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Global IPv6 Development Report 2022

Measurement, analysis on socioeconomic impact and policy recommendations



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Executive Summary

With the advent of new communication and information technologies, everything in the world is more closely connected, forming a huge network that bridges people and things. Future-shaping technologies such as AI, 5G, cloud, and IoT are like threads that connect us together.

A fundamental enabler lies at the core of all these technologies: the IP address. It gives devices a "key" that they need to connect to the network; without it, they can't talk to each other.

The previous protocol used for IP addressing was IPv4, which was designed in the early 1980s with a maximum total of only 4.3 billion addresses. The explosive growth of intelligent devices has exhausted the available IPv4 addresses, and IPv6 was introduced to solve this problem once and for all. With 3.8*10³⁸ total addresses available, IPv6 would be able to assign every grain of sand on earth an IP address.

On the basis of providing massive address resources, IPv6 is also developing continuously. In addition to providing basic IP addresses, IPv6 provides higher-quality and smarter connections through the combination of emerging technologies, namely IPv6 Enhanced Innovation¹², offering more future possibilities and accelerainge the deployment of advanced business applications like 5G, cloud, and industrial IoT.

At this moment, we find it necessary to reflect on how the world has progressed in this transition and summarize the concrete socio-economic value IPv6 Enhanced Innovation have created. We construct an IPv6 Development Index and reference data from public databases to calculate and provide a country-level measurement of IPv6 development status. The framework is based on the well-acknowledged approaches previously adopted by the Latin American and Caribbean Internet Address Registry (LACNIC)³, the Organization for Economic Cooperation and Development (OECD)⁴, and Cisco⁵. In terms of data sources, we use data from Asia Pacific Internet Network Information Center (APNIC), Cisco and authoritative research institutions and organizations such as Routeviews, OVH and WOS as raw data input to ensure data reliability and objectivity.

Based on datasets referenced from above databases, we used the Index model to calculate Index result for 92 countries to measure their IPv6 development status, , and conducted a quantitative analysis of the economic impact of IPv6 Enhanced Innovation in various industries. On this basis, we divided 92 countries into three groups according to the level of IPv6 development and identified 3 countries as benchmark countries, and performed an in-depth analysis of their development. In addition, this year's report further analyzes the value, status, and reasons for IPv6 development in 15 countries around the world and puts forward tailored recommendations.

In policy recommendations, this report has been comprehensively upgraded compared with the 2021 study. Based on the common challenges and main differences between the development of IPv6 Enhanced Innovationin different groups of countries, we put forward detailed and executable recommendations for different country ranking groups of IPv6 Development Index.

- ² ETSI GR IPE 001 "IPv6 Enhanced Innovation: Gap Analysis", 2021.08
- ³IPv6 Deployment for Social and Economic Development

⁵Internet IPv6 Adoption: Methodology, Measurement and Tools

¹ ETSI White Paper No. 35 "IPv6 Best Practices Benefits Transition Challenges and the Way Forward", 2020.08

⁴Internet Addressing: Measuring Deployment of IPv6, K.Perset, OECD digital economy paper No.172, Apr 2010

The results are strongly in favor of IPv6 Enhanced Innovation development though our analyses and estimates may be subject to limitations in sample scope and size: In 2025, it is estimated that the total industry value brought by IPv6 Enhanced Innovation will reach 7.3 trillion US dollars.

In conclusion, now is the perfect time for deployment of IPv6 Enhanced Innovation. Industrywide adoption of IPv6 Enhanced Innovation has taken off. Major telecom operators, internet content providers, and equipment manufacturers have all participated in the rush into a new digital world.

1. IPv6: definition and value

In today's world, IP address is an important basic resource of the Internet, the basis for identification and data transmission between systems, and an important infrastructure for highquality development of the global economy. However, with the wide application of the Internet, challenges and constraints of the global Internet Protocol version 4 (IPv4), such as the exhaustion of IP addresses and the difficulty in guaranteeing service quality, have become increasingly prominent due to the undervalued demand for both size and quality for IP addresses by the development of the Internet and the digital economy in the early stage of Internet design. In this context, it is gradually becoming a globally acknowledged consensus that we should vigorously develop and deploy Internet Protocol Version 6 (IPv6) following the guidelines and best practices from IPv6 Enhanced Innovation. This will provide sufficient network addresses and broad innovation space for Internet and the digital economy.

IPv6 Enhnaced Innovation guide to a proper deployment of IPv6 protocol as a basis to other functionalities defined in IETF, like SRv6. Innovative applications will provide much more convenient, open, intelligent, and secure internet and to facilitate an intelligent world where everything is intelligently connected.

1.1 Overview of IPv6

The IP address is the basis of the IP protocol (Internet Protocol) and is the unique identifier for network devices to access the Internet or a local network. Internet Protocol version 6 (IPv6) is the latest IP revision, developed as a successor to IPv4. While greatly enhancing the address pool, IPv6 and its updated technologies can connect and empower more other technologies to promote the overall development of society.





IPv6 technical advantages:



Figure 2. IPv6 technical advantages

Advantages and technical features of IPv6 Enhanced Innovation

Based on IPv6 massive addresses, IPv6 Enhanced Innovation comprehensively improves IP network capabilities in six dimensions of ultra-broadband, wide connection, determinism, low latency, automation and security, and provides services for governments, operators, enterprises and enterprises in various industries and usage scenarios. The requirements of end users in various usage scenarios provide a high-quality foundation.



 In October 2021, ETSI partnered with 15 leading IP industry players to publish its first report ETSI GR IPE 001 "IPv6 Enhanced Innovation: Gap Analysis"

Source: Desktop research; Roland Berger

Figure 3. IPv6 Enhanced Innovation advantages and technical features⁶

Key technologies in IPv6 Enhanced Innovation includes SRv6, IPv6 Enhanced Innovation Network Slicing, IFIT, BIERv6 and APN6, etc.

1.2 Necessity of transition to IPv6 Enhanced Innovation

To fully support the development of the digital economy, large-scale deployment of IPv6 is the basis and necessary foundation for realizing an intelligent world where everything is

⁶ETSI GR IPE 001 "IPv6 Enhanced Innovation: Gap Analysis", 2021.08

connected. Actively deploying IPv6 Enhanced Innovation innovative applications is an important measure to achieve higher-quality development based on IPv6 to better facilitate the 5G and cloud era.



Figure 4. Necessity of Developing IPv6 Enhanced Innovation

1.3 Economic and social benefits of IPv6 Enhanced Innovation



Figure 5. Social and economic benefits of IPv6 Enhanced Innovation

2. Industry Economic Value by IPv6

2.1 IPv6 economic impact 2025 estimate

2.1.1 IPv6 industry-sector economic impact model

Today the scope of IPv6 is not only IP addresses, but also includes IPv6 Enhanced Innovations including SRv6 and other technologies. IPv6 development will positively affect virtually every industry sector. Since industries have differing economic and regulatory structures that will affect the timing for IPv6 adoption, we chose 2025 as the analysis timeframe and focused on short-to-mid-term impact.

After analyzing the micro- and macro-economic impacts expected by IPv6, we projected forward to 2025, and looked at the economic contributions of IPv6 Enhanced Innovation through three lenses in 12 major industry sectors (See Appendix A for details). The first lens examined the value created by innovative technologies and their application scenarios, mainly focusing on 5G/IoT/cloud, empowered by IPv6 Enhanced Innovation. The second lens focused on the level of efficiency improvements enabled by IPv6 and IPv6 Enhanced Innovation. The third lens examined cost reduction by preventing data security issues with different issue type. The following provides an overview of the methodology for these three impacts.

Value points	Applications	Calculation						
A Infrastructure of digital	Value created via 5G	Economic value of industry	nic value of * % of economic value contributed by 5G applications			outed by 5G	*	IPv6-improved % of 5G
economy	Value created via IoT	Economic value contributed by IoT applications						IPv6-improved % of IoT
	Value created via Cloud	Economic value of industry	*	% of economic valu applications	ie contrib	outed by cloud	*	IPv6-improved % of Cloud
B Increased efficiency	Efficiency improved due to NAT removal	Economic value of industry	*	Level of Digitalization	*	NAT removal %	*	IPv6-improved % of NAT removal
C Improved security	Cost reduction by avoidance of human error				*	Human error #	*	IPv6-improved % per sub-type
	Cost reduction by reduction of system failures	Economic value of industry	*	* Avg. cost per incident		System failure #	*	IPv6-improved % per sub-type
	Cost reduction by prevention from malicious attacks				*	Malicious attacks #	*	IPv6–improved % per sub-type
Country-specific indicator	rs Global indicators							

Figure 6. Methodology of IPv6 value creation by industry

2.1.2 IPv6 value creation by industry result analysis

Based on our model and expert input, we estimate that potential global value created across multiple industry sectors enabled by IPv6 could reach \$7.3 trillion in 2025. This represents about 3.7% of all global real output in 2025.

IPv6 industry value creation:

The following figure presents the consolidated value enablement findings by industry, ranking from highest impact (information & communication, 5.1% of its total sales) to lowest impact (construction & real estate, 1.9% of its total sales).

		Qualitative impact by IPv6					Quantitative impact by IPv6			
	Infrastr	ucture of digital	economy	Improved security	Increased efficiency					
Industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [bn \$]	% of industry	sales		
Information & communication	•		•	•	•	573			\$ 5.1%	
Manufacturing	•	٠	•		٠	1,848		4	\$ 5.0%	
Public service & utilities	•		•	•	•	994		ø	4.6%	
Hospitality & entertainment	•		•	•		305		0	3.9%	
Transport. & storage	•	•	•		•	520		\$	3.8%	
Health & social work	•		•	•	•	380			3.7%	
Education	•		٠	•		208			3.7%	
Prof. services & finance	•		٠	•	•	931		\$	3.4%	
Wholesale & retail	•		•			610	<	\$	3.0%	
Energy	•		•			174		>	3.0%	
Ag., forestry & fishing	•	۲	۲			156	\$		2.0%	
Construction & real estate	•		•			623	0		1.9%	
Total						7,327			3.7%	
Low impact 🔍 🔍 🌑 High impact										
Source: Desktop research, expert interview; R	oland Berger									



2.2 Major impacts and industry use cases of IPv6⁷

IPv6 as a fundamental enabler for other technologies have a wide range of impact on different industries. A detailed introduction of IPv6 Innovation enabled industry use-cases can be found in the full report.

Industry	Application (some examples)	Infra. of digital economy	Increased efficiency	Improved security
Manufacturing	Smart manufacturing: production visualization, remote operation			
Info. & communication	Intelligent operations: predictive maintenance, intelligent detection			
Wholesale & retail	Smart shelves: environment monitoring, automatic warning			
Public service &utilities	Smart water system: real-time monitoring of pipe network operation			
Prof. services & finance	Risk control platform: warning, identification and prevention			
Transport. & storage	Driverless: responsive navigation and operation with low latency			
Health & social work	Telemedicine: remote physician coaching operations			
Ag., forestry & fishing	Smart agriculture: remote monitoring, real-time data analysis			
Construction& real estate	Operations security: wearable devices monitor workers' moving line			
Energy	Smart drilling system: soil detection, automatic adjustment of drilling			
Education	Smart classroom: interactive distance learning, AR classroom			
Hospitality & entertainment	Mobile games: real-time interaction and enhanced experience			
		Low impact		High impact

Source: Desktop research, expert interview; Roland Berger

Figure 8. IPv6 enabled scenarios in each industry

⁷ Based on desktop research from various press release and official websites

3. IPv6 Development Index and Country Analysis

3.1 IPv6 Development Index

Although IPv6 has great potential for economic value creation, each country has a different level of development. We construct an IPv6 Development Index that aims to provide a country-level measurement of IPv6 deployment status. The IPv6 Development Index is based on the well-acknowledged methodologies of the Latin American and Caribbean Internet Address Registry (LACNIC)⁸, the Organization for Economic Cooperation and Development (OECD)⁹, and Cisco¹⁰.

3.1.1 Methodology

Based on references to the LACNIC, OECD and Cisco, we constructed the IPv6 Index by measuring the specificity of IPv6 in three major areas of deployment. These three aspects are IPv6 pennetration (including IPv6 address planning, IPv6 deployment in networks, IPv6 deployment in content providers and user access to the network via IPv6), the performance of IPv6, and the level of innovation emphasizing on IPv6 Enhanced Innovation (including technical standards, policy, academics and pilot commercial projects of IPv6 Enhanced Innovation).



Figure 9. Methodology of IPv6 Development Index

⁸IPv6 Deployment for Social and Economic Development

⁹Internet Addressing: Measuring Deployment of IPv6, K.Perset, OECD digital economy paper No.172, Apr 2010

¹⁰Internet IPv6 Adoption: Methodology, Measurement and Tools

Index Type	Level 1 dimen	sion	Level 2 dimension			
Туре	Index	Indication	Index	Description	Source ¹¹	Weight
	Planning	Ratio of allocated v6 prefixes to allocated v4 prefixes; Ratio of allocated IPv6 prefixes	Allocation of IPv6 prefixes	Ratio of allocated v6 prefixes to allocated v4 prefixes	APNIC	8%
	from which traffic has been seen to all allocated v6 prefixes IP	Dev. of advertised IPv6 prefixes	Ratio of advertised v6 prefixes to allocated v6 prefixes	APNIC	8%	
IPv6 penetration	Network	Measure the level of deployment of IPv6 in the network, incl. data centers of telecom operators and cloud service providers	Adoption of IPv6 transit AS	Ratio of dual-stack IPv6 Transit AS to all dual-stack Transit AS	Routeviews	17%
	Content	Measure the level of deployment of IPv6 in websites from content providers	The website's support for IPv6	Weighted ratio of IPv6 enabled to tested top 500 websites	OVH, Cisco, Google, Alexa	17%
	Users	Measure the accessibility to the internet through IPv6 for end-users	End-user accessibility to IPv6	Ratio of IPv6 capable users to number of internet users	APNIC	17%
Performance	Performance	Measure the quality of network and effects of IPv6 deployment during end-users' visits to the	Speed of IPv6 network connection	Average RTT difference between IPv6 and IPv4 on dual stack end devices	APNIC	8%
		internet through IPv6	Reliability of IPv6 network connection	IPv6 failure rate on dual-stack end devices	APNIC	8%
	Standard contribution	Measure the contribution to international standards of IPv6 and IPv6 Enhanced innovation by each country	Standard contribution	# of companies, universities and other institutions in working groups of IEEE and IETF	IEEE, IETF	3%
	Policy Measure the # of organizations and support I Policy supportive policies to promote IPv6 and IPv6 Enhanced innovation by each country I	Policy support	# of org. established and policies published by the gov. to regulate the development of IPv6 and IPv6 Enhanced	Official websites	3%	
Innovation	Academic contribution	Measure the academic contribution to IPv6 and IPv6 Enhanced innovation by each country	Academic contribution	# of academic papers on IPv6 and IPv6 Enhanced innovation technology published in top-level publications	WOS	3%
	Innovative application	Measure the level of deployment of IPv6 Enhanced innovation innovation projects to evaluate the capabilities of future innovation	Innovative application	# of operators and enterprises with IPv6 Enhanced Innovation pilots or commercial use cases	Desktop research	8%

¹¹ Data set in this report are as of August 2022; source includes APNIC IPv6 (https://stats.labs.apnic.net/ipv6/), APNIC v6pop (https://stats.labs.apnic.net/v6pop), APNIC v6perf (https://stats.labs.apnic.net/v6perf), APNIC roas (https://stats.labs.apnic.net/roas), etc. and desktop research

We use the weighting method to sum the sub-indicators involved in the three dimensions to calculate the final IPv6 development index of each country. The weight of each sub-indicator refers to the distribution of the indicator to balance different input variables. Finally, the IPv6 development index is calculated by normalizing different sub-indices, and the average value of each sub-indicator is calculated to determine the weight of the actual application.

The framework is based on approaches previously adopted by the OECD¹², LACNIC¹³ and Cisco¹⁴. In terms of data sources, we use Asia Pacific Internet Network Information Center (APNIC), Cisco and other authoritative research institutions and organizations such as Routeviews, OVH and WOS as raw data input to ensure data reliability.

3.1.2 IPv6 Development Index result

The numerical range of the IPv6 development index is from 0 to 1, and a higher index value means a better development process of IPv6 and its innovative applications. We selected 92 countries around the world and calculated the IPv6 development index for each country in 2022 using data from the Asia-Pacific Internet Network Information Center (APNIC) and other relevant sources.

Based on the specific index values, we divide these countries into three categories: frontrunners, accelerators and starters. The Frontrunner countries are the top 25% of the IPv6 development index, the Starters are the bottom 25% of the countries, and the rest are the Accelerator countries. For the sake of comparability of indicators among different countries, we measure the deployment of IPv6 compared with IPv4 in the index.

¹²Internet Addressing: Measuring Deployment of IPv6, K.Perset, OECD digital economy paper No.172, Apr 2010

¹³IPv6 Deployment for Social and Economic Development

¹⁴Internet IPv6 Adoption: Methodology, Measurement and Tools

3.1.2.1 Global country ranking & groups



Figure 10. Country ranking of IPv6 Dvelopment Index

Figure 11. Country Ranking of Global IPv6 Development Index

3.1.2.2 Regional country ranking

Middle East

 \triangleright



Figure 12. Country ranking of global IPv6 Development Index - Asia Pacific



Figure 13. Country ranking of global IPv6 Development Index – Middle East



Figure 14. Country ranking of global IPv6 Development Index - Northern Africa

Southern Africa



Figure 15. Country ranking of global IPv6 Development Index - Southern Africa

Southern and Central America



Figure 16. Country ranking of global IPv6 Development Index - Southern and Central America

> North America



Source: Roland Berger

Figure 17. Country ranking of global IPv6 Development Index - North America



Figure 18. Country ranking of global IPv6 Development Index - Northern and eastern Europe

Western Europe



Figure 19. Country ranking of global IPv6 Development Index - Western Europe



3.1.2.3 Analysis of differences among groups

The average value of different development stages varies greatly, and the grouping method can better summarize and reflect the characteristics of the development stages of countries in each group and the elements that need to be completed. We categorize countries into three groups: **Front-runners**, **Adopters and Starters**. Among them, the leaders are countries that are relatively leading in the development of IPv6 and its innovative applications.



Figure 21. Average index score by groups

Driver analysis:

At the sub-indicator level of the IPv6 Development Index, the differences between countries mainly come from the four dimensions of network, users, performance and innovation. This illustrates the importance of improving users' ability to access the Internet through IPv6, deploying cutting-edge IPv6 innovative applications to improve IPv6 performance, and making sufficient cutting-edge preparations for the future.



Figure 22. Average index score by groups

In the comparison of the various groups of the IPv6 Development Index, we found that performance and innovation are the main factors that separate the differences among the three groups of front-runners, adopters, and starters:

- Performance: There are certain differences among the three groups
 - End-to-end equipment quality: the quality of operator networks, content provider networks, and terminal equipment will directly affect the deployment of IPv6. The digitalization level of most starters and some accelerator countries is in the initial stage. Since operators have a relatively weak foundation in digital infrastructure equipment and applications, the deployment performance of IPv6 may be poor compared to the frontrunners.
 - IPv4 deployment maturity: Since the deployment of IPv4 line equipment in many countries is very mature, and IPv4-related optimization is complete, IPv6 equipment still needs time to be optimized. As a result, compared with IPv4, the performance advantages of IPv6 are difficult to fully reflect.

Front-runners in Performance	Adopters in Per	formance		Starters in Per	formance
India	Greece	United Kingdom	South Africa	Russia	Cameroon
United Arab Emirates	Saudi Arabia	Portugal	Rwanda	Norway	Mozambique
Kuwait	Mexico	Vietnam	Croatia	New Zeland	Libya
Jordan	Estonia	Austria	Iraq	Mauritius	Ghana
Belgium	Czech Republic	Switzerland	Nigeria	Morocco	Zambia
Finland	Sweden	Peru	Pakistan	Ethiopia	Slovenia
Uruguay	Ireland	Denmark	South Korea	Tunisia	Bangladesh
United States	Ecuador	Slovakia	Brazil	Uganda	
Japan	Kenya	Romania	Philippines	Tanzania	
Hungary	Poland	Cote d'Ivoire	Qatar	Namibia	
Colombia	Oman	Germany	Algeria	Indonesia	
Canada	Belarus	Malaysia	Spain	Angola	
Thailand	Egypt	Luxembourg	Serbia	Botswana	
Australia	Lebanon	Paraguay	Bahrain	Venezuela	
Argentina	France	Singapore	Bulgaria	Lithuania	
Chile	China	Italy	Uzbekistan	Senegal	
Kazakhstan	Netherlands	Bolivia	Ukraine	Turkey	

Note: Overall rating based on "speed of IPv6 network connection" and "reliability of IPv6 network connection" and grouped by the ranking percentiles Source: Roland Berger

Figure 23. (Country	ranking of	of IPv6	Develor	oment l	Index –	Performance
J -	- ,	0					

- > **Innovation:** There are certain differences among the three groups
- The development process of IPv6 Enhanced innovation pilot projects: the innovation initiatives of adopters and starters are more focused on carrying out commercial project pilot projects of IPv6IPv6 Enhanced innovative technologies in line with the trend. Most of the front-runners already have IPv6 Enhanced innovation commercial pilot projects such as SRv6, which has achieved an intergenerational leap in technology.
- IPv6 Enhanced technical capabilities: Most of the leading countries are in the leading position in the accumulation of IPv6 Enhanced innovation and communication-related technologies and the degree of advanced disciplines, have strong capabilities to form technological breakthroughs and innovations, and deeply participate in the formulation of IPv6IPv6 Enhanced innovationrelated industry standards.

Front-runners in Innovation	Adopters in In	novation			Starters in Innovation	on
China	Belgium	Czech Republic	Slovenia		United Arab Emirates	Paraguay
France	Austria	Sweden	Romania		Tanzania	Bolivia
Japan	Kuwait	Netherlands	Malaysia		Namibia	Venezuela
United States	Kazakhstan	Switzerland	Serbia		Mozambique	Bangladesh
Spain	Portugal	Denmark	Bulgaria		Libya	Thailand
Italy	Iraq	Rwanda	Morocco		Zambia	New Zeland
Germany	Nigeria	Croatia	Ethiopia		Colombia	Jordan
Luxembourg	Algeria	Norway	Peru		Australia	Oman
Qatar	Bahrain	Saudi Arabia	Senegal		Vietnam	Belarus
Finland	Uzbekistan	Estonia	Turkey		Pakistan	Egypt
Greece	Tunisia	Ireland	Singapore		Brazil	Russia
South Africa	Angola	Poland	South Korea		Argentina	Lebanon
Kenya	India	Slovakia	Mauritius		Cote d'Ivoire	Ukraine
United Kingdom	Hungary	Indonesia	Botswana		Uruguay	
Uganda	Canada	Lithuania	Cameroon		Chile	
	Mexico	Ghana			Ecuador	
Have planned or carried out commercial pilots of innovative IPv6 technologies (e.g., SRv6), or have strong motivations for such deployment Swore Reland Baser	The government and o deployment, and are p technology (e.g., SRvi IPv6 Enhanced Innova	operators attach great impo preparing commercial pilot 5) or there is a good enviro tion deployment	ortance to IPv6 of innovative IPv6 nnment and foundation for	Ti at Ei ei	he government and opera tached high importance ti hhanced Innovation innov hvironment and foundatio hproved	tors have not yet he deployment of IPv6 ation projects, or the n have yet to be

Figure 24. Ranking of deployment of IPv6 innovation

In IPv6 penetration rate, the network and users are also aspects with large differences in the performance of different groups, but the specific manifestations are different:

- > Network: There is a big difference between starters with frontrunners & adopters
 - Digitalization level: The digitalization level and the development requirements of 5G and IoT will increase the motivation of operators to deploy IPv6. Front-runners and adopters generally have a high level of digitalization, and their terminals have a high demand for 5G and IoT development. The motivation of their domestic operators to deploy IPv6 will also increase significantly.
 - Operator industry concentration: Many countries among front-runners and adopters have a

Source: Roland Berger

high degree of operator industry concentration and a large average size of operators. Since the penetration of new technologies generally starts from leading enterprises and gradually develops to small and medium-sized enterprises, the resistance encountered during IPv6 transformation is relatively small, so the transformation speed is relatively fast.

1	Ethiopia	24	Austria	47	United Arab Emirates	70	Argentina
2	Qatar	25	Saudi Arabia	48	New Zeland	71	Spain
3	Oman	26	Finland	49	Czech Republic	72	Ireland
4	Morocco	27	Greece	50	Bahrain	73	Iraq
5	Mauritius	28	Jordan	51	Lithuania	74	Uganda
6	Uruguay	29	Luxembourg	52	Thailand	75	Cote d'Ivoire
7	Namibia	30	Ecuador	53	South Africa	76	South Korea
8	Kuwait	31	Denmark	54	Hungary	77	India
9	Angola	32	Senegal	55	Italy	78	Bulgaria
10	Switzerland	33	Estonia	56	Canada	79	Lebanon
11	Sweden	34	Venezuela	57	Turkey	80	Indonesia
12	Colombia	35	Philippines	58	Croatia	81	Bangladesh
13	Belarus	36	Singapore	59	Mexico	82	Romania
14	Netherlands	37	Belgium	60	Tunisia	83	Poland
15	China	38	Malaysia	61	Kazakhstan	84	Libya
16	Germany	39	United Kingdom	62	Kenya	85	Russia
17	Norway	40	Slovenia	63	Tanzania	86	Cameroon
18	Bolivia	41	Algeria	64	Serbia	87	Nigeria
19	Paraguay	42	Rwanda	65	Slovakia	88	Ukraine
20	Botswana	43	Peru	66	United States	89	Mozambique
21	Brazil	44	Vietnam	67	Egypt	90	Uzbekistan
22	Portugal	45	Chile	68	Australia	91	Ghana
23	Japan	46	France	69	Pakistan	92	Zambia

Figure 25. Country ranking of IPv6 Development Index – Network

- Users: There is a big difference between the frontrunners and the starters, mainly affected by the level of digitalization and equipment supply
 - Digitization level: Frontrunners have a high level of digitalization, and end users have high requirements for IPv6 and IoT applications.
 - IPv6 deployment in the public sector: IPv6 deployment within the government also widely exists in leading countries, which further affects the popularization of terminal IPv6.
 - Ratio of terminal stock to increase: some frontrunners belong to latecomer countries and have accelerated the development of digital construction in recent years; due to a large number of new users, new terminal increments can directly deploy IPv6 equipment, and deployment is more resistant than equipment replacement small.
 - Concentration of operators: Among the starters, the concentration of operators in many countries is relatively low, and the market competition is full. Since terminal routes are mainly provided by operators, it will take a long time for IPv6 to be recognized by the market, and the speed of implementation and deployment in terminals is relatively slow.

2Belgium 25Thailand 48Indonesia	71Turkey
3 Malaysia 26 Austria 49 Belarus	72Lithuania
4 Saudi Arabia 27 Switzerland 50 South Korea	73Uganda
5Uruguay 28Singapore 51Slovakia	74Botswana
6 Germany 29 New Zeland 52 Rwanda	75Qatar
7 Greece 30 Paraguay 53 Denmark	76Bahrain
8 Finland 31 Peru 54 Bulgaria	77 Tanzania
9United States 32Romania 55Kazakhstan	78Namibia
10 Mexico 33 Ecuador 56 Serbia	79Senegal
11 Vietnam 34 Ireland 57 Croatia	80Uzbekistan
12 Hungary 35 Norway 58 Italy	81 Morocco
13 France 36 Argentina 59 Kenya	82Mauritius
14 China 37 Colombia 60 Russia	83Angola
15 United Arab Emirates 38 Philippines 61 Spain	84Algeria
16 Japan 39 Czech Republic 62 Egypt	85Libya
17 Luxembourg 40 Kuwait 63 South Africa	86Ghana
18 Portugal 41 Bolivia 64 Pakistan	87Zambia
19 United Kingdom 42 Poland 65 Bangladesh	88Tunisia
20 Brazil 43 Jordan 66 Cote d'Ivoire	89Iraq
21 Estonia 44 Chile 67 Lebanon	90 Mozambique
22 Australia 45 Sweden 68 Ukraine	91Ethiopia
23 Netherlands 46 Slovenia 69 Nigeria	92Cameroon

Figure 26. Country ranking of IPv6 Development Index – Users

3.1.2.4 IPv6 Penetration analysis

Source: Roland Berge

In the IPv6 development index, the four indexes of planning, network, content and user represent the penetration of IPv6 in each link of end-to-end deployment.

1	Belgium	24	Switzerland	47	Belarus	70	Serbia		
2	Uruguay	25	Austria	48	Denmark	71	Angola		
3	India	26	Norway	49	Algeria	72	Lebanon		
4	Brazil	27	Czech Republic	50	Morocco	73	Iraq		
5	Malaysia	28	Peru	51	Qatar	74	Bulgaria		
6	Germany	29	Singapore	52	Slovakia	75	Nigeria		
7	Finland	30	Sweden	53	Ethiopia	76	Spain		
8	Greece	31	Thailand	54	Kenya	77	Pakistan		
9	Saudi Arabia	32	China	55	Tanzania	78	Bahrain		
10	United Arab Emirates	33	Ecuador	56	Rwanda	79	Senegal		
11	Vietnam	34	Canada	57	Romania	80	Mozambique		
12	France	35	Philippines	58	Poland	81	Libya		
13	United States	36	Australia	59	Namibia	82	Cameroon		
14	Mexico	37	Argentina	60	Venezuela	83	Lithuania		
15	Paraguay	38	New Zeland	61	South Africa	84	Turkey		
16	Netherlands	39	Kuwait	62	Bangladesh	85	Kazakhstan		
17	Luxembourg	40	Bolivia	63	Croatia	86	Cote d'Ivoire		
18	Colombia	41	Ireland	64	Tunisia	87	Ukraine		
19	Hungary	42	Slovenia	65	Botswana	88	Russia		
20	Portugal	43	Jordan	66	Italy	89	Zambia		
21	United Kingdom	44	Oman	67	Egypt	90	Ghana		
22	Estonia	45	Mauritius	68	Uganda	91	South Korea		
23	Japan	46	Chile	69	Indonesia	92	Uzbekistan		
Sourc	- Control of the second s								

Figure 27. Country ranking of IPv6 Development Index – IPv6 penetration



Figure 28. Country ranking of IPv6 penetration

3.2 Benchmarking country analysis

Among many countries, we selected the United States, China and Germany from the front-runners group for analysis as benchmark countries, in order to summarize their strengths and provide reference cases and leading deployment for other countries.

3.2.1 USA

The United States is a digitalization pioneer. It now has a highly developed digital industry, resulting in high demand for IP addresses. As a result, IPv6 was implemented early in the United States, and its adoption rate is higher than in most other nations. On the other hand, the United States possesses a huge number of IPv4 addresses, and its equipment and services are optimized to meet the needs of IPv4, whereas the setup of IPv6 native equipment and services has not yet been optimized. Therefore, it will take time for the relative penetration of IPv6 (in comparison to IPv4) to increase.

Implications

- The legislative priorities of early adopters with a healthy digital economy must be forward-looking, such as making the connection between IPv6 and other emerging technologies such as 5G and IoT. Pioneering the investigation of cutting-edge technologies and trial applications to transform the digital infrastructure is the means for leading nations to keep their competitive advantage.
- Undoubtedly, the growth of the digital economy is the driving force behind the development of IPv6. The necessity and economic significance of adopting IPv6IPv6 Enhanced Innovations rises as the demand for IP inside the digital infrastructure rises.
- Enforcing end-to-end IPv6-only networks for government services, healthcare, and education, etc., considerably increases the implementation of IPv6IPv6 Enhanced Innovations.

	•		Qualitative impact by IPv6 Quantitative impact by IPv6 Quantitative impact by IPv6								
	Infrastructure of digital economy			Improved security	Increased efficiency						
Industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales				
Information & communication	٠					269,364		\$ 8.00%			
Manufacturing		•				379,581		07.90%			
Public service & utilities				•		397,575	Ý	6.20%			
Hospitality & entertainment				•		110,864	\$	6.10%			
Transport. & storage			٠			98,099	\$	5.90%			
Education			٠			23,693		5.50%			
Health & social work			٠	•	•	183,092	\$	5.40%			
Prof. services & finance			٠	•		452,441	ø	4.80%			
Wholesale & retail					•	222,830	ø	4.20%			
Energy						51,302	\$	4.00%			
Ag., forestry & fishing						20,988	o	3.60%			
Construction & real estate						193,245		2.60%			
Total	///////////////////////////////////////	///////////////////////////////////////	///////////////////////////////////////			2 403 074		5 20%			

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in the US would total \$2.4 trillion by 2025, equivalent to 5.2 % of the gross value of these industries in 2025.

Figure 29. IPv6 industry value creation in United States

IPv6 development status

➢ USA is ranked 7 out of 91 countries with a score of 0.53 and falls into the category of frontrunners. This means that USA is considered a leader in development of IPv6.



Figure 30. IPv6 development in United States

3.2.2 China

The Chinese government has achieved significant results in driving the IPv6 transition among operators, content service providers, and key device manufacturers through a set of multi-level and highly binding policies.

Implications

- National policies are observed to work the best when endorsed by a high-level strategic blueprint. The Digital China strategy outlined in the 14th Five-Year Plan is considered an example. To expedite the digital transition, it is recommended that governments embrace strategy that includes goals and support for the digital society, government, and economy.
- Binding policies with clearly defined targets and standards can effectively accelerate the penetration of IPv6 among operators, service providers, and users within a short time frame. Among all stakeholders, operators are most prone to policy influence and play the largest role in driving the deployment at the network and users' end.
- The active deployment of IPv6/IPv6 Enhanced Innovations by the leading operators can have a substantial effect on the overall deployment rate in the national networks. Moreover, it secures the provision of an IPv6 network environment for content providers.
- The active deployment of IPv6/IPv6 Enhanced Innovations by the leading operators can have a substantial effect on the overall deployment rate in the national networks. Moreover, it secures the provision of an IPv6 network environment for content providers.
- Governments should also work to advance breakthrough digital infrastructure technologies. Government support for IPv6 Enhanced Innovations technologies and businesses, as well as pilot projects, will considerably ease the growth of the digital sector and boost the national digital economy in the future.

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in the China would total \$578 billion by 2025, equivalent to 1.7 % of the gross value of these industries in 2025.

•			Qualitative in	npact by IPv6 ———	•	Quant	itative impact by IPv6 ——	•
	Infrastru	ucture of digital	economy	Improved security	Increased efficiency			
Industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales	
Information & communication				•	•	41,298	1	2.6%
Public service & utilities	•			•	•	81,638	ø	2.3%
Manufacturing	•	•	٠			159,311	\$	2.1%
Health & social work			٠	•	•	21,257	\$	2.0%
Hospitality & entertainment				٠		40,485	0	2.1%
Prof. services & finance			٠	•	•	53,213	Ø	1.7%
Education			٠	•		18,430	\$	1.7%
Transport. & storage	•					55,929	\$	1.5%
Wholesale & retail	•		•	•		28,210	\$	1.4%
Energy	•				•	14,659	o	1.3%
Ag., forestry & fishing	•					14,012	Ø	0.8%
Construction & real estate						49,942	0	0.8%
Total						578,385		1.7%
Low impact								

Source: Desktop research, expert interview; Roland Berge

IPv6 development status

China is ranked 12 out of 92 countries with a score of 0.47 and falls into the category of frontrunners. This means that China is considered a leader indevelopment of IPv6

	Overall		IPv6 pe	netration		Performance	Innovation
	score	Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front- runners	0.50	0.38	0.40	0.38	0.90	0.47	0.44
Adopters	0.36	0.39	0.38	0.38	0.27	0.38	0.36
Starters	0.26	0.33	0.31	0.35	0.04	0.25	0.31
China Ranking	0.47	0.17 96	0.43 16	0.26 91	0.81 16	0.41	0.73
Source: Roland Berg	er						

Figure 32. IPv6 development status in China

3.2.3 Germany

Due to a relatively high degree of digitalization, the users' natural demand for IP addresses becomes a potent driver for IPv6 transition. In addition, as Germany began the deployment process early and the active public sector has contributed significantly to the promotion of IPv6, Germany is at the forefront of IPv6 implementation globally.

Implications

- The government should take the lead in deploying IPv6 and then encourage the private sector to make the appropriate change.
- As the digital economies grow, the modernization of digital infrastructures in major industries (e.g., manufacturing) is projected to generate enormous demand for IPv6 capabilities. Therefore, governments should integrate IPv6 into industrial settings (such as smart manufacturing) and support pilot projects for its implementations.

Figure 31. IPv6 industry value creation in China

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in Germany would total \$288 billion by 2025, equivalent to 4.2 % of the gross value of these industries in 2025.

	•		Qualitative in	npact by IPv6	••	Quantitative impact by IPv6					
	Infrastru	cture of digital	economy	Improved security	Increased efficiency						
Industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales				
Information & communication	٠			۲		18,83		o.0%			
Manufacturing	•		•		•	77,049	Ø	5.1%			
Public service & utilities	•			۲	•	36,525		5.0%			
Energy					•	3,078	\$	4.7%			
Transport. & storage			٠	•		18,736		4.4%			
Hospitality & entertainment					•	11,666	\$	4.4%			
Education			٠	•		10,464	\$	4.2%			
Health & social work						20,307	\$	4.2%			
Prof. services & finance			٠			43,665	ø	3.9%			
Wholesale & retail					•	22,190	ø	3.6%			
Construction & real estate						2,408	ø	3.2%			
Ag., forestry & fishing						23,506	0	2.2%			
Total						288,431		4.2%			
Low impact											
Source: Desktop research, expert interview:	Roland Berger										



IPv6 development status

Germany is ranked 4 out of 92 countries with a score of 0.53 and falls into the category of frontrunners. This means that Germany is considered a leader indevelopment of IPv6

	Overall		IPv6 per	netration		Performance	Innovation
	score	Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front- runners	0.50	0.38	0.40	0.38	0.90	0.47	0.44
Adopters	0.36	0.39	0.38	0.38	0.27	0.38	0.36
Starters 0).26	0.33	0.31	0.35	0.04	0.25	0.31
Germany Ranking	0.53	0.43 26	0.42 17	0.41	1.05 6	0.34	0.53
Germany Ranking	0.53	0.43 26	0.42 17	0.41	1.05 6	0.25	0.53

Figure 34. IPv6 development status in Germany

3.3 Typical country analysis

3.3.1 Front-runners

3.3.1.1 France

France has a solid digital basis, as well as a strong academic reputation and influence in the telecommunication field. As the French public sector' started deployment of IPv6 since 2012, the private sector shows good IPv6 penetration; however, due to the fragmented market of operators and content services, there are a large number of small operators and small websites that have not yet transformed to IPv6, and it will take time to further the penetration.

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in France could total \$164 billion by 2025, equivalent to 3.6% of the gross value of these industries in 2025.

	•		Qualitative in	npact by IPv6	••	Quantitative impact by IPv6				
	Infrastru	ucture of digital	economy	Improved security	Increased efficiency					
Industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales			
Manufacturing		٠				28,806		\$ 5.9%		
Information & communication						15,419	Ø	4.9%		
Public service & utilities						20,959	ø	4.5%		
Energy			٠		•	1,788		4.0%		
Transport. & storage			٠			9,673	\$	3.8%		
Hospitality & entertainment				•		7,761	\$	3.8%		
Health & social work	•		٠	•	•	12,536	\$	3.6%		
Education			٠		•	6,262		3.5%		
Prof. services & finance			٠			29,066	\$	3.3%		
Wholesale & retail						15,123	ø	3.0%		
Ag., forestry & fishing					•	2,437	ø	2.2%		
Construction & real estate						15,081	0	1.9%		
Total						164,911		3.6%		
Low impact										
Source: Desktop research, expert interview; R	oland Berger									



IPv6 development status

France is ranked 8 out of 92 countries with a score of 0.51 and falls into the category of frontrunners. This means that France is considered a leader in the development of IPv6

	Overall		IPv6 per	netration		Performance	Innovation
	score	Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front- runners	0.50	0.38	0.40	0.38	0.90	0.47	0.44
Adopters	0.36	0.39	0.38	0.38	0.27	0.38	0.36
Starters	0.26	0.33	0.31	0.35	0.04	0.25	0.31
France Ranking	0.51	0.40 39	0.39 47	0.35 75	0.84 15	0.41 34	0.70

Figure 36. IPv6 development status in France

Recommendations

			Navigator				Implementer		Supervisor
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supervision & inspection
Public sector Key	Highlight the importance of transformation towards IPv6 in the national digital strategy Introduce detailed action plans and timelines for IPv6 with clear phases become to the strategy of the strategy		• Sharing platforms for industry players to share best				The state and relevant authorities should make commitmen	More IPv6 programs in vocational training and give certificates	Require
service a service providers	and subjects goals	and subjects based on the goals				role as an IPv6 "observator y" to foundation measure, courses		More foundation	private sector players to publish
Users & enterprises						evaluate and advise		IPv6 & IPv6 Enhanced Innovation in colleges	plans

Figure 37. Policy recommendations for France

3.3.1.2 Saudi Arabia

Saudi Arabia has a high demand for IPv6 in the process of promoting the transformation of the digital economy. Around 2021, the government actively deployed IPv6 through the state-owned top operators, mandating quick IPv6 deployment and rapid penetration by the top operators.

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in Saudi Arabia would total \$123 billion by 2025, equivalent to 6.5 % of the gross value of these industries in 2025.

	•		Qualitative im	pact by IPv6	• •	Quanti	tative impact by IPv6 ——	 8.6% 8.0% 7.5% 7.3% 7.3% 7.1% 7.0% 		
	Infrastru	cture of digital	economy	Improved security	Increased efficiency					
Industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales			
Information & communication	•					8,829		\$ 8.6%		
Energy	•		•			41,086	ø	8.0%		
Public service & utilities	٠			•	•	13,384	Ø	7.5%		
Transport. & storage	٠		٠			4,790		7.3%		
Manufacturing	٠	٠	٠			15,937	\$	7.3%		
Hospitality & entertainment		٠	٠	•		3,064		7.1%		
Prof. services & finance			٠			4,839	\$	7.0%		
Health & social work			٠			3,633	ø	6.8%		
Education			٠			6,589	ø	6.1%		
Wholesale & retail	٠		٠		•	7,646	ø	5.5%		
Ag., forestry & fishing	٠					1,346	ø	4.0%		
Construction & real estate						11,923		3.3%		
Total						123,066		6.5%		
Low impact										



IPv6 development status

Saudi Arabia has a high demand for IPv6 in the process of promoting digital economic transformation. Around 2021, the government will drive SOE head operators to carry out rapid IPv6 deployment, quickly infiltrate and lay out commercial pilot applications of IPv6 Enhanced Innovation cutting-edge technologies

Saudi Arabia is ranked 10 out of 92 countries with a score of 0.51 and falls into the category of front-runners. This means that Saudi Arabia is considered a leader in the global deployment of IPv6



Figure 39. IPv6 development status in Saudi Arabia

Recommendations

			Navigator				Implementer		Supervisor	
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supervision & inspection	
Public sector Key device &	Improve Saudi Strengthen the Arabia's Actively organize and attend international IPv6 summits policy tion of vision 2030 Actively participate in the setting of international IPv6 agenda and in the design of standards in IPE			 Encourage in smart cit supportive tax incentiv Continuous cloud techn services 	AI, 5G and IoT ies with policies and /es ly develop the nology and		Provide sufficient	Strengthen supervision on planning and construction of the "new future" smart city		
service providers	targeted policies and stage plans	ion Program			 Encourage IPv6 and IP technology support ap SRv6 Promote th of IPv6 Ent Innovation 	applications of E to achieve leaps and blications of e applications hanced features		financial support for the R&D of IPE related technology		

Figure 40. Policy recommendations for Saudi Arabia

3.3.1.3 Malaysia

Malaysia started the deployment process of IPv6 10 years ago and stepped up its policies in recent years. From 2020 onwards, IPv6 certification is made mandatory for all types of network equipment. However, due to a fragmented operator market, the deployment of IPv6 still needs time.

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in Malaysia would total \$108 billion by 2025, equivalent to 3.2 % of the gross value of these industries in 2025.

	•		Qualitative im	pact by IPv6	••	Quantitative impact by IPv6				
	Infrastru	ucture of digital	economy	Improved security	Increased efficiency					
Industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales			
Public service & utilities	٠					11,203		4.4%		
Manufacturing	•	•	•			28,281	ø	4.3%		
Information & communication	٠			٠	٠	11,252	ø .	4.1%		
Health & social work			•	•		3,316	ø	3.5%		
Transport. & storage			•		•	7,494	\$	3.4%		
Prof. services & finance			•		•	9,081		3.1%		
Education			•		•	4,257	\$	3.1%		
Hospitality & entertainment					•	4,722	\$	3.1%		
Wholesale & retail					•	13,433	\$	2.6%		
Energy					•	6,509	ø	2.2%		
Ag., forestry & fishing					•	2,392	ø	1.8%		
Construction & real estate						6,341	0	1.8%		
Total						108,281		3.2%		
Low impact 🔍 🔵 🌑 🖨 High impact										

Source: Desktop research, expert interview; Roland Berge

Figure 41. IPv6 industry value creation in Malaysia

IPv6 development status

Malaysia is ranked 11 out of 92 countries with a score of 0.50 and falls into the category of front-runners. This means that Malaysia is considered a leader in the development of IPv6 globally.

0	Overall IPv6 penetration					Performance	Innovation
	score	Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front- runners	0.50	0.38	0.40	0.38	0.90	0.47	0.44
Adopters	0.36	0.39	0.38	0.38	0.27	0.38	0.36
Starters	0.26	0.33	0.31	0.35	0.04	0.25	0.31
Malaysia Ranking	0.50	0.36 45	0.40 39	0.41 22	1.15 3	0.34 48	0.36 50
Source: Roland Berg	jer						__

Figure 42. IPv6 development status in Malaysia

Recommendations

			Navigator					Supervisor	
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supervision & inspection
Public sector		Strengthen th on mandator and promote applications of from domest	ne implementation y certification of full support for of IPv6 technolo ic enterprises	on of policies f IPv6 devices the gy in devices	Strengthen financial subsidies and policy support to promote	Promote 5G industry, such as providing policies and subsidies	Realize the end-to-end IPv6 only target in gov. networks		
Key device & service providers		Improve dom encourage ac institutions in	nestic IPv6 stand stive participation the world	lards, and n by domestic	deployment				Implement further requirement on IPv6
Users & enterprises					Promote digital industries & industrial clusters	Continue the native deployment of IPv6	Strengthen fina for IPv6 techno research and ir and encourage members to jo IPv6 project tea	ancial support ology movation, more in the ETSI am	performance on top of mandatory certification

Source: Roland Berger

Figure 43. Policy recommendations for Malaysia

3.3.1.4 United Arab Emirates

Large international enterprises account for a large proportion of the UAE's network operators and content providers, enabling the government to lead SOE operators to rapidly deploy IPv6 when IPv4 addresses are relatively abundant.

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in UAE would total \$218 billion by 2025, equivalent to 6.7 % of the gross value of these industries in 2025.

	Qualitative impact by IPv6 Quantitative impact by IPv6							
	Infrastru	ucture of digital	economy	Improved security	Increased efficiency			
industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales	
Manufacturing	•		•		•	32,707		0 .7%
Information & communication	•		•	•		12,093	\$	9 .1%
Energy	•		•			50,203	Ø	8.3%
Health & social work			•	•	•	3,888	ø	7.9%
Education			•			3,310		7.1%
Public service & utilities	•			•	•	28,568	\$	7.1%
Hospitality & entertainment				•		6,426	\$	6.9%
Transport. & storage	•		•			22,070	\$	6.2%
Prof. services & finance			•			23,000	\$	6.2%
Wholesale & retail	•					15,553	ø	5.6%
Ag., forestry & fishing	•					1,384	ø	5.2%
Construction & real estate						19,616	ø	3.4%
Total						040 040		6 70

ow impact

Figure 44. IPv6 industry value creation in

United Arab Emirates



IPv6 development status

Figure 45. IPv6 development status in United Arab Emirates

Recommendations

			Navigator					Supervisor	
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supervision & inspection
Public sector	Continue to r policy guidau introduce me policies in IF addition to th digital econo and Al strate Strangthon p	einforce nce and bre targeted Pv6 and IPE in ne established my strategy gy	 Actively org attend intern summits Actively par setting of in IPv6 agenda design of st IPF 	anize and national IPv6 ticipate in the ternational a and in the andards in	 Raise aware and IPE Apply restri- use of NAT/ Provide fina policy incen and IPE 	eness of IPv6 ctions on the CGNAT ncial and tives for IPv6		Encourage telecom operators to expand native deployment of IPv6 and provide	Set up key indicators of IPv6 and IPv6 Enhanced Innovation to timely evaluate the
Users & enterprises	 Strengthen p and systema in the fields (IPv6 to drive demand 	tic planning of 5G, loT and the growth of	IFE	IPE		iteration on of IPv6 & IPE e applications ianced projets e development stry nigh-tech		technical support and guidance	results by periods and promote policy implementa tion

Figure 46. Policy recommendations for United Arab Emirates

3.3.1.5 Brazil

As one of the first-movers in South America, Brazil has a fairly substantial share of South American prefix resources. Nonetheless, development of 5G, AI, and other related industries that drive the growth of the user end demand began rather late, the level of government digitalization is also low.

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in Brazil would total \$163 billion by 2025, equivalent to 1.1 % of the gross value of these industries in 2025.

	•		Qualitative in	npact by IPv6	•••	• • Quantitative impact by IPv6			
	Infrastr	ucture of digital	economy	Improved security	Increased efficiency				
Industry	5G	ΙοΤ	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales		
Information & communication			•	•		10,169		🔷 1.5%	
Manufacturing		•		•		35,405		1.5%	
Public service & utilities	٠		•		•	22,943	Ø	1.2%	
Transport. & storage	٠					11,221	Ø	1.1%	
Hospitality & entertainment			٠		•	5,323	\$	1.1%	
Health & social work			•		•	8,965		1.0%	
Education			٠			8,654		1.0%	
Prof. services & finance			٠	•		20,375	\$	1.0%	
Wholesale & retail			٠			19,934	0	0.9%	
Construction & real estate						3,241	\$	0.8%	
Energy						9,971	<u> </u>	0.8%	
Ag., forestry & fishing						7,452	0	0.5%	
Total						163,652		1.1%	
Low impact									
Source: Desktop research, expert interview; R	oland Berger								

Figure 47. IPv6 industry value creation in Brazil

IPv6 development status

Brazil is ranked 14 out of 92 countries with a score of 0.48 and falls into the category of frontrunners. This means that Brazil is considered a leader in the development of IPv6 globally.



Figure 48. IPv6 development status in Brazil

Recommendations

			Navigator					Supervisor	
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supervision & inspection
Public sector		 Arouse awa attention of parties to IP Set up a spo responsible 	reness and relevant 2v6 ecial e organization			 Cultivate technology community Raise awareness 			
Key device & service providers		to ensure th transformati supervise th developmen transformati the later sta	ne smooth ion and ne nt of ion work in		Provide preferential policies and subsidies for important 5G	of IPv6 for Portuguese speakers • Initiate IPv6 week in Brazil and		Cultivate professiona I talents, such as offering	Promote policies to ensure the compatibility of device
Users & enterprises		une later sta	це		equipment and service suppliers	expand it to Latin America		professional courses, free resources, etc.	with new technologies

Figure 49. Policy recommendations for Brazil

3.3.1.6 Mexico

Mexico is experiencing a time of fast growth in its digital economy. There are numerous new IP requirements for which IPv6 can be installed immediately, making it easier to popularize IPv6 on the user end. Due to the huge number of small operators, however, IPv6 upgrade on the network side will take some time.

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in Mexico would total \$26 billion by 2025, equivalent to 1.1 % of the gross value of these industries in 2025.

	•		Qualitative im	pact by IPv6	•••	Quantitative impact by IPv6			
Industry	Infrastr 5G	ucture of digital IoT	economy Cloud	Improved security Improved security	Increased efficiency Increased efficiency	Value [mn \$]	% of industry sales		
Information & communication		•	•	•		1,323		\$ 1.8%	
Public service & utilities				٠		3,143		1.5%	
Hospitality & entertainment			٠	•		1,181		1.5%	
Health & social work				•		1,178	ø	1.3%	
Manufacturing			٠			7,630	ø	1.2%	
Education			٠	•		1,050		1.1%	
Prof. services & finance			٠	•		2,890	\$	1.1%	
Transport. & storage			٠	٠	•	1,967	ø	1.0%	
Wholesale & retail			٠		•	3,433	ø	0.9%	
Energy						1,167	Ø	0.7%	
Construction & real estate			٠			529	>	0.7%	
Ag., forestry & fishing						702	ø	0.5%	
Total Low impact						26,194		1.1%	

Source: Desktop research, expert interview; Roland Berger



IPv6 development status

Mexico is ranked 16 out of 92 countries with a score of 0.47 and falls into the category of frontrunners. This means that Mexico is considered a leader in the development of IPv6 globally.

	Overall	all IPv6 penetration Performance			Performance	Innovation	
	score	Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front- runners	0.50	0.38	0.40	0.38	0.90	0.47	0.44
Adopters	0.36	0.39	0.38	0.38	0.27	0.38	0.36
Starters	0.26	0.33	0.31	0.35	0.04	0.25	0.31
Mexico Ranking	0.47 16	0.28 79	0.36 61	0.40 30	0.92 12	0.48 20	0.41 29
Source: Roland Berg	er						

Figure 51. IPv6 development status in Mexico

Recommendations

			Navigator				Implementer		Supervisor	
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supervision & inspection	
Public sector	Accelerate th of mobile net infrastructure fast, reliable Internet conr	ne construction twork e to establish and available nections	Provide sharing platforms for industry players to		 Incentivize operators to upgrade IPv6 Targeted to v colief 					
Key device & service providers			sharing of progress and best	sharing of progress and best practices		or bank credit support			Provide financial subsidies	
Users & enterprises		practice			Encourage operators to participate in IPE pilot projects of innovative projects			for training programs targeted to help employees develop digital skills		

Source: Roland Berger

Figure 52. Policy recommendations for Mexico

3.3.2 Adopters

3.3.2.1 Thailand

Lack of IPv4 address incentivize both public and private sectors in Thailand to migrate to IPv6. Thailand's continuing top-down IPv6 strategic planning has enabled a seamless IPv6 transition, although frontier technology and forward-looking projects are still lacking.

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in Thailand would total \$31 billion by 2025, equivalent to 3.4 % of the gross value of these industries in 2025.

	•		Qualitative in	npact by IPv6	••	- + - Quantitative impact by IPv6			
	Infrastr	ucture of digital	economy	Improved security	Increased efficiency				
Industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales		
Information & communication	•	٠		۲	•	1,364	<u> </u>	5.3%	
Manufacturing	•	•	•			8,327		4.4%	
Public service & utilities		•		•	•	3,259	\$	4.4%	
Health & social work	•			•	•	643	\$	4.4%	
Transport. & storage	•	•				1,939	ø	3.8%	
Education	٠				•	817	\$	3.6%	
Prof. services & finance	٠				•	2,607	\$	3.4%	
Hospitality & entertainment	•			٠	•	2,191		3.0%	
Wholesale & retail	•	•			•	4,822	\$	2.9%	
Energy		•			•	2,324	ø	2.4%	
Construction & real estate					•	1,202	\$	2.1%	
Ag., forestry & fishing		•				1,096		1.8%	
Total						30,593		3.4%	
Low impact									
Source: Desktop research, expert interview;	Roland Berger								

Figure 53. IPv6 industry value creation in Thailand

IPv6 development status

The Thailand 4.0 strategy proposed in 2016 focuses on consolidating existing industrial development capabilities (focusing on industries like automobiles and smart appliances), establishing new industries (focusing on industries like robotics and digitalization), and forming high-tech value chains (focusing on industries like networking, electromechanical integration, and innovation and culture), which are in line with the IPv6 value plateau of information technology. Therefore, IPv6 implementation can in large facilitate Thailand's strategic change.

Thailand is ranked 36 out of 92 countries with a score of 0.40 and falls into the category of adopters. This means the level of IPv6 development in Thailand is in the medium level in the world.

	Overall		IPv6 pe	netration		Performance	Innovation
	score	Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front- runners	0.50	0.38	0.40	0.38	0.90	0.47	0.44
Adopters	0.36	0.39	0.38	0.38	0.27	0.38	0.36
Starters	0.26	0.33	0.31	0.35	0.04	0.25	0.31
Thailand Ranking	0.40 36	0.30 72	0.37 53	0.38 39	0.62 27	0.55	0.21

Figure 54. IPv6 development status in Thailand

Recommendations



Figure 55. Policy recommendations for Thailand

3.3.2.2 Philippines

Not high levels of digitalization and demand for addresses are observed. Because of the insufficient infrastructure, however, a substantial number of new end devices can directly implement IPv6, reducing transition costs and facilitating user adoption.

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in Philippines would total \$25 billion by 2025, equivalent to 3.9 % of the gross value of these industries in 2025.

	•		Qualitative in	pact by IPv6	•	Quantitative impact by IPv6			
Industry	Infras 56	tructure of digital	economy Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales		
Manufacturing			olouu			5 208	// or industry sales	A 6 20/	
Health & social work						387		6.0%	
Information & communication		•	•	•	•	1,492	0	5.6%	
Education			•		•	591		4.2%	
Transport. & storage			٠		•	1,994		4.2%	
Public service & utilities			٠		•	3,971		4.2%	
Prof. services & finance			•			2,795	ø	3.8%	
Hospitality & entertainment			٠		•	1,037	Ø	3.7%	
Wholesale & retail			٠		•	4,790	ø	3.3%	
Energy						701	ø	3.2%	
Construction & real estate			•		•	1,574	ø	2.2%	
Ag., forestry & fishing						1,099	0	2.1%	
Total						25,640		3.9%	
Low impact 💿 🔵 🌑 High impact									

ource: Desktop research, expert interview; Roland Berger

Figure 56. IPv6 industry value creation in Philippines

IPv6 development status

Philippines ranks 43 out of 92 countries with a score of 0.37, grouped as an adopter. This means the level of IPv6 development in Philipines is in the medium level in the world.

	Overall		IPv6 per	netration		Performance	Innovation
	score	Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front- runners	0.50	0.38	0.40	0.38	0.90	0.47	0.44
Adopters	0.36	0.39	0.38	0.38	0.27	0.38	0.36
Starters	0.26	0.33	0.31	0.35	0.04	0.25	0.31
Philippines Ranking	0.39	0.38 43	0.40 36	0.40 25	0.42 41	0.27 64	0.45 16

Figure 57. IPv6 development status in Philippines

Recommendations

			Navigator				Implementer		Supervisor
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supervision & inspection
Public sector		 Promote policy and rules, and 	Introduce inn the operators	ovation awards	to motivate	Develop digi	tal skills and raise	public awaren	ess
		timely evaluate				 Accelerate developme 	the nt of network-		Provide a fair competitive
Key device & service providers		results Develop roadmaps, baselines and 				enabled se public sect • Promote IF capabilities offices and	ervices in the tor Pv6 support s of government I key facilities		environment by lowering entry barrier, simplifying the process
lleare &		metrics				Accelerate E-governm	development of ent services		for license application, etc.
enterprises		Issue relevan and strength e	t policies as soc en the network i	n as possible to nfrastructure	accelerate				
Source: Roland Berger									

Figure 58

. Policy recommendations for Philippines

3.3.2.3 Italy

Italy has an edge in advanced technology research and academic contributions, but due to its high number of SMEs and poor digital economy penetration, there is less demand for IP addresses and a lack of impetus in IPv6 deployment by big operators.

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in Italy would total \$104 billion by 2025, equivalent to 3.3% of the gross value of these industries in 2025.

	•		Qualitative in	npact by IPv6	••	Quanti	tative impact by IPv6	•
	Infrastr	ucture of digital	economy	Improved security	Increased efficiency			
Industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales	
Information & communication						6,939		4.8%
Manufacturing	•	•	•		•	27,244	ø	4.3%
Public service & utilities	•			•		13,365	ø	4.2%
Transport. & storage	•		•		•	6,521	ø	3.6%
Education			٠			3,116	Ø	3.4%
Health & social work			•		•	6,095		3.4%
Energy					•	1,600		3.2%
Hospitality & entertainment			•	•	•	6,400	\$	3.3%
Prof. services & finance			•		•	12,330	>	3.2%
Wholesale & retail			٠		•	11,324	ø	2.8%
Ag., forestry & fishing	•				•	1,375	ø	2.2%
Construction & real estate						8,624	ø	1.8%
Total						104,932		3.3%
Low impact								

Source: Desktop research, expert interview; Roland Berger

IPv6 development status

Italy ranks 48 out of 92 countries with a score of 0.35, grouped as an adopter. This means the level of IPv6 development in Italy is in the medium level in the world.

	Overall		IPv6 per	netration		Performance	Innovation
	score	Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front- runners	0.50	0.38	0.40	0.38	0.90	0.47	0.44
Adopters	0.36	0.39	0.38	0.38	0.27	0.38	0.36
Starters	0.26	0.33	0.31	0.35	0.04	0.25	0.31
Italy Ranking	0.35 48	0.34 56	0.37 56	0.35 74	0.12 61	0.34 48	0.58 6
Source: Roland Berge	or						

Figure 60. IPv6 development status in Italy

Recommendations

			Navigator				Implementer		Supervisor	
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supervision & inspection	
Public sector	Develop targeted policies in line with digital transformati	Introduce policies with specific and mandatory	Encourage the Italian IPv6 Task Force to keep playing its				Issue mandatory policies on specific IPv6 transition	Develop a high- quality education system that emphasizes		
Key device & service providers	on trends	targets and timelines	leading role		 Provide mgmt., funding and talent support 	Increase awareness of IPv6 and IPE among small and	roadmap and timeline for govt end-users	the integration of STEM- related disciplines		
Users & enterprises					 Support cloud economy Support IPE tech projects 	medium- sized enterprise users		in higher education		

Source: Roland Berger

Figure 61. Policy recommendations for Italy

Figure 59. IPv6 industry value creation in Italy

3.3.2.4 Algeria

The rapid growth of the ICT industry in Algeria in recent years, the strong government investment in critical ICT infrastructure and the constantly updated legal framework and regulations have all contributed in part to the deployment of IPv6.

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in Algeria would total \$5.2 billion by 2025, equivalent to 1.0% of the gross value of these industries in 2025.

	•		Qualitative in	••	Quantitative impact by IPv6			
	Infrastru	ucture of digital	economy	Improved security	Increased efficiency			
Industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales	
Public service & utilities				•		202	o 1.5 ¹	
Information & communication	•			٠		212	o 1.4	
Manufacturing		•			•	265	of 1.3	
Hospitality & entertainment			•	٠	•	3,417	o 1.3	
Health & social work				٠		111	S 1.1	
Education						54	0.8	
Prof. services & finance			٠	•	•	228	0.8	
Transport. & storage					•	76	0.8	
Wholesale & retail			•		•	222	0.6	
Construction & real estate						38	Q.5'	
Energy						290	0.5	
Ag., forestry & fishing						96	0.3	
Total						5,211	1.0	



IPv6 development status

Source: Desktop research, expert interview; Roland Berge

Algeria ranks 52 out of 92 countries with a score of 0.34, grouped as an adopter. This means the level of IPv6 development in Algeria is in medium level in the world.

	Overall		IPv6 per	netration		Performance	Innovation
	score	Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front- runners	0.50	0.38	0.40	0.38	0.90	0.47	0.44
Adopters	0.36	0.39	0.38	0.38	0.27	0.38	0.36
Starters	0.26	0.33	0.31	0.35	0.04	0.25	0.31
Algeria Ranking	0.34 52	0.55 6	0.40 42	0.40 25	0.00 86	0.27 64	0.44
Source: Roland Berge	r						

Figure 63. IPv6 development status in Algeria

Recommendations

			Navigator				Implementer		Supervisor	
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supervision & inspection	
Public sector	Promulgate laws and regulations to lead the standardized development	 Pay attention IPv6 and iss plan with sp Issue releva planning and implementat 	n to dev. of ue an action ecific timeline nt strategic d ion rules		Continue to increase govt funding in ICT infrastructure construction		Govt should take the lead in incorporating IPv6 capabilities			
Key device & service providers	of the digital industry	 Include expension to the promo- deployment national bud 	enses related otion of IPv6 into the get				into procurement plans, government programs,			
Users & enterprises					Promote digital transform. of SMEs and improve infrastructure		online services, etc.			
Source: Roland Berger										

Figure 64. Policy recommendations for Algeria

3.3.2.5 South Africa

The general level of digitalization in South Africa is low, and in the lack of larger incentives, terminal demand for IPv6 is still modest, and operators are just beginning to switch to IPv6 due to the oversupply of IPv4 addresses in the country.

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in South Africa would total \$45 billion by 2025, equivalent to 5.1% of the gross value of these industries in 2025.

	•		Qualitative in	••	Quantitative impact by IPv6			
	Infrastr	ucture of digital	economy	Improved security	Increased efficiency			
Industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales	
Information & communication						2,691		o 7.1%
Manufacturing	•		٠		•	11,946		6.6%
Health & social work			•			895		6.5%
Education			٠		•	838	ø	5.7%
Hospitality & entertainment			٠		•	1,079		5.6%
Transport. & storage	•		•		•	3,402	\$	5.5%
Public service & utilities	٠				•	9,077	ø	5.0%
Prof. services & finance			٠		•	6,241	\$	4.8%
Wholesale & retail			•		•	4,478		4.4%
Energy					•	1,390	ø	4.1%
Ag., forestry & fishing	•				•	955	ø	3.0%
Construction & real estate						2,922	0	2.9%
Total						45,914		5.1%
Low impact								
Source: Desktop research, expert interview;	Roland Berger							

Figure 65. IPv6 industry value creation in South Africa

IPv6 development status

South Africa ranks 54 out of 92 countries with a score of 0.34, grouped as an adopter. This means the level of IPv6 development in South Africa is in the medium level in the world.



Figure 66. IPv6 development status in South Africa

Recommendations

			Navigator				Implementer		Sup	ervisor	
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supe ins	rvision & pection	
Public sector	Formulate le strategies in clarify phase assessment supervisory	gislation and relevant fields, ed goals, methods and departments	 Set up IPv6 leadership groups Promote the 				Promote government deployment of IPv6	 Promote intl. exchange Promote cultivation 			
Key device & service providers Users & enterprises	 Promote tele operators to through pref policies and subsidies Improve 5G- strategic pla industrial tec standards 	ecom upgrade IPv6 ierential financial -related nning and chnical	research and intl. exchange of relevant scientific research institutes	 Encourage t IPv6 and up capabilities Encourage o providers to equipment v Encourage r deployment Guide conte to upgrade r infrastructure 	o support grade DC content upgrade with subsidies native of IPv6 int providers related re	Strengthen the promotion of IPv6 technology, value and importance		of talents in colleges with more budget support			

Source: Roland Berger

Figure 67. Policy recommendations for South Africa

3.3.2.6 Spain

Spain began the development of IPv6 technology early and has certain advantages in advanced technology development and academic contributions, but the major operators lack motivation in IPv6 deployment and there is no effective policy to promote the implementation; therefore, it has not yet surpassed the United States as the global leader in IPv6 deployment.

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in Spain would total \$75 billion by 2025, equivalent to 3.3% of the gross value of these industries in 2025.

	•		Qualitative im	pact by IPv6		Quanti	tative impact by IPv6	
	Infrastru	cture of digital	economy	Improved security	Increased efficiency			
Industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales	
Manufacturing		٠	•		•	17,144	 	4.7%
Information & communication				•		5,555	İ	4.6%
Public service & utilities						9,896	ø	4.1%
Transport. & storage			٠		•	4,757	ø	3.6%
Energy						991		3.5%
Health & social work			•	•	•	4,897	¢	3.3%
Education			•		•	2,893	¢	3.2%
Prof. services & finance			•		•	8,606	\$	3.1%
Hospitality & entertainment			•		•	6,152	\$	3.1%
Wholesale & retail			•		•	7,226	0	2.8%
Ag., forestry & fishing					•	1,412	ø	1.9%
Construction & real estate						6,436	0	1.7%
Total						75,964		3.3%
Low impact 🕘 🔵 🌑 High impact								

Source: Desktop research, expert interview; Roland Berger

IPv6 development status

Spain ranks 61 out of 92 countries with a score of 0.33, grouped as an adopter. This means the level of IPv6 development in Spain is in medium level in the world.

	Overall		IPv6 pe	netration		Performance	Innovation
	score	Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications
Front- runners	0.50	0.38	0.40	0.38	0.90	0.47	0.44
Adopters	0.36	0.39	0.38	0.38	0.27	0.38	0.36
Starters	0.26	0.33	0.31	0.35	0.04	0.25	0.31
Spain Ranking	0.33 61	0.26 85	0.34 75	0.36 68	0.09 64	0.27 64	0.63

Figure 69. IPv6 development status in Spain

Recommendations

Source: Roland Berger

			Navigator				Implementer		Supervisor
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supervision & inspection
Public sector			 Encourage IPv6- related activities Encourage 				Promote end-to-end deployment of govt. networks	 Incorporate IPv6 and IPE-related content into higher education 	
Key device & service providers		Tax or restrict NAT/CGNAT technology	to provide policy advice	Vigorously promote the constructio n of 5G network	Provide preferential policies and financial	Increase awareness of end users and businesses		courses • Provide funds for IPv6 and IPE-related	
Users & enterprises					incentives for operators deploying IPv6			technology industry- university- research projects	

Source: Roland Berger

Figure 70. Policy recommendations for Spain

Figure 68. IPv6 industry value creation in Spain

3.3.2.7 Nigeria

As the most populous country in Africa, Nigeria is valued by many multinational content providers of large sizes and leading expertise, resulting in satisfactory content support for IPv6. However, limited by its low level of digitization, in the absence of significant growth in the digital industry, IPv6 deployment in Nigeria remains at a medium level in the world.

IPv6 industry sector impact

We estimate that the potential value of IPv6 deployment across multiple industries in Nigeria could total US\$52 billion by 2025, which is equivalent to 5.8% of the total real output value of these industries in 2025.

	•		Qualitative in	npact by IPv6	••	• • Quantitative impact by IPv6			
	Infrastructure of digital economy			Improved security	Increased efficiency				
Industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales		
Manufacturing		•	•			8,109		0 10.7%	
Health & social work			•		۲	842	~	7.9%	
Public service & utilities	•					4,844	\$	7.8%	
Transport. & storage	•		•		•	2,138		7.7%	
Information & communication	٠					7,141	\$	7.6%	
Prof. services & finance			•		•	2,280	ø	6.8%	
Hospitality & entertainment			•		•	1,025	\$	6.7%	
Education			•		•	2,163	ø	6.1%	
Wholesale & retail			•		•	11,391	ø	5.2%	
Energy					•	5,660	ø	4.4%	
Construction & real estate					•	4,002	o	3.4%	
Ag., forestry & fishing	•					2,472	o	3.3%	
Total						52,066		5.8%	
Low impact									

Source: Desktop research, expert interview; Roland Berge



IPv6 development status

Nigeria ranks 67 out of 92 countries with a score of 0.30 and is grouped as adopter. This means Nigeria's IPv6 deployment level is in the middle of the world

	Overall		IPv6 pe	netration		Performance	Innovation		
	score	Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications		
Front- runners	0.50	0.38	0.40	0.38	0.90	0.47	0.44		
Adopters	0.36	0.39	0.38	0.38	0.27	0.38	0.36		
Starters	0.26	0.33	0.31	0.35	0.04	0.25	0.31		
Nigeria Ranking	0.30 67	0.34 55	0.27 91	0.43	0.01 72	0.34	0.44		

Figure 72. IPv6 development status in Nigeria

Recommendations

			Navigator					Supervisor	
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supervision & inspection
Public sector	 Improve 5G strategic pla industrial te standards Provide clea guidelines a 	related anning and chnical ar policy and institutional	ted • Keep the g and active ral role of Nigeria icy IPv6 Council to drive the			Increase publicity and publish IPv6-related indicators on a regular	Promote the adoption of IPv6 single stack and the upgrades of infrast. at	Support the cultivation of relevant talents through transnation	
Key device & service providers	frameworks	in the 5G field drive the domestic transition from IPv4 to IPv6		Support operators to invest in commercial pilot		basis	gov.	al training cooperation, free projects, etc.	
Users & enterprises					projects represented by SRv6				

Figure 73. Policy recommendations for Nigeria

3.3.2.8 Egypt

The digitalization infrastructure in Egypt is very limited, but the digital economy has grown fast over the past few years. IPv6 and digitalization have evolved concurrently. Due to the absence of a mandated regulation, the digital economy's increased need for intellectual property must nevertheless be relayed to operators and end users.

IPv6 industry sector impact

We estimate that the potential value created by deploying IPv6 across multiple industries in Egypt would total \$47 billion by 2025, equivalent to 5.0 % of the gross value of these industries in 2025.

	•		Qualitative in	••	Quantitative impact by IPv6				
	Infrastr	ucture of digital	economy	Improved security	Increased efficiency				
Industry	5G	101	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales		
Information & communication					•	1,616		origi ali ali ali ali ali ali ali ali ali al	
Manufacturing	•	٠	•			8,308		o 9.4%	
Public service & utilities	•			•	•	4,659	ø	8.2%	
Prof. services & finance			•			2,039	x	6.3%	
Health & social work			•	•		1,695	\$	6.1%	
Hospitality & entertainment			٠	•	•	2,625	ø	5.7%	
Education			٠		•	1,502	\$	5.6%	
Transport. & storage	•		•		•	7,321	\$	5.1%	
Wholesale & retail			•		•	4,339	ø	4.7%	
Energy					•	5,857	ø	3.7%	
Construction & real estate					•	4,239		2.9%	
Ag., forestry & fishing	•					2,742	0	2.8%	
Total						46,942		5.0%	
Low impact									

Source: Desktop research, expert interview: Roland Berg

Figure 74. IPv6 industry value creation in Egypt

IPv6 development status

Egypt ranks 70 out of 92 countries with a score of 0.30, grouped as an adopter. This means the level of IPv6 development in Egypt is in medium level in the world



Figure 75. IPv6 development status in Egypt

Recommendations

			Navigator			Supervisor			
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supervision & inspection
Public sector	 Issue releva soon as pos accelerate th of mobile ne infrastructur 	nt policies as sible to ne construction etwork re	Set up IPv6- related orgs, and keep the organization active to				Accelerate networking process of the public sector:		
Key device & service providers	indicators	-side IPv6 key	promote implementat ion of policies		 Support IPv6 transition Support investment 		digitalization level of government terminals, and require	digitalization level of government terminals, and require	
Users & enterprises					in IPE innovative technology commercial pilot projects		new websites and online services to support IPv6		

Figure 76. Policy recommendations for Egypt

3.3.3 Starters

3.3.3.1 Indonesia

Due to the low level of digitalization among terminals and therefore lack of demand, Indonesia faces weak incentives from leading ISPs and content providers to migrate to IPv6. However, it is among the world's leading countries in the deployment of cutting-edge IPv6 technologies.

IPv6 industry sector impact

We estimate that the potential value of IPv6 deployment across multiple industries in Indonesia could total US\$78 billion by 2025, which is equivalent to 3.0% of the total real output value of these industries in 2025.

	•		Qualitative in	npact by IPv6	••	Quantitative impact by IPv6			
	Infrastructure of digital economy			Improved security	Increased efficiency				
Industry	5G	loT	Cloud	Improved security	Increased efficiency	Value [mn \$]	% of industry sales		
Health & social work			•			1,333		4.8%	
Public service & utilities	•		•		•	7,191		4.8%	
Manufacturing	•	•	٠		•	18,983		4.6%	
Information & communication	•		•		•	5,652		4.5%	
Transport. & storage	٠		٠		•	5,773	Ø	3.5%	
Education			٠		•	2,339		3.3%	
Prof. services & finance			٠		•	6,378		3.3%	
Hospitality & entertainment			•	•	•	3,402	\$	3.2%	
Wholesale & retail			•		•	9,019	ø	2.8%	
Energy					•	3,611	ø	2.4%	
Construction & real estate					•	9,190	ø	1.7%	
Ag., forestry & fishing	•					4,923		1.7%	
Total						77,794		3.0%	
Low impact in the second secon									

Source: Desktop research, expert interview; Roland Berger

IPv6 development status

Indonesia ranks 74 in 92 countries, with a score of 0.29, and is grouped as an adopter. This means that IPv6 deployment status in Indonesia is in medium level.

	Overall	IPv6 penetration				Performance	Innovation	
	score	Planning	Network	Content	Users	Performance	Overall rating based on standards, policy, academics and applications	
Front- runners	0.50	0.38	0.40	0.38	0.90	0.47	0.44	
Adopters	0.36	0.39	0.38	0.38	0.27	0.38	0.36	
Starters	0.26	0.33	0.31	0.35 0	0.04	0.25	0.31	
Indonesia Ranking	0.29 74	0.33 63	0.31	0.30 88	0.21 51	0.21 75	0.39	

Figure 78. IPv6 development status in Indonesia

Recommendations

			Navigator				Implementer		Supervisor	
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supervision & inspection	
Public sector		Introduce mandatory measures based on the existing IPv6	Continue the cooperation with the Indonesian IPv6 Task		Upgrade network infrastructur e to ensure the quality of		Increased deployment of IPv6 in the public sector			
Key device & service providers	Formulate mandatory transformat ion requiremen	deployment roadmap	Force and co-lead in organizing events		connection					
Users & enterprises	ts for leading ISPs and content service providers				Introduce inc incl. subsidies incentives to overall level digitalization	entive policies, s and tax i mprove of				

Source: Roland Berger

Figure 77. IPv6 industry value creation in Indonesia

4. Policy Recommendation

4.1 Challenges faced in IPv6 Enhanced Innovation development



Figure 80. The three roles and nine initiatives of government

4.2 General recommendations by group

In general, for countries in different development stage, the government have varied emphasis:

	•	The three roles of government	•
	Navigator: Plan and motivate	Implementer: Support the implementation	Supervisor: Regulate and supervise
Front- runners	 Enhance international influence on development of IPv6 and IPv6 Enhanced Innovation standards Introduce more specific plans for more extensive industry applications Break through technical bottlenecks and jointly promote intl. standardization of innovative tech 	 Focus on further increasing end-user demands on digitalization to unleash the industry application potential of IPv6 Provide sufficient and strong supports for the long- term leadership in the development of IPv6 and IPv6 Enhanced Innovation 	 Aimed to improvement overall quality of implementation, take targeted actions on key groups on top of comprehensive supervision and improvement mechanism
Adopters	 Increase the strategic importance of IPv6 at the national level Provide thorough planning of operational details and roles & responsibilities to ensure implementation Introduce IPv6 transition deployment details to support high-quality growth of the industry 	 Provide supports on core technology and implementation and cultivate key capabilities Focus on guiding and encouraging the commercial pilot and application of innovative IPE technology, and expanding and deepening the industry and application scenarios of innovative IPE technology 	All-round supervision and support for improvement
Starters	Clearly define IPv6 goals and strategies Form a strong force for implementation	 Targeted publicity and education for service providers Conduct initial deployment to enhance the network infrastructure 	Mandatory inspections to ensure implementation

Figure 81. Policy focus for different segments

4.3 Detailed recommendations by group

4.3.1 Front-runners





Figure 82. Policy recommendations for front-runners

Figure 83. Policy recommendations for adopters

4.3.3 Starters

			Navigator				Implementer		Supervisor
Relevant stakeholders	Goal setting	Roadmap design	Organization formation	Standards development	Incentive policy	Awareness improvement	Deployment by government	Talent cultivation	Supervision & inspection
Public sector	1 Design high-	2 Design initial plan and	3 Form organizations	4 Establish domestic industry standards			7 Introduce deployment plans for public sector		Conduct mandatory inspections
Key device & service providers	strategy	timelines for IPv6 deployment	and responsibilities		5 Provide funding to operators and service providers for deployment	Raise the awareness of operators	Improve network infrastructure	Leverage international support to develop capabilities	
Users & enterprises									

Source: Roland Berger

Figure 84. Policy recommendations for starters

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