 make the Netherlands less attractive as a digital market for foreign companies, for example? Could the rollout and use of the Internet of Things be held back? What does slow adoption mean for our image as a centre of innovation and a good place to invest? If we don’t do anything, we might get caught out by developments that we can’t respond to quickly enough.”

Internet.nl
IPv6 is one of the standards whose use is promoted by the Platform for Internet Standards via the Internet.nl portal. The others are DNSSEC, HTTPS, DMARC, DKIM, SPF and STARTTLS/DANE. Whereas IPv6 is mainly about scalability, the other standards are primarily for security. “What the standards have in common is that they’re all modern, open internet standards,” says Bart Knubben, Coordinating Consultant at the Forum for Standardisation, the organisation that manages the ‘use-or-explain’ list and one of those behind the Internet.nl portal. “However, you can make a case for IPv6 on the grounds of security as well.”

For example, over the last few years, Rabobank has implemented IPv6 on all its outward-facing systems. Having more and more customers behind CGNATs makes it harder to identify security risks, such as phishing, because many of the tools work on the basis of IP addresses. That also creates problems when it comes to blocking unwanted visitors, because the user you want to block may share a NAT address with a lot of legitimate users. Rabobank is now in the process of enabling IPv6 on its internal network.

6

Top-down initiative

“The Association of Netherlands Municipalities (VNG) is actively pushing to get its members to adopt IPv6,” Knubben continues. Nearly a hundred municipal websites now support the protocol [1, 2]. “Because most municipal authorities contract out their on-line services, their migration path is from outside to inside: first the website, then the mail and other services, and finally the internal network.”

“Many central government websites are provided by the National Government Internet Platform (PRO). There are currently about 180 sites, and they all support IPv6. However, Logius also has its own number plan, meaning that government organisations that develop and maintain on-line services independently can turn to Logius for government-specific, supplier-independent IPv6 addresses. Indeed, because IPv6 is on the ‘use-or-explain’ list, government organisations are obliged to include the implementation of IPv6 in any upgrade project. Members of the public can get information about their local authority’s support for IPv6 from Waarstaatjegemeente.nl or run a test from the Internet.nl portal.”

7 New élan

Until recently, the lead advocate of the IPv6 rollout was the IPv6 Task Force, established in 2005 for the Ministry of Economic Affairs. Although European research has found that the adoption of IPv6 progresses faster in countries that have task forces, the existence of one in the Netherlands has not had the desired effect. When the IPv6 Task Force was wound up, its promotional role passed to the Platform for Internet Standards.

“We use an array of measures to encourage adoption by government bodies,” says Knubben. “First, there is the ‘use-or-explain’ list, which requires the use van IPv6. We monitor and report on the effect of that list. In addition, we provide assistance with IPv6, via the Internet.nl portal and other channels.”

Incentive scheme

SIDN has also embraced the role of IPv6 advocate. In its capacity as administrator of the .nl zone, SIDN has introduced a financial incentive for IPv6 adoption. Since the middle of last year, registrars receive a registration fee rebate for domain names whose DNS, web and mail servers are IPv6-enabled.

“Over the years, there have been various initiatives aimed at promoting the adoption of IPv6,” says Davids, “but none have had the desired impact. We decided to get involved because of the Netherlands’ poor performance on IPv6 adoption. We know from our experience with DNSSEC that an incentive can be a very effective tool.”

Sights now set higher

The success of SIDN’s incentive scheme is apparent from the upturn in the graph below. In the space of a year, nearly a million IPv6-enabled domains have been added. Such names have gone from 12 per cent of the total to 28 per cent (1.6 million of the 5.8 million domain names in the .nl zone). That has definitely contributed to the high adoption levels observed amongst DNS services: such services are usually provided by external operators who also act as registrars. However, the international domain name lists – the Alexa top million and the Fortune Global 500 – also yield much higher scores for DNS than for web and mail services, implying that SIDN’s incentive scheme is only part of the story.

› Graph 24: Growth in proportion of domain names in the .nl zone that qualify for SIDN’s IPV6 incentive

“Our original target was to get from 12 per cent to 20 per cent in the first year,” Davids continues. “But we’ve got off to such a good start that we’re now hoping to reach 35 per cent by the end of the year.”

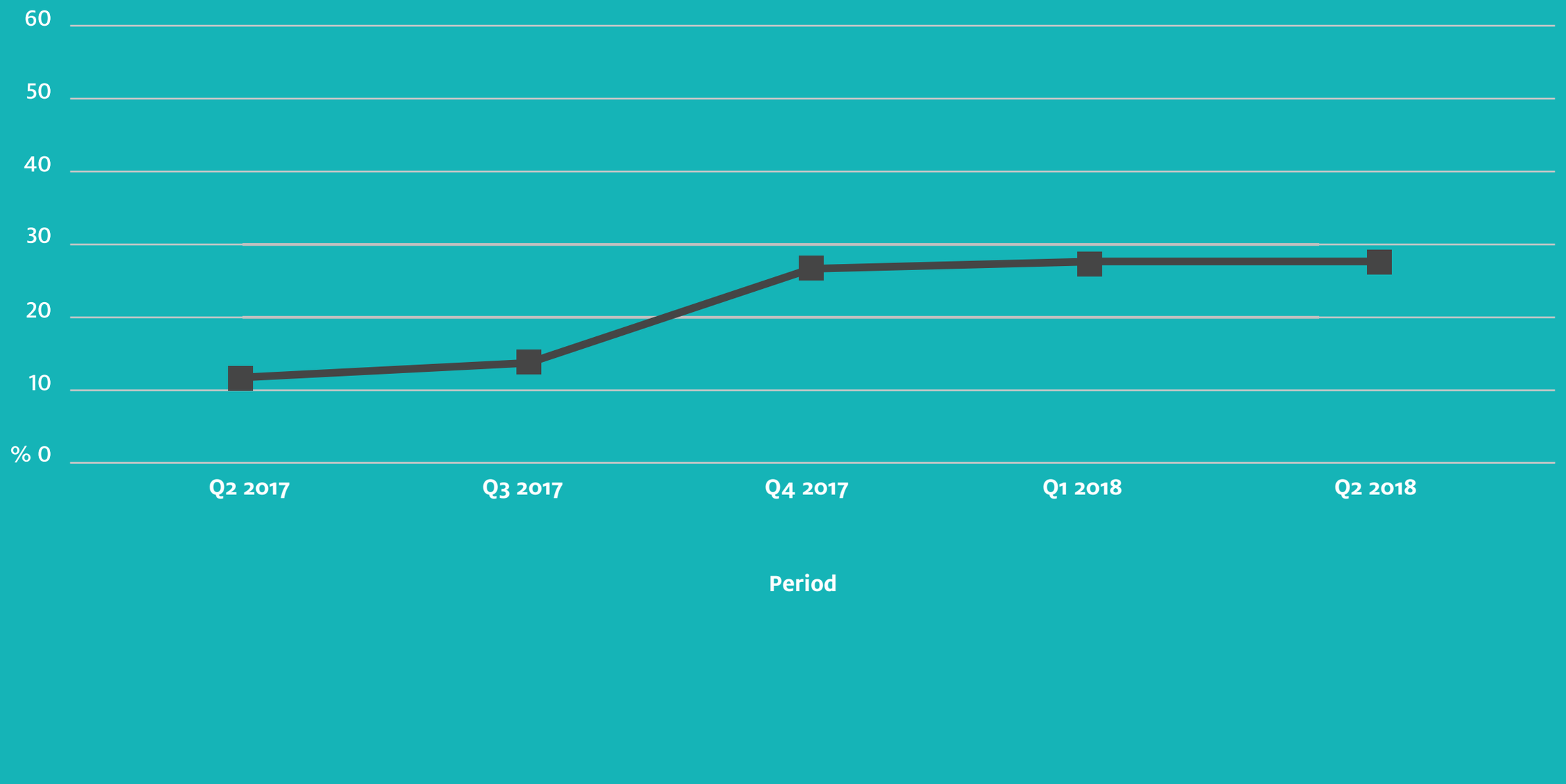
Registrar Scorecard

As well as incentivising IPv6, SIDN has similar arrangements to boost three other determinants of quality in the .nl zone. The DNSSEC incentive was the first to be introduced, and has now been running for six years. A year ago, an incentive for ‘sustainable portfolio optimisation’ was brought in: registrars are rewarded for net portfolio growth and for active use of the domain names in their portfolios. The latest addition to the stable is an incentive for supporting the e-mail security standards DKIM, SPF, DMARC and STARTTLS/DANE. The latter incentive is linked to SIDN’s involvement (via the Platform for Internet Standards) with the Secure E-mail Coalition.

7

The Dmap crawler & classifier mentioned above is used to scan for almost all the incentivised parameters.

The vehicle for delivering the various incentives is the Registrar Scorecard (RSC), which also provides purely informative feedback on registrant data quality and the processing of abuse reports.



Graph 24: Growth in proportion of domain names in the .nl zone that qualify for SIDN's IPv6 incentive

8 Conclusion

Tour de force
"Since the nineties, the internet community has been making a big technical effort to keep the IPv4-based network going," Davids points out. "However, IPv4 has now been stretched to the limit." Davids recalls the words of Vint Cerf, one of the 'fathers of the internet': "IPv4 wasn't expected to connect 4 billion people. It was an experiment that got away. The production version of the internet is IPv6."

Davids sees the vast address space as easily the most compelling argument for implementing IPv6 as quickly as possible. "It's not the protocol's only selling point, though: IPv6 also makes routing more efficient. And we really do need to get rid of all the workarounds associated with IPv4. They are an increasing source of problems and their use is ultimately a dead-end strategy. It doesn't make sense to keep investing in workarounds when we have a proper solution: IPv6. In fact, we've had it for years, and it's already in widespread use elsewhere. All Google services have used IPv6 for ages, and it's supported by other heavyweights, such as Netflix, LinkedIn and Facebook. The pioneer phase is over: anyone who isn't using IPv6 now is lagging behind."

The Netherlands Inc.
"Our very poor performance in this field compared with neighbouring countries represents a missed opportunity for 'The Netherlands Inc.'," continues Davids. "The lack of interest and vision in the industry really doesn't help. Our internet companies don't seem to fully appreciate the value of the shared infrastructure, and that makes them part of the problem."

"I wouldn't like to speculate where the ultimate impact will be hardest, but I do believe that the companies that are dragging their heels are holding back further successful development of the internet in this country. And that affects us all."

Internet of Things
The Internet of Things (IoT) is often mentioned as the innovation that needs IPv6 most. Analysts predict that tens of billions of devices will be connected to the internet in the coming years, and possibly hundreds of billions in due course. Most IoT-specific networks, such as LoRaWAN and Zigbee, use protocols with their own address spaces, but IP addresses are essential for the hubs and gateways needed for remote communication with IoT devices. Furthermore, countless appliances that don't currently have IP addresses will need them in the future, in order to operate within domotic systems and smart cities. Such appliances include thermostats, refrigerators, webcams, TVs, cars, parking bays, waste bins and other street furniture.

"In the future, every lamppost may be fitted with a camera, a mini weather station, a movement sensor, an infrared sensor, and an air quality sensor," suggests Davids. "And every one of them may need its own IP address. That's totally impossible with IPv4. The poor support for IPv6 means that startups and pilot programme organisers are currently unlikely to see the Netherlands as the most attractive place for investment or innovation in this field.

According to Davids, innovation in the field of mobile communication is being held back as well. "In the US, almost all mobile phones have native IPv6. And there are all sorts of other appliances out there that have IPv6-enabled 4G or 5G connections. That enables the rollout of new mobile applications, which are directly contactable using their IPv6 addresses wherever they go. That must create a better environment for development than we have here."

8

Worrying
"What surprises me is that some organisations don't appear to be doing anything about IPv6," says Davids. "Away from the standard hosting packages, IPv6 use is all over the place, but the average levels of use are lower. The corner shop is more likely to support IPv6 than a large company, simply because the corner shop is using an affordable hosting package sold by a service provider that has enabled IPv6 for all its clients."

Davids sees the divergence and low average scores, coupled with the absence of policy-led decision-making, as indicative of a worrying ignorance of or disregard for IPv6 in the ICT world. "The issue is on such a scale that I fear we are heading for trouble if the inaction continues."

Regulations
"I've always believed that you shouldn't seek to regulate the internet, but perhaps we need to make an exception where IPv6 is concerned. A contact in the industry recently compared the situation to a bike race, where all the contenders are sitting in the bunch, watching each other; no one wants to be the first to make a move. My contact would welcome regulation, because then everyone could get on with implementation instead of holding back to see what their competitors will do. In the US, the National Institute of Standards and Technology (NIST) is currently drafting regulations that will require all government hardware to have native IPv6 support within two years."

"Maybe what we need is to define internet access in European law, just as other goods and services are defined," suggests Davids. "So that you can't claim to be selling an internet access service if the connection you're offering isn't secure, up-to-date and complete. Whatever approach we take, the government needs to take responsibility, because the current impasse has to be broken for the good of the national economy, especially considering our large international clientele."

Vision
At the same time, decision-makers in the access provider sector need a market development vision. "Bandwidth problems lead directly to dissatisfied customers," Davids points out, "but IPv6 is a more hidden issue; customers aren't calling to complain that IPv6 isn't supported. Access providers need to recognise that they are part of a market ecosystem, and that their own results depend to a significant extent on the health of that ecosystem.
"It's true that operating an IPv6 network alongside an IPv4 network costs money, but we're not talking big numbers. The technical infrastructure is already there: IPv6 doesn't require new cables and routers, it simply entails a modest additional administrative burden. And, ultimately, as IPv4 and all its workarounds disappear from the scene, an IPv6-based network will in fact be cheaper, because it's simpler, more scalable and more stable."

Work to do
"By offering financial incentives to registrars, SIDN is helping to strengthen the business case for IPv6 within the internet access industry. And organisations such as SURFnet, RIPE, the Platform for Internet Standards and, until recently, the IPv6 Task Force are doing what they can to promote adoption of the protocol. However, the market players have a responsibility as well. Occasionally, someone tries to start a discussion about the importance IPv6, but in my view we've passed the point where there's a debate to be had. The decision to adopt IPv6 has already been made by the big players and in neighbouring countries. Are we going to ignore the way the world is headed, or are we going to join the migration before we're left behind?"

Colophon

This document summarises a research report compiled by Offerman Consulting for SIDN
Contributors:

Offerman Consulting
Adrian Offerman – Specialist journalist

SIDN
Nick Boerman – Business Intelligence Analist
Marco Davids – Research engineer
Marnie van Duijnhoven – Communications manager

Subscribe to our newsletter www.sidn.nl/nieuwsbrief

Please mail enquiries to
communicatie@sidn.nl

SIDN
Postbus 5022
6802 EA Arnhem
The Netherlands

Meander 501
6825 MD Arnhem
The Netherlands
T +31 (0)26 352 55 00
www.sidn.nl