

DATA CENTRE MARKET STUDY MEXICO JULY 2022

Prepared by Arni Consulting Group

1. Mexico: general overview.....	4
2. Position of the Mexican economy in the region.....	9
3. State of the data centre market in Mexico	10
 3.1 Market size of data centres in Mexico	10
3.1.1 Data Centre Locations	11
3.1.2 Top players in data centres	13
3.1.3 Mexico Advantages for Data Centre investment.....	14
3.1.4 Foreign and domestic investment in technological infrastructure for Data Centres and Telecommunications.	14
4. Trends in the data centre market in Mexico.....	17
 4.1 Infrastructure development	19
4.1.1 Computing vs 5G Deployment.....	20
4.1.2 Acceleration and migration to Cloud infrastructure.....	21
4.1.3 Increased automation	23
4.1.4 Remote Monitoring	26
4.1.5 Latency and bandwidth limitations with Edge Computing	27
4.1.6 IT hybrid: Own data centres/ external + public cloud /or private	29
 4.2 Energy Efficiency.....	31
 4.3 Modular Data Centre.....	35
 4.4 Climate Change	36
 4.5 Cooling Solutions	37
 4.6 COVID 19 Impact	39
 4.7 Artificial Intelligence	40
5 Regulatory framework for data centre	43
 5.1 Federal Telecommunications Institute (FTI)	44
 5.2 ICREA Certification.....	46
6 Competition with other Latin American countries	50
 6.1 Communication Infrastructure.....	52
 6.2 . Innovation Policy in Mexico	53
 6.3 Cybersecurity	54
7 Factors influencing the development of data centres in Mexico.....	57
 7.1 Increase in Internet users in the country	59
 7.2 Energy Efficiency.....	60
 7.3 Qualified staff	62

7.4 Connectivity.....	64
8 Technology and its influence on the Development of Mexico Data Centres.....	65
8.1 Video transmission	67
8.2 Digitalization of companies.....	70
8.2 Virtual reality.....	72
8.3 Big Data Analysis.....	73
8.4 Artificial Intelligence in data centres.....	75
8.5 Implementation of automation	77
9 New data centre projects in Mexico.....	79
9.1 Key players	81
9.1.1 Data centres	81
9.1.2 Cloud Services	84
9.1.3 Data Centre Providers	87
9.1.4 Government and regulatory bodies	89
10 Challenges and Opportunities for the Establishment of Data Centres.....	91
10.1 Challenges	91
10.1.1 Key challenges for data centres in Mexico	91
10.1.2 Security challenges facing data centres.....	92
10.1.3 IoT: the big challenge for data centres.....	92
10.1.4 Key points of the new approach to be considered by data centre managers in the new normal.....	93
10.2 Opportunities	93
10.2.1 Opportunities for Data Centers.....	93
10.2.2 New technologies are being deployed globally.....	95
10.3 Difficulties	99
11 Conclusions and comments.....	101
Figures Index.....	103
Tables Index	103
Graphic Index.....	103

1. Mexico: general overview

According to the last national census, the population in Mexico in 2020 was slightly over 126 million people, which places Mexico as the 11th most populous country in the world.¹ Currently, annual population growth is 1%. The fertility rate has steadily decreased since 1990 when it reached 3.4 and 2.1 women/children respectively in 2020².

Mexico has a young population. The median age in 2020 was 29 years, but the population is gradually ageing. In 2000, the median age was 22. The population of Mexico is projected to stop growing in 2050; 65 year age group is expected to represent 16.8% of the population. This age group currently represents 8.5% of the population of Mexico.^{3,4}

Table 1 Demographic Indicators

Indicator	Data in 2020 or most currently available
Total Population	126,014,024 people
Fertility rate	2.1 women/children
Life expectancy	75.1 years
Median age of population	29 years
Population from 0 –14 years of age (% of total)	25.2%
Population 65 years and greater (% of total)	8.5%
Infant mortality rate (Infant mortality rate under 1/1000 live births)	12.6

Sources: CONAPO, 2019; Hernández-Bringas & Narro-Robles, 2019; INEGI, 2020

Mexico is among the 15 largest economies globally and is the second-largest economy in Latin America. The country is highly dependent on the United States, its largest trading partner and the destination of almost 80% of its exports.

¹ National Institute of Statistics Geogprahy and Information (INEGI) <https://www.inegi.org.mx/>

² World Bank, FY2020–FY2025 Country partnership framework for the United Mexican States; January 19 2020 Accessed February 12, 2022 Referenced from <https://documents1.worldbank.org/curated/en/927991583031630169/pdf/Mexico-Country-Partnership-Framework.pdf>

³ Consejo Nacional de Población (CONAPO, Proyecciones de la población de México y de las entidades federativas.) 2016-2050, 2019 Accessed February 12, 2022, Referenced from http://www.conapo.gob.mx/work/models/CONAPO/Cuadernillos/33_Republica_Mexicana/33_RMEX.pdf

⁴ National Institute of Statistics Geogprahy and Information (INEGI) <https://www.inegi.org.mx/>

According to the International Monetary Fund (IMF), GDP was estimated to have grown by 6.2% in 2021, mainly due to a significant increase in remittances and a gradual improvement in the labour market that positively impacted household consumption. The country is expected to grow in the coming years, albeit at a lower pace.

At the beginning of 2022 the IMF forecasting growth of 4% and 2.2% in 2023. With vaccination rates rising and the labour market improving, household consumption is expected to be a key growth driver. Inflation has been above target since 2017 and continued to grow in 2021 to 5.4%, the highest rate since 2018. Domestic factors, such as the recovery in demand for various services and upward pressures from food and energy prices, fueled inflation in 2021.⁵

The composition of the Mexican GDP is divided into three sections: agriculture is the primary sector and accounts for 3.5% of the GDP, followed by the industry as the secondary sector 33.8% of the GDP, and services as the third sector, accounting for 62.7% of the GDP.⁶

The country's debt-to-GDP ratio declined to 59.8% in 2021 and is expected to remain stable in the coming years, at 60.1% in 2022 and 60.5% in 2023. The labour market is gradually recovering after the initial impact of the pandemic. Mexico's unemployment rate declined slightly to 4.1% in 2021 and expects to reach 3.7% in 2022 and remain stable in 2023. However, the informal sector still accounts for 60% of employment.

⁵ Santander, Trade markets, Mexico Economic and Political Outline, Accessed February 17, 2022 Referenced from Accessed February 17, 2022 Referenced from <https://santandertrade.com/en/portal/analyse-markets/mexico/economic-political-outline>

⁶ Tetakawi, Mexico GDP by sector, September 21, 2021, Accessed April 17, 2022, Referenced from <https://insights.tetakawi.com/mexico-gdp-by-sector>

Table 2 Growth indicators in Mexico's economy

Growth Indicators	2019	2020	2021 (e)	2022 (e)	2023 (e)
GDP (Billions USD)	1.269,43	1.073,92 e	1.285,52	1.371,64	1.446,78
GDP (Anual growth %, constant prices)	-0,2	-8,3e	5,3	2,8	2,7
GDP per cápita (USD)	10.029	8.404e	9.967	10.541	11.025
Public Finance Balance (% of GDP)	-2,1	-2,8e	-3,3	-3,2	-3,0
Public Debt (% of GDP)	53,3	61,0e	59,8	60,1	60,5
Inflation Rate (%)	3,6	3,4e	5,4	3,8	3,0
Unemployment	3,5	4,4e	4,1	3,7	3,7
Current Transfer Balance (Billions USD)	-3,95	26,12e	0,45	-3,51	-6,42
Current Transfer Balance (% of GDP)	-0,3	2,4e	0,0	-0,3	-0,4

Source: IMF- World Economic Outlook Database, October 2021

Fitch ratings expect government expenditures to increase by 1.2% of GDP compared to the 2022 budget due to increased social spending (including pensions) and infrastructure projects such as the Maya Train⁷ and Interoceanic Corredor of the Tehuantepec Isthmus⁸ (0.9% of GDP). Fitch GDP growth forecast for 2022 is 2.0%.
⁹

Based on Mexico Central Bank's last survey, Mexico will grow in 2022 by only 1.7 %, and the final inflation rate at the end of the year will be around 6.75 %. The specialists mentioned that an important factor affecting Mexico's investment is the lack of the rule of law. The current administration has created instability and a lack of support for private investment.¹⁰

⁷ Maya train Project <https://www.trenmaya.gob.mx/>

⁸ Interoceanic Corredor of the Tehuantepec Isthmus project <https://www.gob.mx/ciit>

⁹ Fith Ratings, Optimistic Projections May Tilt Mexico Budget Risks to Downside, April 7, 2022 Accessed April 17, 2022 Referenced from <https://www.fitchratings.com/research/sovereigns/optimistic-projections-may-tilt-mexico-budget-risks-to-downside-07-04-2022>

¹⁰ Castañares, Guillermo, Economía mexicana crecerán solo 1.72% este 2022: Encuesta de Banxico México, El Financiero, May 03, 2022, Accessed February 17, 2022 Referenced from <https://www.elfinanciero.com.mx/economia/2022/05/02/economia-mexicana-crecera-solo-172-este-2022-encuesta-de-banxico/>

According to the World Bank, the industry employed 25.5% of the workforce and accounted for 29.6% of GDP. In 2021, manufacturing employment rebounded above its pre-pandemic levels as the sector benefited greatly from increased U.S. activity.¹¹

The study includes information from different sources that help understand the current situation of Data Centres in Mexico, which has an essential role in the market, their growth, requirements, conditions, location and significant investment.

The pandemic began in 2019 and has increased the demand for data. The data centres allowed 84.1 million people to connect to the Internet and perform work, education, and entertainment tasks.¹²

Therefore, the data centre management must guarantee a daily and around-the-clock operation. Data generation is given in a representative volume. The support of the data centre is critical; these facilities are in an environment that allows controlling computer systems, processing, storage, and backup power banks¹³. In 2020, data centres in Mexico occupied an area of 250,000 M² and are expected to triple by 2022. By 2023, the global market for data centres will be worth more than 174 Billion dollars.¹⁴

Mexico has played a prominent role in Latin America in establishing a data centre using its unique construction standard. Such standard is endorsed by the International Computer Room Experts Association (ICREA). The association aims for the correct and continuous operation of the data centres that provide service to market segments such as financial institutions, telecommunications etc. Companies such as ABB, IBM, and Schneider Electric have positioned themselves in Mexico as leaders in integrated solutions for data centre physical infrastructure.¹⁵

¹¹ Santander, Trade markets, Mexico Economic and Political Outline, Accessed February 17, 2022 Referenced from Accessed February 17, 2022 Referenced from <https://santandertrade.com/en/portal/analyse-markets/mexico/economic-political-outline>

¹² Forbes México, La población mexicana usuaria de internet aumentó 72% en 2020, Tech Future, June 22, 2020, Accessed February 14, 2022 Referenced from <https://www.forbes.com.mx/la-poblacion-mexicana-usuaria-de-internet-aumento-72-en-2020/>

¹³ Instituto Federal de Telecomunicaciones (IFT), Estudio de Cloud Computing en México, July 2020, Accessed February 14, 2022 Referenced from <http://www.ift.org.mx/sites/default/files/dgci.estudio-cloud.computing.pdf>

¹⁴ Medina Alejandro, Un viaje al centro de un data centre: el epicentro de la vida digital, Actualidad, Forbes México, October 30, 2019, Accessed February 14, 2022 Referenced from <https://www.forbes.com.mx/un-viaje-al-centro-de-un-data-centre-epicentro-vida-digital/>

¹⁵ El Heraldo, México, mercado emergente en la industria de la data centre, Tecnología, July 07, 2021, Accessed February 17, 2022 Referenced from <https://heraldodemexico.com.mx/tecnologia/2021/1/7/mexico-mercado-emergente-en-la-industria-del-data-centre-242623.html>

It is essential to mention that there are a series of factors that have favoured progress and digital transformation in Mexico, which gives an advantage over their competitors, some of the key factors were.

- Fair taxes for technology areas
- Public policies in favour of innovation.
- The direct relation of proximity and schedules with the United States.
- Cheaper labour force.¹⁶

Another essential element that promoted the growth of data centres in Mexico during the past administration was the government support for developing energy efficiency (green technologies) and clean energy (hydroelectric, cogeneration, etc.).

¹⁶, Carrillo Gabriel, Tendencias 2019-2020 del mercado de Centros de Datos en México: ¿Nuevo Hub latinoamericano?, Reportajes, DCD September 19, 2019, Accessed February 17, 2022 Referenced from <https://www.datacentredynamics.com/es/features/tendencias-2019-2020-del-mercado-de-centros-de-datos-en-m%C3%A9xico-nuevo-hub-latinoamericano/>

2. Position of the Mexican economy in the region

Mexico's economic situation has always been linked to the United States economy. If the U.S. economy is good, so is Mexico's, but to a lesser extent. Mexico's main problem, which seriously affects the economy, is drug trafficking, corruption, organized crime, and the poverty of a large population sector.¹⁷

According to the 2020 Population and Housing Census, 126,014,024 people live in Mexico. Compared to other countries, Mexico ranks 11th among the most populated nations in the world.¹⁸

Mexico ranked 37th out of 43 countries evaluated in the International Competitiveness Index (IMCO, 2021), which meant dropping two positions from last year. With this result, the country went from a medium-low evaluation to a low one in the Mexican Institute for Competitiveness (IMCO).¹⁹

In 2022, the region's two leading economies, Brazil and Mexico, will experience growth of 1.4% and 3.3%, respectively. Mexico is the second largest economy in Latam.²⁰

However, both economies face significant increases in inflation during 2021. In the case of Mexico, prices grew by 5.6% in 2021, while in Brazil, they rebounded to 7.8%.²¹

¹⁷ Carrillo Gabriel, Tendencias 2019-2020 del mercado de Centros de Datos en México: ¿Nuevo Hub latinoamericano?, Reportajes, DCD, September 19, 2019, Accessed February 17, 2022 Referenced from <https://www.datacentredynamics.com/es/features/tendencias-2019-2020-del-mercado-de-centros-de-datos-en-m%C3%A9xico-nuevo-hub-latinoamericano/>

¹⁸ National Institute of Statistics Geogprahy and Information (INEGI) <https://www.inegi.org.mx/>

¹⁹ Mexico News Daily, Mexico drops to 37th place on the competitiveness ranking of 43 countries. Accessed February 17, 2022, Referenced from <https://mexiconewsdaily.com/news/mexico-drops-to-37th-place-on-competitiveness-ranking-of-43-countries/>

²⁰ Bajpai Prableen, An overview of the Trillion-Dollar economies in the world, Nasdaa ; April 29, 2022 Accessed May 8, 2022 Referenced from <https://www.nasdaq.com/articles/an-overview-of-the-trillion-dollar-economies-in-the-world>

²¹ Servicios Diario Digital, Las economías latinoamericanas que más crecerán en el 2022, December 2021 Accessed February 17, 2022 Referenced from <https://www.diariodigital.com.do/2021/12/01/las-economias-latinoamericanas-que-mas-creceran-en-el-2022.html>

3. State of the data centre market in Mexico

According to the data presented at the Conference “Trends in Data Centre”, Mexico contributes 25 per cent of Latin America's investment in data centres, making it the second-largest market in the region. The digitalization of companies has allowed the Data Centre industry to continue growing; digital transformation is implemented in 100 per cent of large Mexican companies, more than 50 per cent of medium-sized companies, and 40 per cent of small companies.²²

Data centres will see medium-term growth in the Edge (micro data centre closer to users) and Mega segments of 30 and 10 per cent; respectively, medium-sized centres will register a considerable decrease.²³

The past health crisis has confirmed that the way we use technology will change permanently and that the digital transformation of the economy will happen at an accelerated pace, giving way to a hyperconnected society.

3.1 Market size of data centres in Mexico

Data centres in Mexico are beginning to generate a relevant aspect for the technological and economic structure of the country; the proximity to the U.S. market and the advanced infrastructure that these data centres offer. Other features like electricity supply, data protection law, growing gaming, and OTT (Over the Top) markets make these data centres more relevant.

The implementation of the 5G infrastructure (5g Telcel), owned by America Movil, with an investment of 1.8 million dollars; It will allow 28 million users in 18 cities to use the 5G Infrastructure. This new technology will enable users and companies to be more competitive using IoT, AI, eCommerce, and distance learning. All these require data centres to manage the increase in data demand.²⁴

²² DCD, México aporta 25% de la inversión de AL en Data Centres, October 4, 2018, Accessed February 14, 2022
Referenced from <https://www.datacentredynamics.com/es/noticias/m%C3%A9xico-aporta-25-de-la-inversi%C3%B3n-de-al-en-data-centres/>

²³ IDEM

²⁴ Rodriguez Darinka, La red 5G en 18 ciudades de México: ¿quiénes pueden conectarse?, El País February 2022
Accessed Mach 1, 2022 Referenced from <https://elpais.com/mexico/2022-02-24/la-red-5g-en-18-ciudades-de-mexico-quienes-pueden-conectarse.html>

In 2019, data centres in Mexico covered 250,000 square meters²⁵, and only in 2021, the surface used for data centres in the country reach 750,000 square meters, which makes Mexico the second largest data centre market in Latin America, only behind Brazil. CBRE Inmobiliaria points out that currently, the telecommunications, financial and government industries have the highest demand for this type of service; however, with the advance in technology and the Internet of Things (IoT), any industry may require data centres.²⁶

Data from the research group Aritzon indicates that the Mexican market will reach \$905MM in investments by 2026 and register a compound annual growth rate of 8.33% between 2021 and 2026.²⁷ Oracle, Microsoft, and Amazon Web Services are some of the technology giants considering bringing their cloud infrastructure to Mexico, the latter planning to open a data centre in Querétaro.

3.1.1 Data Centre Locations

Among the most representative locations for investors, Querétaro is one of the leading and fastest-growing state in the data centre market in Mexico (internationally along with Seoul, Mumbai, Jakarta, and Portland); this is due to its industrial park, local infrastructure, and investment promotion program. By the end of 2020, six large data centres were under construction in the municipalities of El Marqués, Colón, Pedro Escobedo, and San Juan del Río, with a total supply of 48 megawatts (MW), with investments of \$50MM and representing 1,152 jobs. U.S. company Cloud HQ will also invest a sum of \$600MM. Other states considered for data centre investment are Aguascalientes, Guadalajara, and Monterrey.²⁸

²⁵ EL CEO, México, el segundo mercado más importante de data centres en Latinoamérica, Bienes raíces, February 19, 2019, Accessed February 16, 2022 Referenced from <https://elceo.com/bienes-raices/mexico-el-segundo-mercado-mas-importante-de-data-centres-en-latinoamerica/>

²⁶ El Heraldo, México, mercado emergente en la industria del data centre, Tecnología, July 07, 2021, Accessed February 17, 2022 Referenced from <https://heraldodemexico.com.mx/tecnologia/2021/1/7/mexico-mercado-emergente-en-la-industria-del-data-centre-242623.html>

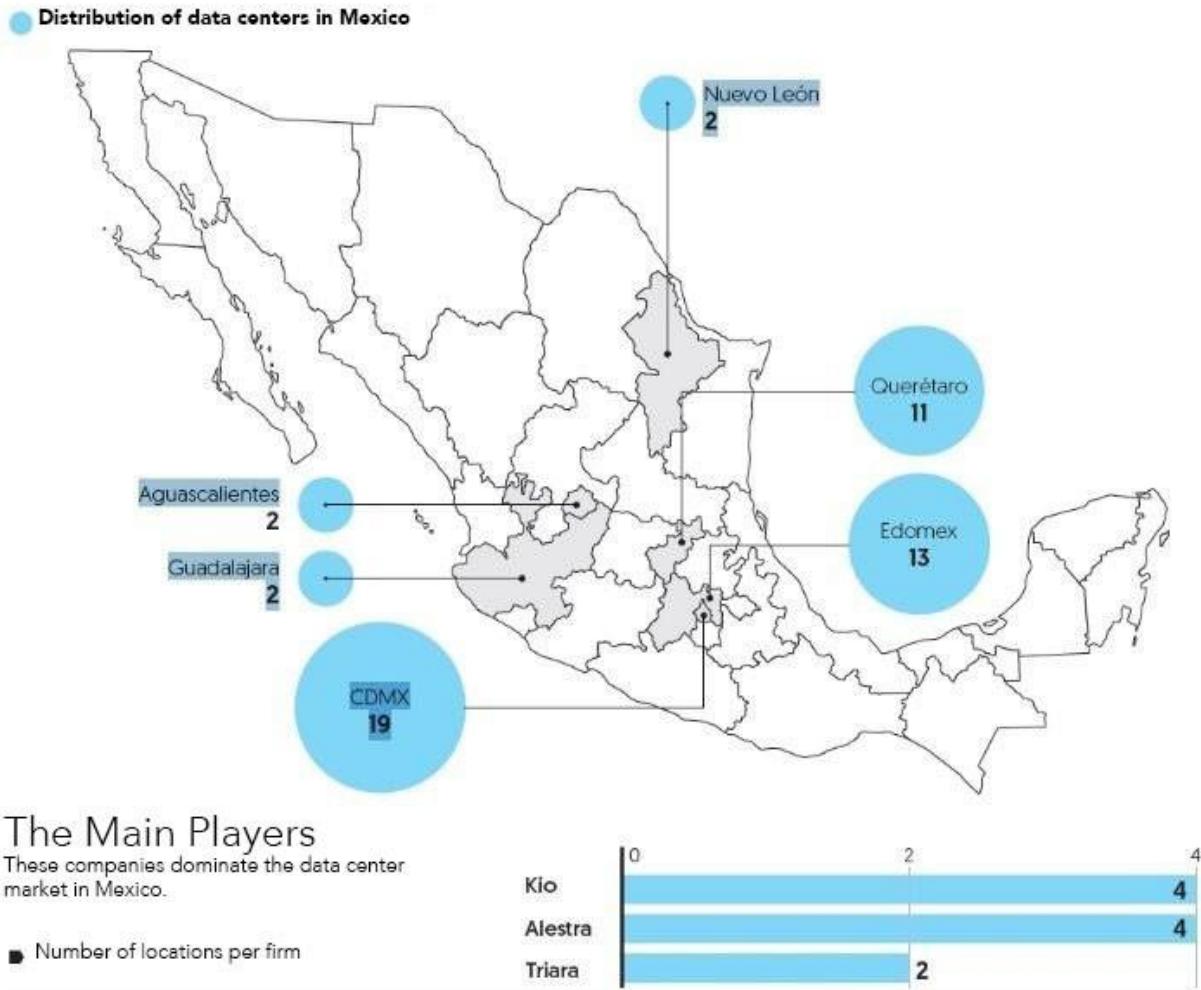
²⁷ Bnamicas, Qué esperar del mercado mexicano, Reportaje, December 21, 2021, Accessed February 15, 2022 Referenced from <https://www.bnamicas.com/es/reportajes/que-esperar-del-mercado-mexicano-de-centros-de-datos-en-2022>

²⁸ Alfaro Yanin, Querétaro, el paraíso de los centros de datos, Negocios, Milenio April 03, 2021, Accessed February 16, 2022 Referenced from <https://www.milenio.com/negocios/queretaro-el-paraiso-de-los-centros-de-datos-en-mexico>

Figure 1 Location of the main data centres in Mexico.

Where they are located?

These data centers are mainly in Mexico City and the State of Mexico, followed by Querétaro.



Source: El Economista Newspaper <https://www.economista.com.mx/>

Companies with data centres in Querétaro are "KIO Networks²⁹ Equinix³⁰, Huawei³¹, Odata³², Digital Reality³³, Triara³⁴, Cloud HQ³⁵, and Ascenty³⁶. Ascenty is a Brazilian company controlled by Digital Realty and Brookfield Infrastructure Partners, which

²⁹ <https://www.kionetworks.com/en/about-us>.

³⁰ Mexico City Data Centres & Internet Exchange Point | Interconnection Services by Equinix

³¹ <https://e.huawei.com/mx/videolist/video/7181a93da151466884dc8ab7ee3ffd6b>

³² DC QR01 - ODATA - Colocation (odatacolocation.com)

³³ <https://www.digitalreality.com/data-centres/queretaro>

³⁴ <https://telmex.com/web/acerca-de-telmex/triara.com>

³⁵ <https://www.somosindustria.com/articulo/anuncia-cloudhq-instalacion-en-queretaro/>

³⁶ Ascenty [Data Centre México 1 - Ascenty](https://www.ascenty.com/data-centre-mexico-1-ascenty)

plans to activate two massive data centres in the country by 2022. Ascenty is also the most significant data centre provider in Latin America; it plans to invest \$257MM in data centre projects in Latam by 2022. Meanwhile, Odata, controlled by Brazilian private equity fund Pátria Investimentos and U.S. real estate investment trust Cyrus One, is building data centre clusters in Mexico and Chile. Odata's Querétaro site will have 30 megawatts (MW) capacity, serving a hyper-scale cloud customer.³⁷

The commercial director of the International Computer Room Experts Association (ICREA), based in Mexico, told El Economista newspaper that Querétaro is the city in Latin America with the most data centre infrastructure megaprojects taking place.³⁸

3.1.2 Top players in data centres

Mexico ranks second in Latin America, behind Brazil, in data centre investment. Mexico's opportunities and competitive advantages lie in its privileged geographic location, extensive territory for the construction of data centres, renewable energy collectors, and intellectual capital for the building and operation of data centres.

U.S. provider Equinix announced 2021 an investment of \$200MM capital expenditure to expand its centre in Latam and to open new centres in Sao Paulo, Bogota and Queretaro.³⁹ This group entered the Mexican market due to a \$175MM acquisition of data centres belonging to Axtel, a transaction in January 2020. The group already has two International Business Exchange (IBX) data centres in Mexico, located in Querétaro. It is estimated that the company will invest \$190MM between Brazil and Mexico. Some fundamental aspects that this group found in the Mexican market are the opportunities for land acquisition and large land areas.⁴⁰

³⁷ Bnamericas, Qué esperar del mercado mexicano, Reportaje, December 21, 2021, Accessed February 15, 2022 Referenced from <https://www.bnamicas.com/es/reportajes/que-esperar-del-mercado-mexicano-de-centros-de-datos-en-2022>

³⁸ Carrilo Gabriel, Tendencias 2019-2020 del mercado de Centros de Datos en México: ¿Nuevo Hub latinoamericano?, Reportajes, DCD, September 19, 2019, Accessed February 17, 2022 Referenced from <https://www.datacentredynamics.com/es/features/tendencias-2019-2020-del-mercado-de-centros-de-datos-en-m%C3%A9xico-nuevo-hub-latinoamericano/>

³⁹ Payan Diana, ¿Qué le depara a Equinix en 2022, Infochannel December 8, 2021 Accessed February 15, 2022 Referenced from <https://infochannel.info/equinix-alista-su-expansion-para-2022/>

⁴⁰ Bnamericas, Qué esperar del mercado mexicano, Reportaje, December 21, 2021, Accessed February 15, 2022 Referenced from <https://www.bnamicas.com/es/reportajes/que-esperar-del-mercado-mexicano-de-centros-de-datos-en-2022>

3.1.3 Mexico Advantages for Data Centre investment

A series of factors enabled Mexico in the race to become a Hub for data centres in Latin America. Factors such as the state of infrastructure and the region's energy situation were promoted by the country's 2015 energy reform since more economical and efficient clean energy sources were sought. This has allowed the development of self-supply infrastructure, which makes attractive the construction of a Hub, that has significant energy consumption.

In terms of infrastructure investment, developing highways and optimising maritime ports in Mexico allow the transportation of technologies to be more accessible and economical than in other Latin American countries.

In addition, the Mexican government supported in the past administration the development of technologies that allow energy efficiency, development of green technologies, and clean energy through specific tax incentives, which promoted foreign investment in manufacturing areas, mainly generating new needs for the technological infrastructure of Data Centres and Telecommunications.

Another critical factor is that Mexico has geographical areas where infrastructure development is favoured by economic, social, and climatological situations that offer a great advantage for its development. However, the high energy costs in Mexico force Data Centre designers to look for solutions through which they can provide energy savings and thus, reduce operating costs.

Mexico has a good infrastructure of data centres in its territory, good professionals with extensive training in technological aspects, its privileged geographical position with the United States, good connectivity, relations with strategic countries in central and northern Latin America and the United States. However, it needs to bring together public-private support and collaboration and bet on renewable energy at a reasonable price.

3.1.4 Foreign and domestic investment in technological infrastructure for Data Centres and Telecommunications.

Brazilian companies such as ODATA and Ascenty are the first to invest heavily in data centres in Mexico. In 2019, Lumen Technologies, known as one of the largest carriers in the world, began a process of expansion in Mexico and concluded in early 2020. This expansion consisted of metropolitan fiber-optic networks in Mexico City,

Guadalajara, and Monterrey, two additional nodes in Querétaro, and a new connection between Monterrey and Texas. A second phase consisted of expanding six more cities in the country. In general, content nodes and distribution networks are aimed at users of large data centres in which companies such as Amazon, Netflix, and Google participate.⁴¹

In January 2020, Microsoft announced a US\$1 billion investment for a data centre to be located in Querétaro. In the same month, Equinix completed the purchase of three data centres that belonged to Axtel. In June of the same year, Ascenty announced an investment of \$350MM to create a data centre in Querétaro. ODATA joined with an investment of \$100MM for another data centre. Companies such as Ativy and content networks of companies (E.g., Gold Data) also participate in these projects.⁴²

In 2021, Querétaro was contemplating five mega-projects for data centres, which will materialize in 2023, totalling an investment of \$300MM. Despite attracting significant assets, there is the challenge of guaranteeing energy supply, for which the state government is already in talks with the Federal Electricity Commission (CFE).⁴³

In 2021, three major projects with a foreign investment of US\$1.5 billion were underway in Querétaro, one of them belonging to ODATA, whose project, QR01, became Mexico's first and most significant data centre. This facility required an investment of approximately \$100MM and a built space of 30,400 square meters.

In 2021, Brazil-based Ascenty began operations in Mexico with its first two data centres. This operation represented an investment of \$300MM, which was part of a \$750MM three-year investment plan that also contributed to having data centres in three Latin American countries.

In 2020, Microsoft announced a \$1.1 billion investment plan, including programs and collaborations with universities, public entities, and organizations to establish data

⁴¹ Riquelme Rodrigo, La Era de los hiperescaladores en México apenas comienza, Tecnología, J El Economista, January 03, 2021, Accessed February 17, 2022 Referenced from <https://www.eleconomista.com.mx/tecnologia/La-era-de-los-hiperescaladores-en-Mexico-apenas-comienza-20210103-0002.html>

⁴² IDEM

⁴³ Riquelme, Rodrigo. Querétaro, con cinco megaproyectos de centros de datos para los próximos dos años, Estados, El Economista, January 03, 2021, Accessed February 17, 2022 Referenced from <https://www.eleconomista.com.mx/tecnologia/La-era-de-los-hiperescaladores-en-Mexico-apenas-comienza-20210103-0002.html>

centres in Mexico. The "Innovar" program in Querétaro is the most recent and joins those already in place in Chihuahua, Veracruz, and Chiapas. In addition, in June 2020, it announced a partnership with SAS⁴⁴, a U.S. data management firm, a leader in Analytics with a presence in 145 countries. Finally, Microsoft announced in 2020 plans to invest in countries such as Chile.

In 2020, a study published by IDC Latin America pointed out that, in 2022, 405 of Latin America's GDP will consist of digital business with a spending of 460 million dollars, and 35% will be invested in cloud computing solutions.⁴⁵

Another study by Arizton indicates that by 2027 the data centre market in Latin America will reach an investment of USD 9.11 billion by 2027, growing at a CAGR of 7.13% during 2022-2027. Arizton also mentioned that Mexico is among the strong emerging data centre market in Latin America with the entry of cloud services providers. The investment is expected to increase gradually, with a cumulative investment of over USD 2 billion between 2022 and 2027.⁴⁶

According to Data Centre Map, more than 150 data centres are in operation, from Mexico to the southern region of South America. Latin America is also home to hyper-scale data centres that host the most prominent providers on the planet. It is in this area of the world where Brazil started with this movement, advancing in 2020 to Chile, Colombia, Argentina, and Mexico. Service providers are certified as Tier IV or Tier III.⁴⁷

⁴⁴ https://www.sas.com/en_us/company-information/profile.html

⁴⁵ IDC Latin America, Worldwide IT industry 2022 Predictions and Latin America Implications: Building Resiliency to Thrive in the Next Normal, October, 2020, Accessed February 17, 2022, Referenced from: http://www.idclatin.com/2020/webinars/9_nov_fe/FutureScape2021_LatAm.pdf

⁴⁶ Arizton, Latin America data centre market overview Accessed February 17, 2022, Referenced from <https://www.arizton.com/market-reports/latin-america-data-centre-market-report-2025>

⁴⁷ Quirino, Anderson. 150 centros de datos de coubicaciones activan la economía digital de Latinoamérica en 2021, Infosol, Accessed February 17, 2022, Referenced from <https://www.infosol.com.mx/medios/vertiv/articulos/210430/150-centros-de-datos-de-coubicaciones-activan-la-economia-digital-de-latinoamerica-en-2021/>

4. Trends in the data centre market in Mexico

Data centres and companies must decide how to efficiently manage the digital infrastructure on which their business activities depend on parameters beyond security, storage, transmission, and other essential elements. For this reason, the information that data centres manage plays a vital role for the final user or customer.

Mexico has positioned itself as the following data centre hub in Latin America. The installation of new technological infrastructure is part of that trend. Schneider Electric inaugurated on July 2021 a new intelligent plant in Monterrey. Nutanix, at the end of June 2021, announced the expansion of its business with a new Global Support Centre in Mexico City and new members in its Monterrey team.⁴⁸

The Consulting firm Research and Markets presented a "Mexico Data Centre Market" study. The Study mentioned that there will be an investment of \$1 billion during 2021-2026 in data centres in Mexico. The Mexican states developing the data centres are Querétaro, Mexico City, Guadalajara and Monterrey.⁴⁹

Arizton Advisory & Intelligence mentioned that Mexico's data centre market size was valued at \$632 million in 2021 and is projected to reach over 1 billion by 2027.⁵⁰

2020 was a disruptive year for data centres due to the pandemic and accelerated digitization. This situation forced the rapid adoption of technologies in various sectors and industries that allowed to keep connected with work teams, children and young people taking classes from home. This context has permitted the development of new work, education, and communication models, and data centres are essential for their daily operation.

⁴⁸ Prensario TI Latin America, Noticias, Tendencias del mercado de Centros de Datos en México: ¿Nuevo Hub latinoamericano?, July 14, 2021, Accessed February 22, 2022 Referenced from: <https://prensariotila.com/26395-tendencias-del-mercado-de-centros-de-datos-en-mexico-nuevo-hub-latinoamericano/>

⁴⁹ Tecno Empresa, Centros de datos en México: inversión de más de mil millones de dólares para 2026, November 2021, <https://tecnoempresa.mx/index.php/2021/11/24/centros-de-datos-en-mexico-inversion-de-mas-de-mil-millones-de-dolares-para-2026/>

⁵⁰ Arizton Advisory and Intelligence, Mexico Data Centre Market to Attract More than \$1 Billion Investment by 2027. Over 360 MW Power Capacity to be Added in the Next 5 Years – Arizton, May 10, 2020 Globenewswire Accessed April 22, 2022 Referenced <https://www.globenewswire.com/en/news-release/2022/05/10/2440148/0/en/Mexico-Data-Centre-Market-to-Attract-More-than-1-Billion-Investment-by-2027-Over-360-MW-Power-Capacity-to-be-Added-in-the-Next-5-Years-Arizton.html>

The global trends for 2022 also applied to the Mexico market.

The companies continue searching for cloud solutions due to cost and scalability. Large enterprises are using a hybrid model combination of on-premises public or private cloud. The challenge for growth is keeping data safe and complying with privacy policies.⁵¹

Implementing the 5G infrastructure in Mexico will enable users and companies to be more competitive by using IoT, AI, eCommerce, and distance learning. All these require data centres to manage the increase in data demand.⁵² Over the next decade, this hybrid multi-cloud will play an essential role in advancing digital-first strategies and consuming IT infrastructure as a service.⁵³

AI / ML (Artificial Intelligence / Machine Learning) in the Edge will boost 5G and IoT. As 5G and IoT technologies grow, Edge data is exploding, driving the global market to reach \$43.4 billion by 2027.⁵⁴ Statista mentioned that IoT devices will reach 25,400 million by 2030.⁵⁵ Some technologies that will require AI /ML are autonomous vehicles, drones, surveillance cameras, and IoT medical devices. A 2022 Gartner study focused on emerging technologies, "the objectives of organizations investing in and adopting edge technologies are to improve employee productivity (41%) and automate business processes (39%). AI enhances business processes, delivering automation and productivity gains that translate into measurable ROI, such as cost savings".⁵⁶

New trust models will lead the cybersecurity agenda. Attacks and risks on the internet are on the rise. In 2021, spending on this topic amounted to \$ 6 trillion

⁵¹ CIO, Mexico, Siete tendencias que impulsan la transformación en los centros de datos en 2022, Published May 4, 2022 Accessed March 4, 2022 Referenced from: <https://cio.com.mx/siete-tendencias-que-impulsan-la-transformacion-en-los-centros-de-datos-en-2022/>

⁵² Rodriguez Darinka, La red 5G en 18 ciudades de México: ¿quiénes pueden conectarse?, El País February 2022 Accessed Mach 1, 2022 Referenced from <https://elpais.com/mexico/2022-02-24/la-red-5g-en-18-ciudades-de-mexico-quienes-pueden-conectarse.html>

⁵³ IBM, - español, Multinube híbrida: puede parecer complicado, pero es el enfoque correcto, IBM Systems blog para Latinoamérica February 10, 2020, Accessed March 24, 2022, Referenced from: <https://www.ibm.com/blogs/systems/mx-es/2020/02/multinube-hibrida-puede-parecer-complicado-pero-es-el-enfoque-correcto/>

⁵⁴ Hainzinger Brittany, Artificial Intelligence, Kubernetes clusters for AI ML apps, APP Developer Magazine March 29, 2022, Accessed March 29, 2022, Referenced from: <https://appdevelopermagazine.com/kubernetes-clusters-for-ai-ml-apps/>

⁵⁵ CIO, Mexico, Siete tendencias que impulsan la transformación en los centros de datos en 2022, Published May 4, 2022 Accessed March 4, 2022 Referenced from: <https://cio.com.mx/siete-tendencias-que-impulsan-la-transformacion-en-los-centros-de-datos-en-2022/>

⁵⁶ Hainzinger Brittany Artificial Intelligence, Kubernetes clusters for AI ML apps, March 29, 2022, APP Developer Magazine Accessed March 29, 2022, Referenced from: <https://appdevelopermagazine.com/kubernetes-clusters-for-ai-ml-apps/>

globally. By 2025, spending is estimated at \$10.5 trillion. Despite the risks, businesses will continue to invest in cloud services, so technology leaders must help their companies address today's threats and balance the risks. In Mexico, cybercrime generates losses between 3,000 to 5,000 million dollars annually.⁵⁷

4.1 Infrastructure development

Modern data centres have an infrastructure that has moved from traditional on-premises physical servers to virtual networks that support applications and workloads across physical infrastructure clusters and within a multi-cloud environment. In this new era, data exists and is connected across multiple data centres and public and private clouds. It is essential to mention that developing a data centre involves a high-risk investment, a data centre footprint, a controlled environment, and the respective operating expenses.⁵⁸ The modern model of centralized data centres at an Enterprise level is migrating towards a cloud model, so there is an opportunity for companies to offer cloud services. However, there is also a significant trend towards the Edge model where several companies that provide connectivity services enter the distributed data centre model, becoming another business opportunity.⁵⁹

According to the Statista website, the amount of data created, captured, copied, and consumed globally, was approximately 59 zettabytes (ZB) in 2020 and will increase to 149 ZB in 2024. Data centre facilities must have sufficient power to operate the entire system, adequate ventilation for optimal performance, and security to prevent data leakage.

The American National Standards Institute data centres, best practices standard called ANSI/TIA 942, aims to certify the availability of these buildings' components. Some points to be considered in this certification are size, response time, and redundancy levels. In addition, there are several levels called "Tiers"; this concept indicates the level of reliability. There are four defined levels of availability:

⁵⁷ American Chamber Mexico, Estrategia de Ciberseguridad en México, 2020 Accessed March 04, 2022, Referenced

[https://www.amcham.org.mx/sites/default/files/publications/VF_Estrategia%20de%20Ciberseguridad%20en%20Mexico%CC%81xico%20\(1\).pdf](https://www.amcham.org.mx/sites/default/files/publications/VF_Estrategia%20de%20Ciberseguridad%20en%20Mexico%CC%81xico%20(1).pdf)

⁵⁸ CISCO, Centro de datos y virtualización, ¿Qué es un centro de datos?, Accessed March 10, 2022, Referenced from: https://www.cisco.com/c/es_mx/solutions/data-centre-virtualization/what-is-a-data-centre.html

⁵⁹ Prensario TI Latin America, Tendencias del mercado de Centros de Datos en México, July 14, 2021, Accessed March 04, 2022, Referenced from: <https://prensariotila.com/26395-tendencias-del-mercado-de-centros-de-datos-en-mexico-nuevo-hub-latinoamericano/>

- Tier 1 Data centre (Basic Capacity)
- Tier 2 Data Centre (Redundant capacity components)
- Tier 3 Data Centre (Comprehensive redundancy)
- Tier 4 Data Centre (Fault-tolerant).⁶⁰

The Mexico Data Centre market offers challenges and opportunities. Some aspects to consider are:

The site for the construction must have sufficient energy, adequate conditions of temperature and humidity, and a low risk of natural disasters such as earthquakes and floods. The need for a high skilled labour force for this type of project. The local contractor must understand and adapt to all standards required by international clients, the use of sustainable buildings with high energy efficiency.⁶¹

Important to point out that Mexico's actual government administration has created an uncertain environment regarding green energy policy.

4.1.1 Computing vs 5G Deployment

5G technology arrived in Mexico by Telcel and through the chairman of the board of América Móvil. On February 23, 2022, it was announced that 18 cities would have 5G services as of Monday, February 28, 2022. Among the cities that will enjoy this service are Mexico City, Monterrey, Mérida, Queretaro, Saltillo, Guadalajara, and León. The total population to be reached is 48 million people. This announcement makes Mexico the first country in Latin America with an operator that commercially launches a national 5G network aimed at the mass market. Telcel will therefore be an enabler of development, participating in the Internet of Things (IoT), Artificial Intelligence, and Industry 4.0. Its 5G network is expected to cover 120 cities by the end of 2022, with an investment of \$1.8 billion.

In 2022, Telcel's infrastructure deployment will consist of 2,000 5G-enabled radio bases during the first stage and is expected to reach 5,000 such devices by the end

⁶⁰ KION lo hace posible, Recursos, ¿Qué es un data centre?, Accessed March 09, 2022, Referenced from: <https://www.kionetworks.com/blog/data-centre/qu%C3%A9-es-un-data-centre>

⁶¹ Cohen Jonas, Data Centres, los retos de su implementación en México, October 27, 2001; Real State Accessed March 09, 2022, Referenced from <https://realestatemarket.com.mx/noticias/mercado-inmobiliario/35154-data-centres-los-retos-de-su-implementacion-en-mexico>

of the year. The 3.5 GHz band implied an investment of 900 million pesos for Telcel.
⁶²

Nokia is actively participating in Mexico and has stated that this new network will mark productivity for different industries, such as mining, in which Nokia has participated through 5G. It has seen an increase in productivity and reductions in security costs. One of the industries that make the most use of this technology is the maquiladoras. Nokia also believes that the deployment of the network will generate an impact of around 730 billion dollars by 2035, which will be distributed among several sectors, such as ITC (US\$137 billion), manufacturing (US\$134 billion), services (US\$113 billion), trade (US\$75 billion), real estate (US\$52 billion) and construction (US\$51 billion).⁶³

4.1.2 Acceleration and migration to Cloud infrastructure.

The development of a data centre is a complicated task. It must be a place that provides robust infrastructure and essential elements for its basic daily operation and therefore allows uninterrupted operation 365 days a year and 24 hours a day. Cloud Computing offers storage services, applications, processing, and computing resources through interconnected computers managed by software immediately, on-demand, and charging only for what is being used.⁶⁴

In Mexico, an annual study conducted by Veritas called "Truth in the cloud: realities and myths" interviewed 1,645 cloud architects to learn about their challenges and successes. One of the findings is the advancement in the adoption of hybrid models. Fifty-two per cent of respondents in the country rated their infrastructure as half on-premises and half cloud, thirty-one per cent have the majority in the cloud, and only eight per cent are under an all-cloud scheme. However, when questioned about their desire to move entirely to the cloud, twenty-five per cent showed interest in working under this model.

⁶² El Economista, Empresas, Tendencias para el mercado de Data Centres en Latinoamérica, February 22, 2022, Accessed February 23, 2022, Referenced from: <https://www.economista.com.mx/empresas/Telcel-estrena-su-red-5G-en-Mexico-arrancara-en-18-ciudades-del-pais-20220222-0040.html>

⁶³ Expansión, Tecnología, La 5G tendrá más impacto en manufactura que en conexiones personales, September 03, 2022, Accessed March 24, 2022, Referenced from: <https://expansion.mx/tecnologia/2021/09/03/la-5g-tendra-mas-impacto-en-manufactura-que-en-conexiones-personales>

⁶⁴ Instituto Federal de Telecomunicaciones (IFT), Estudio de Cloud Computing en México, July 2020, Accessed March 11, 2022 Referenced from http://www.ift.org.mx/sites/default/files/dgci.estudio-cloud_computing.pdf

But who is who in the cloud? In Mexico, the most adopted cloud providers are:

- Google Cloud Platform (GCP) with a 44.5%.
- Amazon Web Services (AWS) with a 44.4%.
- Microsoft Azure with a 40.7%.
- IBM with a 38%.
- Oracle with 22.2%.

Companies turn to the cloud for savings, high availability, efficiency, and reduced risk from infrastructure failures.⁶⁵

According to data from Gartner, in 2021, end-user spending on cloud services reached 396 billion dollars. The cloud market left an economic spillover in Mexico of 1,430 million dollars in 2020, 31% above 2019, and by 2021, it was expected to reach 1,877 million dollars. In the opinion of the director of the new business, MR Solutions⁶⁶, the sectors with more development and implementation in cloud services in Mexico are manufacturing with 14% of total investment in storage and computing, commerce with 10%, and financial services with 11.8%.

Another sector that has grown concerning cloud solutions has been the SMB (Server Message Block) sector. It is a client-server protocol that controls access to entire files and directories and serves as the basis for the exchange of information between the different processes. It is one of the best options for deploying operations, as it does not require investments in infrastructure, software, or operating costs.⁶⁷

Examples of companies in Mexico that offer solutions of cloud services:

- CompuSoliciones.⁶⁸
- CT Internacional.⁶⁹
- MR Solutions.⁷⁰

⁶⁵ CIO México, Quién es quién en la nube en México, según estudio 'Truth in Cloud' February 27, 2020, Accessed February 14, 2022, Referenced from: <https://cio.com.mx/quien-es-quien-en-la-nube-en-mexico-segun-estudio-truth-in-cloud/>

⁶⁶ <https://www.mrsolutions.com.mx/>

⁶⁷ Ortega Rául, En 2021 el mercado de Nube en México crecerá 31% (Mil 877 MDD), eSemanal, September 28, 2021, Accessed March 15, 2022, Referenced from: <https://esemanal.mx/2021/09/en-2021-el-mercado-de-nube-en-mexico-crecera-31-mil-877-mdd/>

⁶⁸ <https://www.compusoluciones.com/>

⁶⁹ <https://ctonline.mx/>

⁷⁰ <https://www.mrsolutions.com.mx/>

- Synnex Westcon Comstor.⁷¹
- InfoBlox.⁷²
- Grupo CVA.⁷³

4.1.3 Increased automation

Job automation is a production process carried out, partially or with human intervention, employing production techniques using computer-controlled equipment. It is a process that has revolutionized production in various economic sectors. As a result, there has been an increase in productivity, quality improvement of products and services, speed of output, and a reduction in operating costs.

In Mexico, automation would appear to have a sectoral heterogeneity similar to that observed in other countries concerning the fraction of employment with a high probability of being automated. In most northern entities and central regions, the population tends to be employed in activities with a lower likelihood of automation.⁷⁴

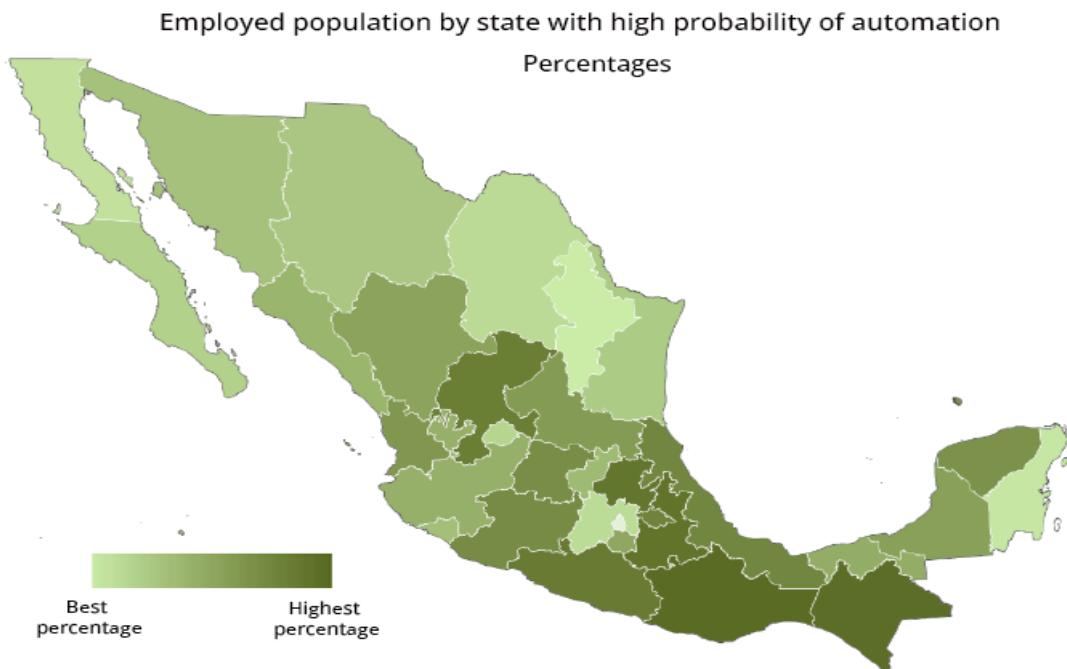
⁷¹ https://la.synnex.com/es_MX/

⁷² <https://www.infoblox.com/>

⁷³ <https://www.grupocva.com/>

⁷⁴ Banco de México, La Automatización en México desde una perspectiva regional, julio – septiembre 2018, Accessed March 14, 2022. Referenced from: <https://www.banxico.org.mx/publicaciones-y-prensa/reportes-sobre-las-economias-regionales/recuadros/%7BE3665296-DCDE-78FD-54CB-0420E1CD9A36%7D.pdf>

Figure 2 Employed population by State with High Probability of Automation



Source: Prepared by Banco de México based on data from INEGI's ENOE and published 2005-2017 Note: The figures presented correspond to the average of all quarterly ENOE surveys published between 2005 and 2017.

How is automation transformed? The 5G network will benefit the business environment by enabling it to connect billions of devices to offer the IoT. The visual reality, robotics, and e-health applications, among other things, will reflect this digital transformation. IDC e-Media notes that by 2023, digital infrastructure will be the underlying platform for all IT and business automation initiatives anywhere and everywhere. DevOps engineers will lead in delivering new IT services and applications on-demand, driven by the requirement for agile, automated, as-a-service, software-defined, self-operating digital infrastructure.

The 5G technology value chain estimates it will generate up to \$3.5 trillion in revenue by 2035 and create 22 million jobs. In addition, 5G will boost global GDP growth by \$3 trillion, cumulative between 2020 and 2035.⁷⁵

In Mexico, we have seen an increased demand for IA due to the effect of the pandemic. IBM's annual survey mentioned that six out of 10 Mexican professionals considered their enterprises using software or automation tools. The motivation to

⁷⁵ CIO México, 5G, 5G, una tecnología clave para la automatización de la industria 4.0, October 7, 2020, Accessed March 12, 2022, Referenced from: <https://cio.com.mx/5g-una-tecnologia-clave-para-la-automatizacion-de-la-industria-4-0/>

use automation is to increase process and task efficiency and to increase productivity.⁷⁶

The data centre's central element is the amount of data currently generated by each participant on the Internet. Data is produced exponentially, and the centre must respond to this growing pressure by enabling information to be stored, processed, and managed using automation.⁷⁷

In 2018 a report by Data Never Sleeps indicated that 2.5 trillion bytes were generated per day, and by 2020 it was predicted that each person would produce 1.7 megabytes for every second.⁷⁸ The Data Never Sleeps 9.0 stated, that the total data consumption globally was 79 zettabytes; the annual number is projected to grow to over 180 zettabytes by 2025.⁷⁹

A load of information on the Internet (Big Data) exceeds human capabilities and the hyper-scale to which data centres are subjected. Therefore, automation becomes indispensable in maintaining the operation in force, allowing technology and software to perform many tasks automatically.

However, automation does not exempt human participation in the data centre's operation process. Human action will monitor the work of computer systems and programs (because technology is not perfect) and complement or optimize them to make tasks derived from large amounts of information efficient. A survey by Uptime Institute revealed that between 2017 and 2018, a third of data centres had an outage, representing an increase of 25% over the past years. Among the most common globally failures were those of energy origin with 33%, network failures with 30%, and those caused by technological and software problems that accounted for 28%.⁸⁰

⁷⁶ Osores, Melisa, Crece adopción de IA en México impulsada por la pandemia y la transformación digital, September 9, 2021,, Accessed June 12, 2022, Referenced from <https://www.computerweekly.com/es/noticias/252506531/Crece-adopcion-de-IA-en-Mexico-impulsada-por-la-pandemia-y-la-transformacion-digital>

⁷⁷ msn noticias, Silicon Week, 4 predicciones de infraestructura digital para la próxima década, December 13, 2021, Accessed March 20, 2022, Referenced from: <https://www.msn.com/es-xl/noticias/otras/4-predicciones-de-infraestructura-digital-para-la-pr%C3%B3xima-d%C3%A9cada/ar-AARLsGf>

⁷⁸ Actions Data, ¿Qué es la automatización de los centros de datos?, November, 2020, Accessed March 15, 2022, Referenced from: <https://www.actionsdata.com/blog/que-es-la-automatizacion-de-los-centros-de-datos>

⁷⁹ <https://www.domo.com/learn/infographic/data-never-sleeps-9>

⁸⁰ Actions Data, ¿Qué es la automatización de los centros de datos?, November, 2020, Accessed March 15, 2022, Referenced from: <https://www.actionsdata.com/blog/que-es-la-automatizacion-de-los-centros-de-datos>

In Mexico, the failures are similar to those globally; energy failure is becoming a common problem in several areas of the country. The reason is the lack of investment in the transmission system; the control, maintenance and expansion of the transmission system are only allowed by the government or with Private Public Partnerships (PPP); during the current administration, the budget for transmission has been reduced. Energy costs will tend to increase due to the lack of competition and the control by CFE; the AMLO administration has blocked the permits for new private suppliers.

4.1.4 Remote Monitoring

One 2021 trend was remote management (which arises from the easy handling of networks), which would allow virtual visits to facilities and learning about the centre's status, among other details.⁸¹ But what variables are essential to measuring through this remote monitoring process? Some vital to the operation are temperature, humidity, liquid spills/condensation, airflow, power failure, equipment failure, light intensity, and physical presence. A couple of companies that offer this type of remote service in Mexico are Pentacom⁸² and Telematic.⁸³

However, a highly secure and available data centre requires monitoring as an essential practice. Without resolving the vulnerabilities in the power and cooling systems that make up the data centre, the physical infrastructure's detail must also be considered representative costs in terms of Capex (Capital Expenditure) and Opex (Operating Expense). Administrators have digital monitoring platforms to have the interface to manage infrastructure assets locally and remotely, which can do through a DCIM (Data Centre Infrastructure Manager) or an RMS (Remote Monitoring System). The DCIM provides real-time data and detailed reports about the data centre to reduce costs, save time and maintain the availability of crucial equipment.⁸⁴

⁸¹ Canales TI, Infraestructura México, Tendencias para el mercado de Data Centres en Latinoamérica, November, 2020, Accessed February 22, 2022, Referenced from: <https://itcomunicacion.com.mx/tendencias-para-el-mercado-de-data-centres-en-latinoamerica/>

⁸² <https://www.pentacom.mx/>

⁸³ <https://www.telemetic.com.mx/>

⁸⁴ Macpherson Jonathan, What Is DCIM? – Data Center Infrastructure Management, Park Place Technologies, November 30, 2021 Accessed March 30, 2022, Referenced from:
<https://www.parkplacetechologies.com/blog/what-is-data-center-infrastructure-management-dcim/>

4.1.5 Latency and bandwidth limitations with Edge Computing

As one of the most important trends in terms of data centres, edge computing will change industry practices in the years ahead, implying significant changes in the way network and telecommunications infrastructures are being implemented. The Telecommunications Industry Association (TIA) forecasts that the Edge Data Centre market will reach \$16 billion by 2025 as it delivers information faster and faster.

In terms of functioning and operation, Edge Computing consists of a distributed data centre model, in which IT cloud servers are hosted in Edge Data Centres that are deployed at the outer edges of the network, which are connected to a larger central data centre or several, which process data as close as possible to the end-user. Edge computing in real terms is a way to merge cloud technology with geographic distribution and can help solve the problem of the time it takes to transmit a packet within the network (latency); thanks to the geographic proximity of the data source, the process allows you to run fewer processes from a cloud, which faces latency and security issues.⁸⁵

An important aspect to consider about Edge Data Centres is that in terms of infrastructure, an individual rack could be used as an Edge if it were equipped in the right way; it could be in a container on the side of the highway or be part of a server room in a factory. They are small, highly dense, resilient, autonomous, and can be automated and controlled remotely; one company in Mexico that provides this service is Teksar.⁸⁶

One example (wind energy, solar parks, industrial zones), where Edge Data Centres, in conjunction with other technologies, will play an important role is autonomous driving since it will only work if the information can interact virtually at the speed of light between vehicles, navigation systems, mobile networks, radar and surveillance systems, traffic signals and traffic computers. All the above demand effective data transmission in real-time, where application-oriented processing of time-critical and business-critical data, immediate analysis, and full availability are part of a robust computing system's performance.

⁸⁵ atn, Edge Computing: ¿Debo implementarlo en mi negocio?, September 2, 2021, Accessed March 30, 2022, Referenced from: <https://atn.com.mx/blog/edge-computing-implementarlo-en-mi-negocio/>

⁸⁶ <https://www.teksar.mx/>

Edge data centres require synchronous and redundant fiber hyperconnectivity in all directions: the cloud, mobile device networks, neighbouring edges, and users.⁸⁷ A company that offers and has Edge data centres in various parts of Mexico is KIO Networks,⁸⁸ its services are focused on two types of industries, industries with a national presence and local industries. These EDGE data centres have high availability and redundancy specifications and are interconnected to their CORE data centre. Figure 3 shows the locations of KIO Networks data centres.

Figure 3 Edge Data Centres in Mexico, KIO Networks.



Source: Kio networks <https://www.kionetworks.com/edge-old>

Another essential characteristic of Edge Data Centres is their involvement with 5G technology, as they contribute to its availability. In addition, with the irruption of technologies such as 5G, artificial intelligence, machine learning, or blockchain, the volume of data it uses has multiplied exponentially. IDC estimates that in 2025, there

⁸⁷ Karina, ¿Por qué optar por Edge Data Centres? December 2, 2019, Computer world, Accessed March 31, 2022, Referenced from: <https://computerworldmexico.com.mx/por-que-optar-por-edge-data-centres/>

⁸⁸ <https://www.kionetworks.com/edge-old>

will be 41.6 billion devices connected to IoT, generating 79.4 Zettabytes of data, and processing them will require ample combined computing power.⁸⁹

4.1.6 IT hybrid: Own data centres/ external + public cloud /or private

A hybrid cloud consists of an IT architecture that incorporates management, orchestration, and portability of workloads from two or more environments. These environments should include some of the following elements:

- At least one private cloud and one public cloud
- Two or more private clouds
- Two or more public clouds
- A virtual environment or dedicated server (bare metal) is connected to at least one public or private cloud.

Interconnectivity enables hybrid clouds to function and thus form the basis of edge computing. In terms of design, hybrid clouds are used to connect private and public cloud environments. Examples of public cloud providers for hybrid cloud design we find:

- Alibaba Cloud
- Amazon Web Services (AWS)
- Google Cloud
- IBM Cloud
- Microsoft Azure

And, to connect them, middleware or VPN (Virtual Protocol Network) provider packages, offering subscription packages we find:

- Google Cloud offers Dedicated Interconnect.
- Amazon Web Services (AWS) offers Direct Connect.
- Microsoft Azure offers ExpressRoute.
- OpenStack offers OpenStack Public Cloud Passport.⁹⁰

⁸⁹ BBVA, innovación, ¿Qué es el 'edge computing' y cómo complementa al 5G?, January 7, 2021, Accessed March 31, 2022, Referenced from: <https://www.bbva.com/es/que-es-el-edge-computing-y-como-complementa-al-5g/>

⁹⁰ Red Hat, ¿Qué es el cloud computing? ¿Qué es la nube híbrida?, March 7, 2018, Accessed March 31, 2022, Referenced from: <https://www.redhat.com/es/topics/cloud-computing/what-is-hybrid-cloud>

Nutanix, in its second Enterprise Cloud Report (ECI)2019, highlights that in Mexico, IT implementation is expected to change from 2019 – 2024. 35% will move to the cloud model and 19% to the multi-cloud model, which shows the anticipated change in the distribution of the various IT implementation models for Mexican companies. A key finding of the report points out that Mexico is more optimistic about hybrid cloud as it is ranked as a more secure IT infrastructure. It also highlights that the strength of security between clouds in Mexico will significantly impact future cloud decisions. 81% of Mexican respondents indicated that the ability to establish and enforce policies that span multiple cloud environments would be the main feature for cloud decision-making in the future. The report conducted in late 2019 by Vanson Bourne surveyed 2,650 IT decision-makers worldwide.⁹¹

The Nutanix⁹² third Enterprise Cloud Index 2020 (ECI) report, conducted by Vanson Bourne, showed that only 9% of respondents in Mexico still exclusively manage traditional, non-cloud-enabled data centres, which is half the global average. While private cloud penetration is moderately higher at 29%. Organizations in Mexico appear to be well-positioned for the next step toward hybrid cloud models, with 53% of respondents expecting to run an integrated hybrid-only environment in the next five years, starting in 2021. The report, conducted by Vanson Bourne, surveyed 3,400 IT decision-makers worldwide and covered companies of various sizes across industries in the Americas, Europe, the Middle East, Africa (EMEA), and the Asia Pacific region.⁹³

Despite the growth of cloud services, Select,⁹⁴ an IT Mexican consulting firm, points out that in 2022 factors such as disruption in supply chains, semiconductor shortages, inflationary pressures (+6% in 2021), uncertainty due to energy reform, rising interest rates and the impact of the so-called Outsourcing Law, will impact the accumulated growth of cloud services in Mexico.

Select also points out that 2022 is expected to be directed towards innovation since there is a trend toward hybrid collaboration, which will open and encourage

⁹¹ Karina, , Tecnología, Modelo híbrido, la Infraestructura de TI ideal para empresas mexicanas, Computer World México June 16, 2020, Accessed April 03, 2022, Referenced from:

<https://computerworldmexico.com.mx/modelo-hibrido-la-infraestructura-de-ti-ideal-para-empresas-mexicanas/>

⁹² <https://www.nutanix.com/mx>

⁹³ CIO México, cloud/nube, México Avanza hacia un modelo de nube híbrida, April 5, 2021, Accessed March 31, 2022, Referenced from: <https://cio.com.mx/mexico-avanza-hacia-un-modelo-de-nube-hibrida/>

⁹⁴ <https://www.selectestrategia.net/>

opportunities. In addition, Select CEO "suggests ICT entrepreneurs offer specialized managed services; allocate more resources to internal strengthening, develop their connectivity services and platforms; and take advantage of alliances with leading wholesalers".⁹⁵

In terms of the hybrid and multi-cloud approach, some aspects that can be expected by 2022 are:

- **Enterprises will strategically migrate workloads as they embrace modernization.** Organizations evaluate the migration of more complex and critical workloads in their modernization process. So, they will need to inventory their IT environments to select applications and workloads suitable for the cloud or those that will remain on-premises.
- **Cloud Future: security will be the frontline as cyber threats grow.** Mitigating vendor concentration risk as cyber threats increase is one of the reasons organizations are adopting the hybrid model. Given the advancement of quantum computing and the ability to break algorithm cyphers, organizations must look at the near term and consider the next 10, 15, and 20 years.
- **Preparing for data governance:** the rise of the cloud for the industry. According to a study by IBM in 2021, 68% of respondents in Mexico agreed that industry-related regulatory compliance is a significant obstacle. So, enterprises are evolving toward specialized clouds to balance innovation with strict compliance protocols.⁹⁶

4.2 Energy Efficiency

Mexico faced uncertainty regarding the energy reform approved in 2015 derived from the existing opposition in the current government. The current president promoted a modification of the Energy Reform, belonging to the political party MORENA, which was expected to be voted in June 2022 and was held in April 2022. Morena opponents have repeatedly mentioned that they will vote against the new energy reform, which, if approved, will affect private investments in the sector. Another critical point that would affect the approval of these reforms is that there

⁹⁵ Cortés Mireya, reportes e investigaciones, Mercado TIC en México continúa recuperándose, impulsado por la nube, CIO México, November 19, 2021, Accessed April 2, 2022, Referenced from: <https://cio.com.mx/mercado-tic-en-mexico-continua-recuperandose-impulsado-por-la-nube/>

⁹⁶ Camilón Carlos, , Nube, Tendencias 2022: un mundo híbrido y multinube, Canales TI December 6, 2021, Accessed April 2, 2022, Referenced from: <https://itcomunicacion.com.mx/tendencias-2022-un-mundo-hibrido-y-multinube/>

would be an average increase in generation costs and a higher emission of greenhouse gases because renewable sources, primarily private, would no longer be used.⁹⁷

On April 18, 2022, the electric reform presented by President Andres Manuel Lopez Obrador was rejected as it did not have most two-thirds of the legislators present. The vote resulted in 275 votes in favour and 223 votes against. The initiative presented sought to invalidate the 2015 energy model.⁹⁸

According to data from the Energy Regulatory Commission ⁹⁹ (CRE, its acronym in Spanish), households, companies, and businesses continue to opt for sustainable energy despite Mexico's situation.

Figure 4 shows the number of contracts for power plants with a capacity of less than 0.5mw, highlighting the states of Nuevo Leon and Jalisco, with 18, 260, and 31, 501 contracts, respectively.

⁹⁷ El Financiero, Coordenadas, El giro en la estrategia de la reforma eléctrica, March 29, 2022, Accessed April 5, 2022, Referenced from: <https://www.elfinanciero.com.mx/opinion/enrique-quintana/2022/03/29/el-giro-en-la-estrategia-de-la-reforma-electrica/>

⁹⁸ The San Diego Union Tribune en español, méxico, La reforma energética de López Obrador es rechazada por la Cámara de Diputados en México, April 18, 2022, Accessed April 18, 2022, Referenced from: <https://www.sandiegouniontribune.com/en-espanol/noticias/mexico/articulo/2022-04-18/la-reforma-energetica-de-lopez-obrador-es-rechazada-por-el-parlamento-de-mexico>

⁹⁹ CRE - <https://www.gob.mx/cre>

Figure 4 Contracts in Mexico for connecting power plants with less than 0.5 MW capacity.

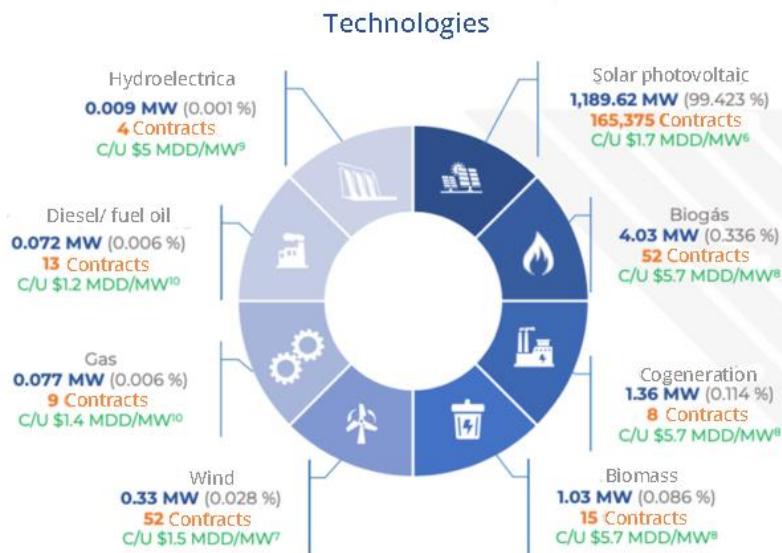


Source: Energy Regulatory Commission. (CRE) <https://www.gob.mx/cre>

Most of the contracts are for photovoltaic installations, with 99.423% (See figure 5), approximately 165,375 contracts, with an investment of roughly 1.7 million dollars per MW. Comparing it with wind energy, which only has 52 contracts, and hydroelectric with four contracts. We can see that most households, companies or businesses in Mexico prefer to use solar energy due to its ease of installation, which is relatively inexpensive for people to acquire.¹⁰⁰

¹⁰⁰ Solarama, empresarial, Desafíos del sector energético en México para este 2021, March 29, 2022, Accessed April 5, 2022, Referenced from: <https://solarama.mx/blog/sector-energetico/>

Figure 5 Technologies in contracts and installed capacity in Mexico.



Source: Energy Regulatory Commission. <https://www.gob.mx/cre>

Despite the contracts in place, and the threat of a counter-reform exercise (by the political party and its current legislative in power), the risk in terms of investment, creation of opportunities for private companies and their participation in new projects in the energy sector. In terms of operating to achieve improvements and growth in the energy sector (with the involvement of private industry), it will present a series of intermittencies due to the political environment that Mexico is going through.¹⁰¹

In recent years, the data centre industry has pursued more climate-friendly practices, and operators are joining the effort against the climate crisis in 2022. On the operational side, Vertiv experts estimate that some organizations will adopt sustainable energy strategies that use a digital solution that matches power consumption with 100% renewable energy and operate on sustainable power 24x7. These hybrid and distributed energy systems can provide both AC and DC power, adding options to improve efficiencies and allow data centres to operate carbon-free eventually. Fuel cells, renewable assets, and long-life energy storage systems, including battery energy storage systems (BESS) and lithium-ion batteries, will play a

¹⁰¹ Quintana Enrique, El giro en la estrategia de la reforma eléctrica, March 29, 2020 Accessed April 5, 2022, Referenced from <https://www.elfinanciero.com.mx/opinion/enrique-quintana/2022/03/29/el-giro-en-la-estrategia-de-la-reforma-electrica/>

key role in delivering sustainable, resilient, and reliable outcomes. There is demand for thermal systems that do not use water, and we will see a gradual reduction of refrigerants with high global warming potential (GWP) in favour of refrigerants with a low GWP.¹⁰²

Power cost is an essential element of a data centre operation. The Global Data Center Market Comparison, published by Cushman & Wakefield, compares 55 global markets by evaluating several criteria. One of them is power cost. Queretaro's power cost (cents/kWh) is 0.12 in the middle of the 55 markets.¹⁰³

4.3 Modular Data Centre

A modular data centre is one whose main components: power, cooling, and equipment, are integrated into a pre-designed module.¹⁰⁴ It offers advantages such as high potential scalability and flexibility to companies and easy and quick to implement an option to provide consistent and predictable performance. All this is highlighted by the Mexican company LOGISA¹⁰⁵, which offers prefabricated data centres.

Gesab¹⁰⁶, a Mexican company that designs modular data centres, offers two options; the first one is structures based on a transport container that is conditioned to house modules, which can have their cooling systems, power supply, etc. The second option has the solutions based on prefabricated components; these solutions are custom built and can be scalable, as appropriate.

Another participant and leading company in this type of data centre are HP. With its offer of modular data centre, HPE,¹⁰⁷ offers an environment that stands out for

¹⁰² Vertiv, Las tendencias del centro de datos de 2022, Accessed April 5, 2022, Referenced from https://www.vertiv.com/es-latam/about/news-and-insights/articles/pr-campaigns-reports/vertiv-2022-data-center-trends/?utm_source=datacenterdynamics&utm_medium=paid-display&utm_campaign=architects-of-continuity&utm_term=branding&utm_content=es_300x250_image-ad_news-release-page

¹⁰³ Cushman & Wakefield. The Global Data Center Market Comparison 2022, Accessed August 8, 2022, Referenced from <https://cushwake.cld.bz/2022-Global-Data-Center-Market-Comparison>

¹⁰⁴ Logisa, soluciones, data centres modulares prefabricados, Accessed April 5, 2022, Referenced from: <https://www.logisa.com/data-centre-prefabricados>

¹⁰⁵ IDEM

¹⁰⁶ <https://gesab.com/mx/noticias/data-centres-modulares/>

¹⁰⁷ <https://www.hpe.com/mx/es/integrated-systems/pods.html>

overcoming the traditional complexities and taking advantage of space more efficiently, ensuring superior reliability that reduces ownership costs.¹⁰⁸

Vertiv,¹⁰⁹ a leader in data centre solutions, customizes its services in modular aspects, which it divides into categories, presented below:

- Network Cabinet
- Small data centre
- Datacentre at the edge of the network
- Main data centre
- Colocation and cloud
- Cable tie station

4.4 Climate Change

Climate change is an issue that every industry and society, in general, must consider generating awareness in favour of the environment, where nature and the living beings coexist in it and find a common way of coexistence with the purpose of not causing more significant damage due to bad decisions and processes involved in the development or operation of technological services or any other industry.

Data centres have a high electricity consumption; according to the International Energy Agency (IEA), they consume approximately 200 terawatts per hour, about 1% of the global electricity demand. Their energy consumption and the generation of CO₂ cause data centres to generate an estimated annual carbon footprint of 0.3% worldwide¹¹⁰. Within the countries' commitments to reduce GHG emissions (Greenhouse Gases), this through creative strategies to attract funding for adaptation plans and climate mitigation in the country.

The National Institute of Ecology and Climate Change (INECC for its acronym in Spanish) estimates that an average temperature increase by 1.0°C could reduce the growth of the national GDP per capita between 0.77% and 1.76%. Likewise, the

¹⁰⁸ Hewlett packard enterprise, centros de datos modulares hpe. Acelera la obtención de años a semanas mediante la implementación preconfigurada y con eficiencia energética de HPE MDC, Accessed April 5, 2022, Referenced from: <https://www.logisa.com/data-centre-prefabricados>

¹⁰⁹ <https://www.vertiv.com/es-latam/solutions/>

¹¹⁰ Cortés Mireya, Eficiencia energética en centros de datos: "vital" frente a los retos de sostenibilidad y lucha contra el cambio climático, CIO México, centros de datos, August 26, 2021, Accessed April 12, 2022, Referenced from: <https://cio.com.mx/eficiencia-energetica-en-centros-de-datos-vital-frente-a-los-retos-de-sostenibilidad-y-lucha-contra-el-cambio-climatico/>

cumulative costs of climate change for Mexico during this century would be comparable to losing between 50% and more than two times Mexico's 2010 GDP.¹¹¹

Reducing the carbon footprint is a challenging goal for data centres; given the conditions in which they operate, operating 24 hours a day, 365 days a year, data exchange continues to increase, increasing, in turn, the volume of information stored. As the facilities grow, there will be greater energy consumption.

4.5 Cooling Solutions

Data centre operators have focused on acquiring renewable energy to power their operations, decreasing the use of coal-based electricity sources. Reducing the environmental impact of data centres is good for the environment; approximately 35% of the energy consumed by data centres goes to power cooling equipment, so initiatives to reduce data centre cooling will significantly contribute to carbon reduction.

Machine Learning can help optimize cooling systems and reduce idle infrastructure use, generating up to 9% cost savings. Another aspect for organizations to consider is the Cloud; migrating to on-demand public cloud-based systems from on-premises data centres is one way that promises to reduce environmental impact. It represents significant carbon reduction and cost savings of up to 19%.¹¹²

Hyperscale providers are leading the way in pursuing green data centres. However, a 451 Research survey found that nearly one-third of multi-tenant data centre (MTDC) representatives commented that all their customers want contractual commitments to efficiency and sustainability.

Some of the technology tools that could help achieve benefits such as: supporting real-time information, increasing job security, reducing network cost, and maximizing performance, would be the following:

¹¹¹ Huerta Alfredo, Opinión, Economía y cambio climático en México, 24 horas el diario sin límites, November 2, 2021 Accessed April 12, 2022, Referenced from: <https://www.24-horas.mx/2021/11/02/economia-y-cambio-climatico-en-mexico/>

¹¹² KIO Networks, Recursos, Centros de Datos: catalizadores de la acción sobre el cambio climático, November 2, 2021, Accessed April 12, 2022, Referenced from:
<https://www.kionetworks.com/blog/transformaciondigital/centros-de-datos-catalizadores-de-la-acci%C3%B3n-sobre-el-cambio-clim%C3%A1tico>

- Suites of hardware and software components for term risk management and cooling energy savings.
- Solutions for monitoring infrastructure status remotely.
- Applications that combine environmental and energy monitoring.
- Thermally efficient cabinets to maintain hot and cold air separation.

Implementing these technologies reduces cooling costs by between 10% and 30% and energy savings of 25% to 30%.¹¹³

Certification of Energy Efficiency for Data Centers (CEEDA)¹¹⁴ is an energy efficiency assessment framework addressing 90 best practices and industry metrics backup by organizations such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Energy Star, European Telecommunications Standards Institute (ETSI) , EU Cloud Code of Conduct (EUCoC) and The Green Grid.

The CEEDA covers the project life cycle from the design and operation and follows of actions plans and operation policies. The Mexican firm Data Centers Consultores was among the first to certify a regional data centre in the region.¹¹⁵

The world leaders of cooling solutions for data centres have operations in Mexico; for example, it is 3M with liquid cooling solutions, cooling by immersion. 3M states that the use of solution can reduce energy and cost up to 97%¹¹⁶

In Mexico, despite the difference in climate and location, the same cooling techniques to control data centre temperature are used, and liquid cooling solutions are starting to be used along with the air-cooling solutions.^{117 118} The central part of Mexico offers the advantage of a similar climate during the year, and not too cold, not too hot, and in some areas, it has nice and cool weather at night that can be used to lower the temperature of data centres.

¹¹³ CIO México, centros de datos, Eficiencia energética en centros de datos: "vital" frente a los retos de sostenibilidad y lucha contra el cambio climático, August 26, 2021, Accessed April 12, 2022, Referenced from: <https://cio.com.mx/eficiencia-energetica-en-centros-de-datos-vital-frente-a-los-retos-de-sostenibilidad-y-lucha-contra-el-cambio-climatico/>

¹¹⁴ <https://www.ceedacert.com/>

¹¹⁵ <https://www.datacenterconsultores.com/es/ceeda-certificacion>

¹¹⁶ https://www.3m.com.mx/3M/es_MX/novec-la/aplicaciones/enfriamiento-por-inmersion-novec/

¹¹⁷ CIO Mexico, Innovar el enfriamiento en el centros de datos, una demanda de la Transformación Digital, July 28 , 2021 Accessed August 8, 2022, Referenced <https://cio.com.mx/innovar-el-enfriamiento-en-el-centros-de-datos-una-demanda-de-la-transformacion-digital/>

¹¹⁸ Kio Networks, Te contamos cuál es la importancia de la climatización de un data center, Accessed August 8, 2022, Referenced <https://www.kionetworks.com/blog/data-center/importancia-de-la-climatizaci%C3%B3n-de-un-data-center>

Queretaro is one of the Mexican states that has become attractive for establishing data centres. It offers an excellent photovoltaic power potential, allowing the use of solar energy, low humidity and proximity to Mexico City.

One crucial issue that will be critical shortly is water availability. Water is an essential element in the cooling process, and the amount of water available in Mexico has been reduced yearly. This year has been challenging in the state of Nuevo Leon, where there has not been enough water to fulfil the population's needs.

4.6 COVID 19 Impact

According to KPMG data, companies in Mexico have advanced their digital transformation by 80% due to the COVID-19 pandemic.

An aspect that the pandemic accelerated in Mexico due to changes in consumer buying habits was the growth of online commerce. The Mexican Association of Online Sales in 2020 noted that e-commerce grew in Mexico by 81% and exceeded 316 Billion pesos, marking a great year since online sales exceeded what companies expected to sell in the next five years. However, one of the difficulties encountered in Mexico is its vast, complex, and diverse territory regarding achieving financial and technological inclusion. As nearly 50% of the population in Mexico does not have a bank account, leaving out millions of people who could become potential buyers. The World Bank, together with the Bank of Mexico, was already working on a project to make digital payments and the creation of a digital identity more accessible.¹¹⁹

The acceleration process derived from the pandemic involved companies transforming themselves using technology as a tool to perform each of their operations. Some of these companies, not having the means to operate in a digital environment, faced the emergency of implementing an entire environment that would allow them to work remotely and even stay connected. Figures from IDC Latin America IT Investment Trends 2020 reveal that 63% of companies in Mexico offer digital services due to customer demands and market competitiveness. However,

¹¹⁹ Barragan Almudena, comercio electrónico, La digitalización de las empresas y el comercio en línea después de la pandemia, EL PAÍS November 11, 2021, Accessed April 15, 2022, Referenced from: <https://elpais.com/mexico/2021-11-12/la-digitalizacion-de-las-empresas-y-el-comercio-en-linea-despues-de-la-pandemia-a-debate-en-el-foro-transformacion-2021.html>

only 37% of companies in Mexico provide digital services as part of their business plan.¹²⁰

Data Centres to meet the needs of a post-COVID pandemic world will have more activity at the edge of the network. The company VMware projects a dramatic shift in the distribution of workloads from 5% today to 30% over the next five years. Availability will remain the top priority, even at the network edge. However, lower latency is a growing necessity to support healthy buildings, smart cities, distributed energy resources, and the 5G network. The increased investment in the network edge will support this new standard (remote working, increased reliance on e-commerce, telehealth, and live video streaming) and the continued rollout of the 5G network.¹²¹

4.7 Artificial Intelligence

Artificial intelligence finds its stage of growth and implementation in various areas and processes, as in the metaverse. It is part of a reality that supports thousands of activities we perform on digital platforms that take place daily in our home's work environment. Gartner published in 2020 that Artificial Intelligence is already managed by 85% of the relationships between companies and customers. IBM estimated in 2020 that by 2022 more than half of the companies in Latin America would be integrated into the cloud management system. These trends show artificial intelligence's boom today, benefiting companies and technologies that will help mobile devices and computers better understand human language.¹²²

Some of the relevant trends that are expected for 2022 in terms of artificial intelligence are the following:

¹²⁰ Guaneros Fernando, Tras la pandemia, la digitalización creció un 80%, Expansión, tecnología November 11, 2021, Accessed April 15, 2022, Referenced from: <https://expansion.mx/tecnologia/2021/06/22/tras-la-pandemia-la-digitalizacion-crecio-un-80>

¹²¹ Vertiv, Las tendencias del centro de datos de 2022, Accessed April 5, 2022, Referenced from https://www.vertiv.com/es-latam/about/news-and-insights/articles/pr-campaigns-reports/vertiv-2022-data-center-trends/?utm_source=datacenterdynamics&utm_medium=paid-display&utm_campaign=architects-of-continuity&utm_term=branding&utm_content=es_300x250_image-ad_news-release-page

¹²² Da Silva Douglas, ARTÍCULO, 5 tendencias de Inteligencia Artificial para 2021, Blog de Zendesk, January 13, 2021, Accessed April 15, 2022, Referenced from: <https://www.zendesk.com.mx/blog/inteligencia-artificial-tendencias/>

- **A market that continues to rise.** According to Gartner, in 2022, the AI software market will be \$62.5 billion dollars, which is 21.3% more than in 2021. The primary use cases for this software are:
 - Knowledge management.
 - Virtual assistants.
 - Autonomous vehicles.
 - Digital workplace.
 - Crowdsourcing data.
- **Hyper-automation of processes.** AI will be a key element in business process automation processes, allowing to speed up operations, and eliminate human biases, in technologies such as artificial vision or computer vision will significantly speed up the quality control tasks of raw materials, finished and semi-finished products.
- **Optimization of human resources.** Implementing AI in various processes has caused workers to feel that AI can replace them. The opposite has been demonstrated; technology solutions can automate tasks, which allows abandoning repetitive tasks. And workers can focus on more relevant and motivating operations. In marketing, sales, and customer service, AI makes it possible to detect opportunities and more valuable customers.
- **Understanding human language.** Natural Language Processing (NLP) represents one of the primary uses in terms of AI; an example is the chatbots found on different websites, allowing us to clarify most of our doubts. But beyond that, NLP can also detect emotions, perform automatic translations, and generate subtitles, among other tasks. Currently, the most advanced NLP model is known as GPT-3, it handles more than 175,000 million parameters, and the GPT-4 version is already being worked on, which includes more than 100 trillion of these parameters.¹²³

In Mexico, the topic of AI is not new; according to market research conducted by IBM, more than 57% of companies in Mexico are already exploring adopting AI for use in different production processes. Half of the Mexican professionals have indicated that automation processes have increased in their workplaces and has

¹²³ Datsion, BLOG, 7 tendencias en inteligencia artificial para 2022, January 13, 2022, Accessed April 15, 2022, Referenced from: <https://datsion.com/blog/tendencias-inteligencia-artificial-2022/>

increased their focus on customer service (47%), followed by marketing and sales (37%) and process automation (26%).¹²⁴

This transformation process in Mexican companies is part of the use of technology and the corporate culture, structure, leadership, and talented team. Mexico has advanced considerably in recent years on digitisation issues. It has a window of opportunity to position itself as a country at the forefront in the development and implementation of AI. However, companies must act quickly and bet on transformation to overcome barriers allowing them an efficient, innovative operation in which AI can be an element to help respond to all those routine tasks. And creativity will become for employees a task that allows them to develop new opportunities for Mexican companies.¹²⁵

¹²⁴ Ochoa David, tecnología, Estas son las barreras para la adopción de la Inteligencia Artificial en México, Expansión, September 10, 2021, Accessed April 23, 2022, Referenced from: <https://expansion.mx/tecnologia/2021/09/10/estas-son-las-barreras-en-la-adopcion-de-inteligencia-artificial-en-mexico>

¹²⁵ Cen Hugo, La Inteligencia Artificial transforma a México, Expansión, opinión, February 14, 2022, Accessed April 18, 2022, Referenced from: <https://expansion.mx/opinion/2022/02/14/inteligencia-artificial-transforma-mexico>

5 Regulatory framework for data centre

In Mexico, the institutions and, therefore, the rules that regulate data centres and their operation are indispensable knowledge factors for any individual, organization, or interested in participating in this market.

In 2014, the standard Mexican NMX489 (NMX-J-C-I-489-ANCE-ONNCE-NYCE-2014)¹²⁶ for high-performance data centres was established, considering security, availability, and energy efficiency. The continued growth of data centres in Mexico, driven by trends such as the Internet of Things (IoT), Big Data, and the Cloud, are driving the direction of the technology sector in various companies and the public sector¹²⁷. Therefore, in 2014, the government launched the National Digital Strategy, which is the action plan for the construction of a Digital Mexico, in which technology and innovation contribute to achieving the primary development goals of the country¹²⁸; seeking to improve Mexico's position in terms of connectivity and digitization within the OECD lists.

The NMX489 Standard promoted by the Mexican Smart Building Institute, taking into account international recommendations, was carried out with a multidisciplinary group in which experts from interested sectors participated, achieving the conjunction of three major national standardization organizations: the Association for Standardization and Certification, A.C. (ANCE)¹²⁹; Standardization and Electronic Certification, S.C. (NYCE)¹³⁰, and the National Organization for Standardization and Certification of Construction and Building, S.C. (ONNCCE).¹³¹

The standard is an instrument that establishes the minimum guidelines for the design, construction, and operation of data centres for governmental, academic, research centres and private companies.

This standard contains the general requirements for:

¹²⁶NMX-j-c-i-489-ance-onnce-nyce-2014

https://dof.gob.mx/nota_detalle.php?codigo=5352377&fecha=15/07/2014#gsc.tab=0

¹²⁷ Canales TI, Casos de Éxito México, Norma Mexicana para Centros de Datos: ¿obligatoria u opcional?, July 29, 2016, Accessed April 18, 2022, Referenced from: <https://itcomunicacion.com.mx/norma-mexicana-para-centros-de-datos-obligatoria-u-opcional/>

¹²⁸ Gobierno de México, Estrategia Digital Nacional, Accessed April 18, 2022, Referenced from: <https://www.gob.mx/epn/mexicodigital>

¹²⁹ ANCE <https://www.ance.org.mx/>

¹³⁰ NYCE <https://www.nyce.org.mx/>

¹³¹ ONNCCE <https://www.onncce.org.mx/es/>

1. Electrical installations, as indicated in NOM-001-SEDE-2012¹³² use of electrical installations.
2. Safety and fire protection conditions in workplaces, as specified in NOM-002-STPS-2010.¹³³
3. The design of building envelopes, as stipulated in NOM-008-ENER-2001¹³⁴, refers to energy efficiency in buildings and non-residential building envelopes design.
4. Energy efficiency in central air conditioners, according to NOM-011-ENER-2006¹³⁵, establishes energy efficiency in central air conditioners, package or split type, and the limits, test methods, and equipment labelling.
5. Structured cabling within the facilities concerning the NMX-I-248-NYCE-2008¹³⁶ standard involves its specifications and testing in the telecommunications sector.
6. The channels and spaces within the facilities, as dictated by the NMX-I-279-NYCE-2009, establish the guidelines for telecommunications cabling for commercial buildings.
7. Grounding in telecommunication systems, as established by NMX-I-108-NYCE-2006, defines must-have grounding conditions.
8. The foreign standards are specified in the bibliography section of the standard itself.

Use of the standard contributes to compliance with environmental, renewable energy, energy efficiency, and sustainability laws, along with confidentiality and privacy of personal data, business practices, and civil protection.¹³⁷

5.1 Federal Telecommunications Institute (FTI)

Federal Telecommunications Institute (IFT for its acronym in Spanish) took over the faculties of the Federal Telecommunications Commission (COFETEL, its acronym in Spanish) extinguished in 2013. IFT is in charge of efficiently developing telecommunications and broadcasting for the benefit of the country's users and audiences by:

¹³² <https://www.gob.mx/cms/uploads/attachment/file/512096/NOM-001-SEDE-2012.pdf>

¹³³ https://dof.gob.mx/nota_detalle_popup.php?codigo=5170410

¹³⁴ <http://legismex.mty.itesm.mx/normas/ener/ener008.pdf>

¹³⁵ http://www.dof.gob.mx/normasOficiales/2464/SENER_2_22062007/SENER_2_22062007.htm

¹³⁶ http://dof.gob.mx/nota_detalle.php?codigo=5063338&fecha=09/10/2008

¹³⁷ Revista mundo hvac&r, Ser Verde, Nueva norma para centros de datos de alto desempeño, Accessed April 18, 2022, Referenced from: <https://www.mundohvacr.com.mx/2015/05/nueva-norma-para-centros-de-datos-de-alto-desempeno/>

- I. Regulation, promotion and supervising of the use, development, and exploitation of the radioelectric spectrum, infrastructure, networks, and the provision of services.
- II. To promote conditions of effective competition in the markets.
- III. To facilitate access to telecommunications and broadcasting technologies and services.

IFT is an independent institution, effective, transparent regulatory and competition authority which contributes to the development of telecommunications and broadcasting, the advancement of the information and knowledge society in Mexico, as well as the improvement of the quality of life and development opportunities for all Mexicans.¹³⁸

As part of their regulatory functions, the IFT will conduct spectrum bidding for 5G mobile services in 2022. In this process, the IFT prepared the draft bidding rules submitted to public consultation, the terms and conditions, and other relevant aspects such as the concession term, coverage obligations, participation limitations, assignment mechanisms, disqualification grounds, and payment of considerations.

¹³⁹

The IFT also expects to complete the Annual Program for the Use and Exploitation of Frequency Bands for 2023. The program has 34 projects divided into five institutional objectives. 27% of these projects aim to promote the deployment, development, and efficient use of networks and infrastructure that facilitate the development of the digital ecosystem and promote digital inclusion. The other 23% of these projects will foster economic and free competition in the telecommunications and broadcasting sectors. The additional 23% of projects will ensure quality, diversity, and plurality, guaranteeing users' rights. 18% of the projects aim to strengthen institutions, and 3% promote the development of a digital ecosystem and the adoption of new technologies and digital use cases.¹⁴⁰

¹³⁸ <http://www.ift.org.mx/>

¹³⁹ Bnamérica, noticia, México confirma licitación de espectro 5G para este año, February 04, 2022, Accessed April 19, 2022, Referenced from: <https://www.bnamicas.com/es/noticias/ift-confirma-licitacion-de-espectro-5g-para-este-ano>

¹⁴⁰ Bnamérica, noticia, México confirma licitación de espectro 5G para este año, February 04, 2022, Accessed April 19, 2022, Referenced from: <https://www.bnamicas.com/es/noticias/ift-confirma-licitacion-de-espectro-5g-para-este-ano>

The so-called Roadmap for the IFT for 2021-2025 stipulated how the regulator establishes the strategic framework that allows planning and focusing the Institute's actions within a five-year time horizon. This strategic framework facilitates the development of the digital ecosystem under a comprehensive and collaborative vision, covering aspects ranging from the promotion, development, deployment, and efficient use of telecommunications and broadcasting networks. The roadmap also considers infrastructure development, competition and free concurrence, the digital ecosystem, the adoption of new technologies and digital use cases.¹⁴¹

The IFT has a data centre within its central facilities, which was updated in 2020 in record time (18 weeks) by the company Teksar and has a TIER III Uptime Institute certification which was achieved thanks to Panduit¹⁴². Placing the institution second nationally and matching its infrastructure with international standards to processing capacity and ITC infrastructure support with a view to the next ten years.

As part of its tasks as a regulator, on April 1, 2022, the IFT granted a concession title to the recently inaugurated AIFA (Felipe Angeles International Airport) to use and take advantage of radio spectrum frequency bands, as well as a single concession title, both for operational use. The use of radio spectrum frequencies will be valid for 15 years, while the concession title will be valid for 30 years.¹⁴³

5.2 ICREA Certification

The International Computer Room Experts Association (ICREA)¹⁴⁴, the global authority for certification of physical infrastructure and the human talent for data centres, 2021 presented its Std-131-2021 update standard for construction, operation, and maintenance of information technology environments. This standard is the compilation of standards applicable to data centre infrastructure in seven areas, which are:

- Electrical installations
- Climate control
- Security and safety

¹⁴¹ IFT, Hoja de Ruta 2021-2025, Referenced from: <http://www.ift.org.mx/conocenos/hoja-de-ruta-2021-2025>

¹⁴² <https://www.panduit.com/>

¹⁴³ EXPANSIÓN, empresas, El AIFA Lanza licitación para internet y telefonía; pagará hasta 2.9 mdp, March 19, 2022, Accessed April 19, 2022, Referenced from: <https://expansion.mx/empresas/2022/04/19/aifa-lanza-licitacion-internet-telefonia-pagara-2-9-mdp>

¹⁴⁴ <https://icrea-international.org/>

- Communications
- Scope
- Governance
- Sustainability

The ICREA-Std-131-2021 standard aims to become an international benchmark for data centres as it provides applicable standards that improve the provision of services.

Since 2003, ICREA -Std-131 standard has made it possible to certify the operating facilities of several Internet service providers. The ICREA standard defines service availability in six levels, which are:

- LEVEL I: The computer room is in a certified QADC (Quality Assurance Data Centre) environment. For availability of 95%.
- LEVEL II: Computer room in WCQA (World Class Quality Assurance) certified environment. For 99% availability.
- LEVEL III: Reliable computer room with World Class Certified Environment S-WCQA (Safety World-Class Quality Assurance). For 99.9% availability.
- LEVEL IV: High-security computer room with HSWCQA (High-Security World-Class Quality Assurance) certification. For 99.99% availability.
- LEVEL V: High security and high availability computer room with HSHA-WCQA (High-Security High Available World-Class Quality Assurance) certification. For 99.999% availability.
- LEVEL VI: High security and high availability computer room with world-class certification RHA-WCQA (Redundant High Available World-Class Quality Assurance Data Centre Net). For 99.9999% availability.

Data centres in Mexico that have been certified by ICREA are:

- Teléfonos de México (TELmex), with TRIARA¹⁴⁵ data centre based in Querétaro and Monterrey. Telmex has been certified by ICREA for more than 13 years due to their security and availability levels that provide their customers with security levels in their IT platforms and computer systems.

TRIARA has high-quality standards and international certifications in infrastructure and processes, ICREA Level 5 certification, called HSHA-WCQA (High-Security High Available World-Class Quality Assurance): NFPA75, opinion

¹⁴⁵ <https://telmex.com/web/acerca-de-telmex/home>

for the protection of IT equipment; ISO 9001; ISO14001; ISO/IEC20000-1 and ISO/IEC27001.¹⁴⁶

- ALESTRA¹⁴⁷, for twelve consecutive years, has received several certifications from ICREA. Alestra data centre are in Nuevo León and Querétaro. ALESTRA obtained five certifications during 2021, 3 in Nuevo León and 2 in Querétaro in levels III, IV, and V, with gold, platinum and diamond awards¹⁴⁸. Axtel¹⁴⁹ (who, until 2019 offered telephony, internet, and TV services for homes) is another company with eight certifications by ICREA and now serves business, government, and wholesale markets; its data centre is marketed through its corporate brand ALESTRA.

To obtain these certifications, Axtel had to meet a series of requirements in terms of sustainability and service, such as high reliability and availability, constant maintenance, high security, scalability, training, and operation.¹⁵⁰

¹⁴⁶ EL universal, unión guanajuato, redes, data centre triara de telmex reciben certificación icrea, May 22, 2019, accessed April 20, 2022, referenced from: <https://www.unionguanajuato.mx/2019/05/22/data-centre-triara-de-telmex-reciben-certificacion-icrea/>

¹⁴⁷ <https://www.alestra.mx/>

¹⁴⁸ The standardcio información 360º Estrategia, centros de datos, Alestra recibe certificación de ICREA para sus centros de datos, November 12, 2021, Accessed April 20, 2022, Referenced from: <https://thestandardcio.com/2021/11/12/alestra-recibe-certificacion-de-icrea-para-sus-centros-de-datos/>

¹⁴⁹ <https://www.axtel.mx/>

¹⁵⁰ Players of life, monterrey, Centros de Datos de Axtel en NL reciben certificaciones de ICREA, May 20, 2018, Accessed April 20, 2022, Referenced from: <https://playersoflife.com/negocios/axtel-recibe-ocho-certificaciones-de-icrea-y-gobernabilidad/>

Table 3. ICREA certifications for data centres in Mexico during 2020 and 2021.

Company	No. of Certifications	Certification Level
Atalait	1	Level IV
Axtel y Alestra	5	Level III, IV y V
Bconnect	2	Level I y III
Benemerita Universidad Autónoma de Puebla (BUAP)	1	Level III
Cloud Data	1	Level IV
Cometra	1	Level II
Cybolt	1	Level III
Equinix APO	2	Level III y IV
Equinix QRO	2	Level III y V
Hospital general de Tapachula	1	Level II
Hospital regional de Tlalnepantla	1	Level I
IBM	1	Level IV
ICA Fluor	1	Level III
Iqsec	1	Level I
KIO	3	Level III, IV y V
Metronet	5	Level III, IV y V
Micronet	1	Level IV
Telcel México	1	Level III
Triara Apodaca	2	Level V
Triara Querétaro	2	Level V
Tutum Tech	1	Level III
Universidad Autónoma de Campeche (UAC)	1	Level III
Universidad Autónoma de Nuevo León (UANL)	2	Level I, II

KIO Networks is the only company with Level VI certification by ICREA, the highest level granted to organizations with at least three interconnected Data Centres (which also have a level III ICREA certification). Allows that in the event of a significant incident or failure of one or two data centres, the other one or two can meet users' needs without suspending service.¹⁵¹

¹⁵¹ Fabregás Felipe, , Empresas, KIO Networks, primera empresa en el mundo en recibir el Nivel 6 de certificación ICREA por sus Centros de Datos, El capital financiero, December 3, 2021, Accessed April 20, 2022,
Referenced <https://elcapitalfinanciero.com/kio-networks-primer-a-empresa-en-el-mundo-en-recibir-el-nivel-6-de-certificacion-icrea-por-sus-centros-de-datos/>

6 Competition with other Latin American countries

Mexico is prepared to become the next industrial and data centre hub in Latin America, with above-average potential in the region to accelerate its competitiveness and development with the support of information technologies.

BSI¹⁵², a British certifier, mentions that the Mexican economy will continue to attract foreign direct investment due to the attractive industrial sector active in different country areas. International relations with the United States and Asia will favour capital investment; a considerable expansion is projected, combined with a technological transformation. In addition, BSI identified three trends in the Mexican market that impact strategic planning for the short and medium-term future:

- Digital trust (information security)
- Sustainability (worker safety and well-being)
- Transformation and increase in the volume of the local industry¹⁵³

As far as data centres are concerned, Mexico competes with other countries like Brazil and Chile. In the World Innovation Index¹⁵⁴, prepared by the World Intellectual Property Organization (WIPO), Chile ranks 53rd and Mexico 55th, marking the leadership in innovation in the region. In recent years, Mexico has seen an increase in companies that have created new technological facilities, such as Schneider Electric in Monterrey, the Spanish cloud services company Gigas and the company ASCENTY.

However, the industrial and data centre hub development may take longer than expected because Mexico was not included in the Foreign Direct Investment (FDI) Confidence Index for the third consecutive year. The 2022 Confidence Index, prepared by the consulting firm Kearney, evaluates the 25 countries that attract and retain the most foreign capital. The 2022 ranking is led by the United States, Canada, Germany, Japan, and the United Kingdom. Only four emerging markets are in this

¹⁵² <https://www.bsigroup.com/es-MX/>

¹⁵³ EL Economista, México se consolida como hub industrial en América Latina y seguirá atrayendo inversión, April 4, 2022, Accessed April 22, 2022, Referenced from: <https://www.eleconomista.com.mx/empresas/Mexico-se-consolida-como-hub-industrial-en-America-Latina-y-seguira-atrayendo-inversion-presume-BSI-20220405-0153.html>

¹⁵⁴ https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2021_exec.pdf

year's Index: China, the United Arab Emirates, Brazil, and for the first time in the Index's history, Qatar¹⁵⁵.

Latin America faces a significant problem in digitising its population, as the region faces a digital gap; half its adult population is not part of the financial inclusion. The closure of schools during the pandemic affected 170 million students in the region, adding that less than 50% of the population in Latin America and the Caribbean has fixed-band connectivity, and only 9.9% have high-quality fiber at home.

Data plans and internet-enabled devices are not affordable for the region's poor population. The cost of a modest data plan of only 1GB represents 2.7% of monthly household income, the price of the cheapest basic smartphone available represents between 4% and 12% of average household income in much of the region, and between 31% and 34% in Guatemala and Nicaragua or even 84% in Haiti.¹⁵⁶

Although 5G technology begins to be a reality in Mexico in 2022, 3G technology continues to dominate in the country and Central America, Venezuela, and Peru. Three countries in the region have already tendered radio spectrum to deploy 5G technology; the first was Chile (the region's digital leader), who, in January 2021, held three separate auctions to allocate the 700 MHz, AWS, and 3.5 GHz bands. This 5G tender raised US\$453 million for a country with almost 20 million inhabitants.

In November 2021, Brazil concluded its 5G auction, the most ambitious in the region, as it tendered the 700 MHz, 2.3 GHz, 3.5 GHz, and 26 GHz bands. In addition, five new competitors will enter the Brazilian market: Winity II, Brisanel, Consorcio 5G Sul, Neko and Cloud2u.¹⁵⁷

Several factors must combine to enhance the development of Latin America, including an increase in infrastructure, the attraction of investments, and a reduction of the digital gap to achieve digitalization.

¹⁵⁵ El economista, México, fuera de las 25 economías más atractivas para la IED, April 7, 2022, Accessed April 22, 2022, Referenced from: <https://www.eleconomista.com.mx/empresas/Mexico-suma-tres-anos-fuera-de-las-25-economias-mas-atractivas-para-IED-Kearney-20220407-0075.html>

¹⁵⁶ EL país, termómetro económico y social de américa, El bajo costo de cerrar la brecha digital en América Latina, august 23, 2021, Accessed April 22, 2022, Referenced from: <https://elpais.com/america/economia/termometro-social-de-america/2021-08-23/el-bajo-costo-de-cerrar-la-brecha-digital-en-america-latina.html>

¹⁵⁷ EL economista, opinión, América Latina avanza hacia 5G, November 12, 2021, Accessed April 22, 2022, Referenced from: <https://www.eleconomista.com.mx/opinion/America-Latina-avanza-hacia-5G-20211112-0027.html>

6.1 Communication Infrastructure

The 2013 Mexican constitutional reform considers telecommunications as public services of general interest. The State will guarantee competition, quality, plurality, universal coverage, interconnection, convergence, continuity, and free access without arbitrary interference. However, the lack of competitors is a problem that prevails in Mexico and slows down the progress of telecommunications services.¹⁵⁸ Federal Telecommunications Institute (IFT) was also created because of the Constitutional Reform, and is responsible for investigating, analysing and sanctioning antitrust violations in the telecommunications sector, as well as determining which companies have market power and implementing measures that favour free trade.¹⁵⁹ The antitrust initiative, promoted by the Federal Telecommunications Institute (IFT), seeks to reduce América móvil's dominance in the market to encourage greater competition, investment, employment, technological improvements, and lower tariffs.¹⁶⁰

Competition in telephony and Internet has not generated coverage or convergence. According to the Herfindahl-Hirschman Index, which measures market concentration, since the 2013 reform, mobile telephony concentration has been reduced by 13%. However, mobile line penetration has only grown by 7.6% in the same period. The concentration of fixed telephony service dropped 36%, but lines only grew by 4.8%. Mobile and fixed Internet connections have grown, but network coverage has not.¹⁶¹

Mexico has the fastest mobile bandwidth in Latin America (34.74 Mbps) as of June 2021, according to the Speedtest Global Index, considering that Telcel has seven of every ten mobile Internet lines. It also has the fastest download speed (26.3 Mbps), above its competitors Movistar (15.7 Mbps) and AT&T (14.6 Mbps).¹⁶²

¹⁵⁸ Bravo, Jorge, La boca llena de competencia, El Economista, Jly 30, 2021 Accessed April 22, 2022, Referenced from: <https://www.eleconomista.com.mx/opinion/La-boca-llena-de-competencia-20210730-0033.html>

¹⁵⁹ Carreño Fernando, Mexico Overview, America Antitrust Review 2020, September 20, 2019, Global Competition Review. Accessed June 22, 2022, Referenced from: <https://globalcompetitionreview.com/review/the-antitrust-review-of-the-americas/2020/article/mexico-overview>

¹⁶⁰ Bravo, Jorge, La boca llena de competencia, El ECONOMISTA, July 30, 2021 Accessed April 22, 2022, Referenced from: <https://www.eleconomista.com.mx/opinion/La-boca-llena-de-competencia-20210730-0033.html>

¹⁶² Bravo, Jorge, La boca llena de competencia, July 30, 2021, EL Economista, Accessed May 2, 2022, Referenced from: <https://www.eleconomista.com.mx/opinion/La-boca-llena-de-competencia-20210730-0033.html>

According to the Affordability Report 2021¹⁶³ of the Alliance for Affordable Internet (A4AI), Mexico is one of the eight countries with the most affordable drivers' index. High ADI scores correlate with reduced broadband costs for the industry and consumers. Since 2013, the Communications Price Index has dropped by 26.8% (except for pay-TV) and mobile telephony by 43.9%.

In 2020, The National Infrastructure Plan for the Broadcasting and Telecommunications sectors considered allocating 20 billion pesos between 2021 and 2022. Despite investments and planning to diversify or generate greater competition in the telecommunications sector in Mexico, investors had to face other challenges. According to the study Spectrum Pricing Effectiveness in Latin America, prepared by GSMA¹⁶⁴, Mexico is one of the most expensive countries in the region since annual fees represent about 85% of the total cost of the license.¹⁶⁵

6.2. Innovation Policy in Mexico

The status of Science, Technology and Innovation (STI) in Mexico has not been growing for decades. Let's compare Mexico's investment in STI with OCDE countries. Mexico invests eight times less in research and development, the total of scientists is nine times less, scientific publications are 5.5 less, and the number of patents per year is 20 times less. Unfortunately, this situation has aggravated in the last year, with the cancellation of 65 trust funds for science and the reduction of economic incentives for researchers in private universities. In Mexico, gross national expenditure on innovation and development for the different institutions involved in the ecosystems shows that the government is the leading player. In the case of OCDE countries, the investment is led by the private sector. To take Mexico to the next level requires the joint responsibility of the government and the private sector with the support of academic institutions and society.¹⁶⁶

Nevertheless, a study published by Deloitte mentions that there is an increase of startups in areas such as financial services (23%), health (11%), information technologies and communications (8%) and education (8%).¹⁶⁷

¹⁶³ <https://a4ai.org/research/affordability-report/affordability-report-2021/>

¹⁶⁴ <https://www.gsma.com/>

¹⁶⁵ Ramires Anderson, 2020: El año de las telecomunicaciones, Expansión, Opinión, January 1, 2020, Accessed May 2, 2022, Referenced from: <https://expansion.mx/opinion/2020/01/01/2020-el-ano-de-las-telecomunicaciones>

¹⁶⁶ Ávila Alfonso, Ciencia, tecnología e innovación en México se encuentran en situación crítica, November 27, 2020. Accessed June 22, 2022, Referenced from <https://egade.tec.mx/es/egade-ideas/opinion/ciencia-tecnologia-e-innovacion-en-mexico-se-encuentran-en-situacion-critica>

¹⁶⁷ Moctezuma Noé, Acelerar la innovación: una oportunidad para México, June 30, 2021, Accessed May 14, 2022, Referenced from <https://expansion.mx/opinion/2021/06/29/acelerar-innovacion-oportunidad-mexico>

Private companies are looking to develop technology in Mexico. Intel, in April 2022, announced an agreement with the Ministry of Economy to strengthen the semiconductor supply chain in Mexico. The company also plans to develop programs to empower the industry through talent. Intel has a design centre in Guadalajara where new product validation occurs.¹⁶⁸

In the Global Innovation Index, 2021, published by Word Intellectual Property Organization (WIPO), Mexico was ranked in the 55th position below Chile, ranked in the 53 position, followed by Costa Rica (56) and Brazil (57). The indicators used in the study are science and innovation investment, technological progress and social-economic impact.¹⁶⁹

The Economic Commission for Latin America and the Caribbean (ECLAC), in their publication "Digital Technology for a new future", considers that the biggest challenge facing Latin America in the development of technology is the digital divide. Latin America needs to ensure the educational development of children and young people.¹⁷⁰

6.3 Cybersecurity

Cybersecurity has become a critical issue for all organizations, vulnerability in systems can have an economic impact and chaos in any company.

Mexico ranked first in the region with 67% of attempted attacks, followed by Brazil with 17.8% and Peru with 5. %, according to Fortinet.¹⁷¹

In 2018, Mexico suffered one of the most significant cyberattacks in its financial sector. The attack was on the Interbank Electronic Payments System (SPEI its acronym in Spanish) of Mexico Central Bank (BAXICO); the attack cost 300 million

¹⁶⁸ Cueto Hector, Intel ve gran potencial tecnológico en Latinoamérica, pero debe eliminarse la brecha digital para realmente alcanzarlo, Business Insider México, May 12, 2022, Accessed May 14, 2022, Referenced from: https://businessinsider.mx/intel-potencial-tecnologico-latinoamerica-brecha-digital_tecnologia/

¹⁶⁹ Global Innovation Index 2021, WIPO Accessed May 14, 2022, Referenced from: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2021.pdf

¹⁷⁰ CEPAL; Tecnologías digitales para un nuevo futuro. Accessed May 14, 2022, Referenced from <https://www.cepal.org/es/publicaciones/46816-tecnologias-digitales-un-nuevo-futuro>

¹⁷¹ Forbes, México, México, primer lugar en ciberataques, en Latinoamérica, November 20, 2021, Accessed May 14, 2022, Referenced from: <https://www.forbes.com.mx/negocios-mexico-primer-lugar-en-ciberataques-en-latinoamerica/>

pesos.¹⁷² The vulnerability of Mexico's financial system has put on discussion the creation of a National Agency of Cybersecurity, which is still under review at congress. The agency would regulate and coordinate with other countries, and Mexico will have coordination and communication mechanisms for local and Latin American cybersecurity events.¹⁷³

In 2021, more than 91,000 million cyber-attack attempts had been registered in Latin America in the first half of the year alone, of which more than 60,000 million occurred in Mexico.¹⁷⁴

Mexico and Latin America face three significant challenges in cybersecurity: the vulnerability of instant messaging applications, the use of targeted Ransomware, and attacks on corporate environments and supply chains.

In the 2020 Cybersecurity Forecast for Latin America, the Russian company Kaspersky mentioned that IT risks will continue to be present in areas ranging from personal life to the processes of international corporations and governments. Kaspersky's forecasts for the region indicate that in individual terms, users will have to face aspects such as:

- Disinformation campaigns in social networks.
- Scams.
- Extortion.
- Theft of credentials of streaming services.
- Personal identity theft through SIM Swapping (identity cloning through SIM cards).

Trends in recent years indicate that cybercriminal groups such as Lazarus Group and Silence will increase their presence, attacking institutions and organizations that provide financial services.¹⁷⁵

¹⁷²Juarez Edgar, Tras ataque, el Banxico buscará robustecer ciberseguridad en Fintech, El Economista May 20, 2018 Accessed May 14, 2022, Referenced from <https://www.economista.com.mx/sectorfinanciero/Tras-ataque-el-Banxico-buscara-robustecer-ciberseguridad-en-fintech-20180520-0079.html>

¹⁷³Ventas Seguridad, Agencia Nacional de Ciberseguridad mexicana: ¿una realidad en 2024?, February 18, 2022 Accessed June 14, 2022, Referenced from <https://www.ventasdeseguridad.com/2022021613117/noticias/empresas/agencia-nacional-de-ciberseguridad-mexicana-una-realidad-en-2024.html>

¹⁷⁴Forbes, México, México, primer lugar en ciberataques, en Latinoamérica, November 20, 2021, Accessed May 14, 2022, Referenced from: <https://www.forbes.com.mx/negocios-mexico-primer-lugar-en-ciberataques-en-latinoamerica/>

¹⁷⁵Unir, La Universidad en Internet, 2020 en Ciberseguridad: qué nos espera en México y América Latina, December 09, 2019, Accessed May 4, 2022, Referenced from: <https://mexico.unir.net/ingenieria/noticias/2020-ciberseguridad-pronosticos-mexico-america-latina/>

The Organization of American States (OAS) published the report Cybersecurity 2020, the report developed by OAS and Inter-American Development Bank (IDB). The information determines the cyber capabilities of Latam. The final score for the region of 25.66, which the top score is 100.¹⁷⁶

Global Cybersecurity Index of the International Telecommunications Union (ITU), which places the region behind Europe, North America and Asia, mentioned that in 2020, the regional average rose to 39.88, reflecting a regional effort and interest in the subject. It is essential to highlight the individual steps of the governments of Brazil (rated 59.2), Chile (56.3), Colombia (59.2), Uruguay (69.4), and Mexico (56.5), which have prioritized the issue and advanced more than 20 points in their rating in the last four years.¹⁷⁷

In 2019 Mexico presented the initiative for the Information Security Law, which focused on modifying the Federal Criminal Code regarding cyber crimes; another initiative was the National Security Law to delimit cyber threats to the Mexican State. Both documents are a niche of opportunity to increase the interest of the Federal Government, companies, and private initiatives to collaborate on intellectual property issues and data protection, among others.¹⁷⁸

Cybersecurity is a central global issue for any economy; technological development and social welfare are directly impacted by cybersecurity. It must become an issue of corporate culture and responsibility. Raising awareness is necessary, as it will benefit everyone.¹⁷⁹

¹⁷⁶ Aguilar Juan Manuel, , Análisis, Ciberseguridad: pendiente en América Latina y México, El Sol de México August 20, 2020, Accessed May 6, 2022, Referenced from:
<https://www.elsoldemexico.com.mx/analisis/ciberseguridad-pendiente-en-america-latina-y-mexico-564898.html>

¹⁷⁷ IDEM

¹⁷⁸ IDEM

¹⁷⁹ Canales TI, Historia, La ciberseguridad en México: Retos y Oportunidades, October 6, 2021, Accessed May 2, 2022, Referenced from: <https://itcomunicacion.com.mx/la-ciberseguridad-en-mexico-retos-y-oportunidades/>

7 Factors influencing the development of data centres in Mexico

Mexico's diversified economy includes high-tech industries, oil production, mineral exploitation, and manufacturing. According to recent World Bank data, agriculture accounted for 3.8% of Mexico's Gross Domestic Product (GDP) in 2020 and employed 12.4% of the country's workforce in 2019. In addition, the Mexican economy is among the 15 most significant globally and is the second-largest economy in Latin America.

However, Mexico is highly dependent on the United States, its largest trading partner and the destination of almost 80% of its exports. Data from the International Monetary Fund (IMF), GDP is estimated to grow by 6.2% in 2021, mainly due to a significant increase in remittances.

Mexico is expected to continue growing in the coming years, albeit slower, with the IMF forecasting 4% growth by 2022; economic analysts expect the GDP to be at the end of the year at 1.76%.¹⁸⁰ The oil sector is critical, as oil production accounts for one-third of government revenues. As for inflation, the predictions change due to oil prices; last May, Mexico's inflation rate was 7.65 % it is expected to end the year at 7% in 2023.¹⁸¹

The labour market is recovering after the impact of the pandemic; the unemployment rate decreased slightly to 4.1% in 2021. It is expected to reach 3.7% in 2022 to remain stable during 2023. However, the informal sector still accounts for around 60% of employment in Mexico.

The total services sector accounts for 60.1% of GDP. It employs 61.9% of the workforce.¹⁸² The services related to telecommunications and broadcast represented 2020 3.4% of Mexico's GDP.¹⁸³ The high-tech, information, and software development sectors are experiencing a real boom, driven by workforce

¹⁸⁰Forbes Staff, Sector privado eleva previsión de crecimiento de PIB de México a 1.76% para 2022 Accessed July 5, 2022, Referenced: <https://www.forbes.com.mx/sector-privado-eleva-prevision-de-crecimiento-de-pib-de-mexico-a-1-76-para-2022/>

¹⁸¹Esaustegui Miguel, Pronostican analistas inflación cercana a 7% en 2022 May 2022, Accessed July 5, 2022, Referenced: <https://www.elsoldemexico.com.mx/finanzas/pronostican-analistas-inflacion-cercana-a-7-en-2022-8225801.html>

¹⁸²Santander, Trade Markets, México: política y economía, March 2022, Accessed May 2, 2022, Referenced from: <https://santandertrade.com/es/portal/analizar-mercados/mexico/politica-y-economia>

¹⁸³Instituto Federal de Comunicaciones, Nota técnica de indicadores económicos y de servicios móviles de telecomunicaciones al 2T 2020 Accessed June 3, 2022, Referenced from <http://www.ift.org.mx/sites/default/files/comunicacion-y-medios/otros-documentos/notatecnica.pdf>

quality, clusters, and low operating costs. Although the services sector was the hardest hit during the pandemic, it significantly recovered in 2021.¹⁸⁴

In terms of data centre growth in Mexico, it will grow by 20% during 2022, according to the Business Development Director of Panduit, a company dedicated to providing data centre infrastructure accessories. Mexico has become an attractive market for developing facilities due to investments in hyperscalers from companies such as Google, Amazon, and local companies like KIO. For Panduit, the second most relevant country of Latin America data centre is Mexico.

The consulting firm Aritzon estimates that the data centre market in Mexico will receive investments of 905 million dollars between 2022 and 2026, with an annual growth of 8.33 per cent.¹⁸⁵

According to a recent BNamericas report, Mexico's attractiveness for data centres is not only driven by the demand for cloud and streaming services but also by aspects such as guaranteed electricity supply, data protection law, growing video game markets (number of gamers 72.3 million by the end of 2020¹⁸⁶) and OTT (over-the-top) platforms, and the implementation of 5G infrastructure.¹⁸⁷

Mexico has positioned itself as an important market for establishing data centres. According to Statist, Mexico has a total of 153 data centres, number 11 in the world based on the number of data centres.

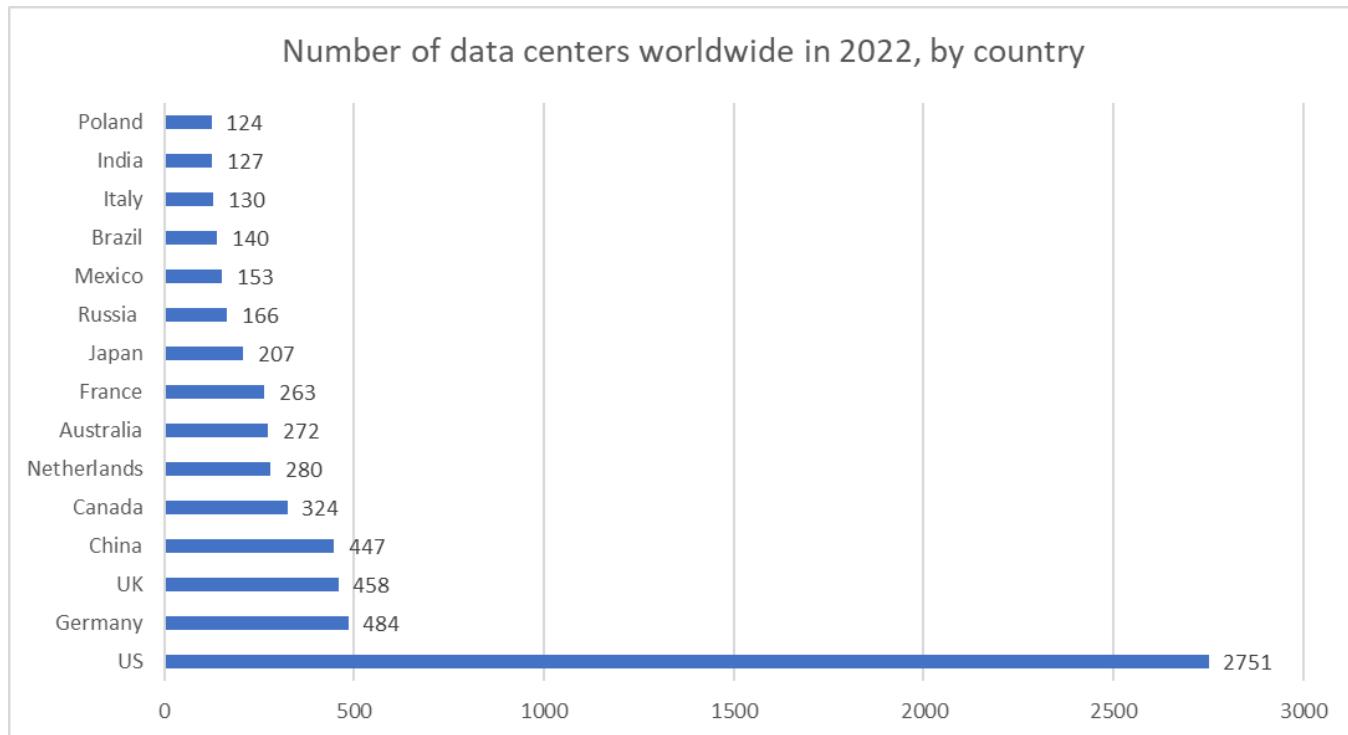
¹⁸⁴ Santander, Trade Markets, México: política y economía, March 2022, Accessed May 2, 2022, Referenced from: <https://santandertrade.com/es/portal/analizar-mercados/mexico/politica-y-economia>

¹⁸⁵ Riquelme Rodrigo, Centros de datos, México, a punto de convertirse en el segundo hub de centros de datos de América Latina: Panduit, El economista, March 24, 2022, Accessed May 3, 2022, Referenced from: <https://www.eleconomista.com.mx/tecnologia/Mexico-a-punto-de-convertirse-en-el-segundo-hub-de-centros-de-datos-de-America-Latina-Panduit-20220324-0064.html>

¹⁸⁶ Artega Alberto, Industria de Videojuegos en México en 2020, Ciu The competitive intelligence unit, March 22, 2021, Accessed May 1, 2022, Referenced from: <https://www.theciu.com/publicaciones-2/2021/3/22/industria-de-videojuegos-en-mxico-en-2020>

¹⁸⁷ Riquelme Rodrigo, Centros de datos, México, a punto de convertirse en el segundo hub de centros de datos de América Latina: Panduit, El economista March 24, 2022, Accessed May 3, 2022, Referenced from: <https://www.eleconomista.com.mx/tecnologia/Mexico-a-punto-de-convertirse-en-el-segundo-hub-de-centros-de-datos-de-America-Latina-Panduit-20220324-0064.html>

Figure 6. Number of data centres worldwide in 2022, by country



Source. Statista 2022 <https://www.statista.com/statistics/1228433/data-centres-worldwide-by-country/>

7.1 Increase in Internet users in the country

In 2019 there were 80.6 million Internet users in Mexico, representing 70.1% of the population aged six and older. This figure reveals 4.3 per cent over 2018 (65.8%). Of the 80.6 million Internet users aged six and older, 51.6 per cent are female, and 48.4 per cent are male. 20.1 million households have internet (56.4%) by fixed connection or mobile devices. In 2019 users connect to the internet by Smartphone (95.3%); Laptop or tablet (33.2%) and desktops 28%.¹⁸⁸

Digital 2021 April Global Statshot Report published in partnership with We Are Social and Hootsuite, estimated 92.01 million Internet users in Mexico and determined the Internet penetration at 71%.¹⁸⁹

¹⁸⁸ Gobierno de México, Secretaría de Comunicaciones y Transportes, ¿Cuántos usuarios de internet somos en México?, February 17, 2020, Accessed May 12, 2022, Referenced from: <https://www.gob.mx/sct/articulos/cuantos-usuarios-de-internet-somos-en-mexico>

¹⁸⁹Digital 2021 April Global Statshot Report, April 2021 Accessed May 12, 2022, Referenced from <https://datareportal.com/reports/digital-2021-april-global-statshot>

The exponential growth in Internet users in Mexico resulted from the COVID-19 pandemic. Thousands of people who needed to study or work required to have an internet connection to communicate with co-workers, schoolmates and with family members. The Association of Internet MX¹⁹⁰ pointed out that Mexico's highest number of Internet users in the last five years was registered during the pandemic.

The average fixed-band Internet speed in Mexico was estimated at 46.77 MBPS, which places the country 50.10 MBPS below the world average. Internet user main activity are social networks; each user in the country has an average of 5 platforms. Data from a survey conducted by the Asociación de Internet MX indicates that Facebook is the most used social network, followed by Whatsapp, Instagram, Youtube, and Twitter.¹⁹¹

Although the increase of internet users has grown considerably in Mexico in recent years, the main problems that users have identified are those related to slow connection, service interruptions, and receiving unwanted information.¹⁹²

7.2 Energy Efficiency

Energy efficiency is the way to increase the affordability of electricity services while reducing emissions. It has been gaining more attention worldwide and is at the core of the Sustainable Development Goals (ODS)¹⁹³. Mexico is a leader in Latin America in terms of efficient energy use, with 32 Official Standards (NOM). To achieve this leadership, the National Commission for the Efficient Use of Energy (CONUEE for its acronym in Spanish),¹⁹⁴ has played a fundamental role. The commission has 59 testing laboratories certified by the Mexican Accreditation Entity (EMA).¹⁹⁵

The Official Standards related to Energy Efficiency and lighting are:

- NOM-030-ENER and NOM-031-ENER on luminaires with LED technology

¹⁹⁰ <https://www.asociaciondeinternet.mx/>

¹⁹¹ Ramos Mariana, 45% de los usuarios de internet en México aumentaron su adopción tecnológica por la pandemia. M4rketingecommerce.mx February 22, 2021, Accessed May 12, 2022, Referenced from: <https://marketing4commerce.mx/45-de-los-usuarios-de-internet-en-mexico-aumentaron-su-adopcion-tecnologica-por-la-pandemia/>

¹⁹² Asociación Mexicana de internet, 18 Estudio sobre los hábitos de personas usuarias de internet en Mexico, May 2022 February 22, 2021, Accessed May 12, 2022, Referenced from: <https://www.asociaciondeinternet.mx/estudios/asociacion>

¹⁹³ <https://www.undp.org/es/sustainable-development-goals>

¹⁹⁴ <https://www.gob.mx/conuee>

¹⁹⁵ https://www.ema.org.mx/portal_v3/

- NOM-008-ENER for buildings
- NOM-013-ENER, which has to do with public lighting

Another function of the CONUEE, is to promote the optimal use of energy, from its exploitation to its consumption, promoting scientific and technological research on sustainable energy use, and providing technical advice.¹⁹⁶

Energy efficiency plays a relevant role in the case of Latin America and the Caribbean, where the demand for energy services is expected to double by 2040. The region is distinguished by considerable inequality in terms of affordability of energy services, and many countries face financial and economic challenges due to their subsidy policies. In Latin America, there are ample opportunities to improve energy efficiency, particularly in the residential sector, whose share of total electricity consumption has increased to 29% in 2018, with an average annual growth rate from the period 2010-to 2018 (2.2%), going from 296,673 GWh (gigawatt-hours) to 374,323 GWh.

The primary use of electricity in Latin America and the Caribbean is food refrigeration, followed by lighting and, in third place, environmental conditioning. These three resources consume an estimated 75% of the electricity consumed in the region's countries. Therefore, the opportunities for saving electricity are located in replacing refrigerators and air conditioners over ten years old. The savings from the replacement of these appliances can reach up to 40% in the consumption of each piece of equipment, avoid the accumulation of refrigerant gases and the destruction of the ozone layer, and mitigate climate change resulting from global warming of these gases.¹⁹⁷

Energy Efficiency should contribute to the national development of Latin American and Caribbean countries through a plan that prioritizes homes, the reconstruction of green buildings, and sustainable cities, seeking to reduce energy and poverty and promote the inclusion of historically disadvantaged social groups. Given the lack of public resources, combined financing mechanisms (public-private partnerships)

¹⁹⁶ Serrano, Raúl, México encabeza la eficiencia energética en Latinoamérica, Iluminet revista de iluminación, September 30, 2019, Iluminet Accessed May 14, 2022, Referenced from: <https://www.iluminet.com/mexico-encabeza-eficiencia-energetica-latinoamerica/>

¹⁹⁷ Urteaga José Antonion eficiencia energética, Eficiencia energética en América Latina y el Caribe ¿por qué importa?, Energía para el futuro, March 4, 2021, Accessed May 2, 2022, Referenced from: <https://blogs.iadb.org/energia/es/eficiencia-energetica-en-america-latina-y-el-caribe-por-que-importa/>

should be encouraged to bring industry on board and facilitate financing for small and medium-sized enterprises (SMEs).

Data centres were allied during the pandemic by guaranteeing the operation of companies and organizations in Mexico and contributing to the digital transformation.

Today data centres face significant challenges to sustainability and fighting against climate change. Data centres have a high energy consumption of approximately 200 terawatts per hour, equal to 1% of global electricity demand. The carbon print of data centres worldwide is 0.3% due to the large amount of energy and generation of CO₂.

The data centres must use renewable energy sources and energy-efficient equipment to reduce the carbon print. A key element in the design of the data centres is access to clean energies, the use of energy-efficient equipment and the materials used in its construction.¹⁹⁸

7.3 Qualified staff

Having efficient and effective personnel to perform tasks within the organization is vital to keep customers satisfied, so employees must be highly qualified to perform the series of operations for which they were hired.

In Latin America, the proportion of companies with significant problems filling vacancies is 65%, but in Mexico, the figure is 74%, placing it as the first in the region.

According to the British recruitment firm PageGroup,¹⁹⁹ 70% of executives in leadership positions stated that talent retention plans in their companies are classified as extremely important in their business agendas. This new trend is being copied from the model of North American and European markets to be replicated in Latin America and the Caribbean to retain talent in areas with a shortage. PageGroup highlighted that in the case of Mexico, 80% of leaders seek to change jobs due to factors that increase their dissatisfaction, such as economic remuneration.

¹⁹⁸ Panduit, Eficiencia energética de los centros de datos, vital para enfrentar el cambio climático, Portal Ambiental, August 25, 2021, Accessed June 2, 2022, Referenced from: <https://www.portalambiental.com.mx/sabias-que/20210825/eficiencia-energetica-de-los-centros-de-datos-vital-para-enfrentar-el-cambio>

¹⁹⁹ <https://www.page.com/>

Specialized talent is scarce in Mexico and is a challenge faced by companies. The Manpower's Talent Shortage Survey showed that 3 out of 4 companies in the country claim to have difficulty filling their vacancies: this proportion places Mexico first in Latin America regarding this barrier to business.²⁰⁰

The problem is finding personnel that have the skills required for the job. In Mexico, there is a lack of coordination between the education and training systems to what today's companies are demanding.

The educational systems in Latin America, but particularly in Mexico, face significant backwardness in basic levels; Mexican children attending school do not reach basic proficiency levels in mathematics, which is very similar in other areas such as science and history. These problems, considered in a long-term governmental agenda, require an approach to how education is directed and delivered in Mexico. Mexico must work on updating and modifying the curricula to certain types of technological competencies by which these students can develop a series of skills that will place them in a position to qualify for skilled jobs that the labour market demands.

In all regions of the world, data centre capacity is growing dramatically; this impacts the need for specialized personnel to design, build and operate these critical infrastructures. The lack of talent is becoming a growing concern regardless of the size of the facility.

However, the growth in talent demand would represent a crisis until 2025, as stated in the study "The people challenge: Global data centre staffing forecast 2021-2025" by Uptime Institute Intelligence. The report says that the number of staff needed to manage data centres worldwide will increase by more than 300,000 professionals by 2025. Hiring technical staff in data centre is "notoriously difficult." Mechanical and electrical engineers in strategy and operations roles, as well as control and supervisory employees, are among the technical staff that will be increasingly needed at least until 2025. Despite the evolution of artificial intelligence and

²⁰⁰ Hernández Gerardo, , Capital Humano, México, líder en AL... pero en escasez de talento especializado para roles clave, El Economista, June 9, 2021, Accessed May 12, 2022, Referenced from: <https://www.economista.com.mx/capitalhumano/Mexico-lider-en-AL...-pero-en-escasez-de-talento-especializado-para-roles-clave-20210608-0112.html>

automation within these facilities, it will be "unlikely" that these technological advances will flatten or reduce staffing needs before 2025.²⁰¹

7.4 Connectivity

Latin America and the Caribbean require an investment of \$70 billion to bridge the digital divide, according to the Inter-American Development Bank (IDB). Mexico and Chile are the best-positioned in the region and have taken the necessary steps to increase connectivity.²⁰²

In 2020, the Economic Commission for Latin America and the Caribbean (ECLAC) proposed to guarantee and universalize connectivity and affordability of digital technologies to address the impacts caused by Covid 19 pandemic. The ECLAC presented five actions:

- I. To build an inclusive digital society.
- II. Promote productive transformation.
- III. Promote digital confidence and security.
- IV. Strengthen regional digital cooperation.
- V. Move towards a new governance model to ensure a 'digital welfare state' that promotes equality and protects the people's economic, social and labour rights.

ECLAC also points out significant differences in connectivity between urban and rural areas. In Latin America, 67% of urban households are connected to the Internet, while only 23% of the rural regions are connected. Young people and older adults have the lowest connectivity: 42% of those under 25 and 54% of those over 66 years.
²⁰³

²⁰¹ Gheorghiu Alexandra, Retrato del talento en los Data Centres: evolución, necesidades y problemas para encontrar July 30, 2021, DCD Accessed May 3, 2022, Referenced from <https://www.datacentredynamics.com/es/features/retrato-del-talento-en-los-data-centres-evolucion-necesidades-y-problemas-para-encontrarlo/>

²⁰² Forbes México, Actualidad, Latinoamérica necesita 70,000 mdd para combatir la brecha digital:BID, January 24, 2022, Accessed May 12, 2022, Referenced from: <https://www.forbes.com.mx/noticias-latinoamerica-necesita-70000-mdd-para-combatir-la-brecha-digital-bid/>

²⁰³ CEPAL naciones unidas, desarrollo productivo y empresarial, CEPAL propone garantizar y universalizar la conectividad y asequibilidad a las tecnologías digitales para enfrentar los impactos del COVID-19, August 26, 2020, Accessed May 10, 2022, Referenced from: <https://www.cepal.org/es/comunicados/cepal-propone-garantizar-universalizar-la-conectividad-asequibilidad-tecnologias>

In 2021, the Mexican Association of internet estimated 89.5 million internet users in Mexico. 95.4% use their smartphone to connect to the Internet for work, study, or recreational activities. According to PWC Mexico, in 2021 alone, 34 billion megabytes (MB) were consumed. If this trend continues, 92% of the Mexican national territory will be connected to the Internet by 2024.

The number of mobile devices in Mexico reached 84 million people in 2021, according to the Mexican Association of Online Sales (AMVO); during the last year, the payment of online services (OPS) through mobile devices had a growth rate of 14% in eCommerce transactions, the highest nationally. As a result, 20% of Mexican consumers currently make all their purchases via smartphone.²⁰⁴

The Organization for Economic Cooperation and Development (OECD), as of June 2020, places Mexico in the penultimate position in fixed broadband connections, with 16.2 out of every 100 inhabitants, while the average of the international organization is 32.5 per 100 people. The same happens in most Latin American countries, where broadband is not so broad as scarce. In global aspects, the connectivity infrastructure presents challenges, as 49% worldwide are not connected, according to the Asociacion de Internet Mx (AIMX).

At the end of 2021, the Ministry of Infrastructure, Communications, and Transportation published the Public Sites Connectivity Program 2022, establishing 24,781 properties as priorities to be connected. The connection will be by wi-fi infrastructure covering highways, public plazas, healthcare centres, schools and community spaces.²⁰⁵

8 Technology and its influence on the Development of Mexico Data Centres

High technology has positioned itself as an essential aspect of economic growth in modern societies. Investment in science and technology is critical to a country's development since it impacts the growth of Gross Domestic Product (GDP) and increases productivity, which translates into improved quality for the population.

²⁰⁴ Asociación Mexicana de internet, 18 Estudio sobre los hábitos de personas usuarias de internet en Mexico, May 2022 February 22, 2021, Accessed May 12, 2022, Referenced from: <https://www.asociaciondeinternet.mx/estudios/asociacion>

²⁰⁵ Federal Official Gazette. Public Sites Connectivity Program 2022, December 2021 https://www.dof.gob.mx/nota_detalle.php?codigo=5639908&fecha=31/12/2021#gsc.tab=0

Research and development investment in Mexico is below the 2% average of the World Bank as a percentage of GDP since it is below 0.5%. Therefore, it is essential to encourage investment in science and technology, which in countries such as Israel and Finland are up to 4%. An aspect relevant for countries such as Mexico would be creating and using Technology Development Centres (TDC) since these would allow transforming knowledge into added value.²⁰⁶

Technology Transfer Centres (TTCs) facilitate technology transfer, understood as knowledge processes, manufacturing methods, technologies, skills, and facilities between the business, education, and government sectors. In Mexico, the private sector linked to the role of TDCs is represented mainly by micro, small and medium-sized enterprises (MSMEs). Due to a lack of economic resources and intellectual capital, MSMEs choose to establish alliances with R&D (Innovation and Technological Development) institutions to find support from governmental entities for project financing.

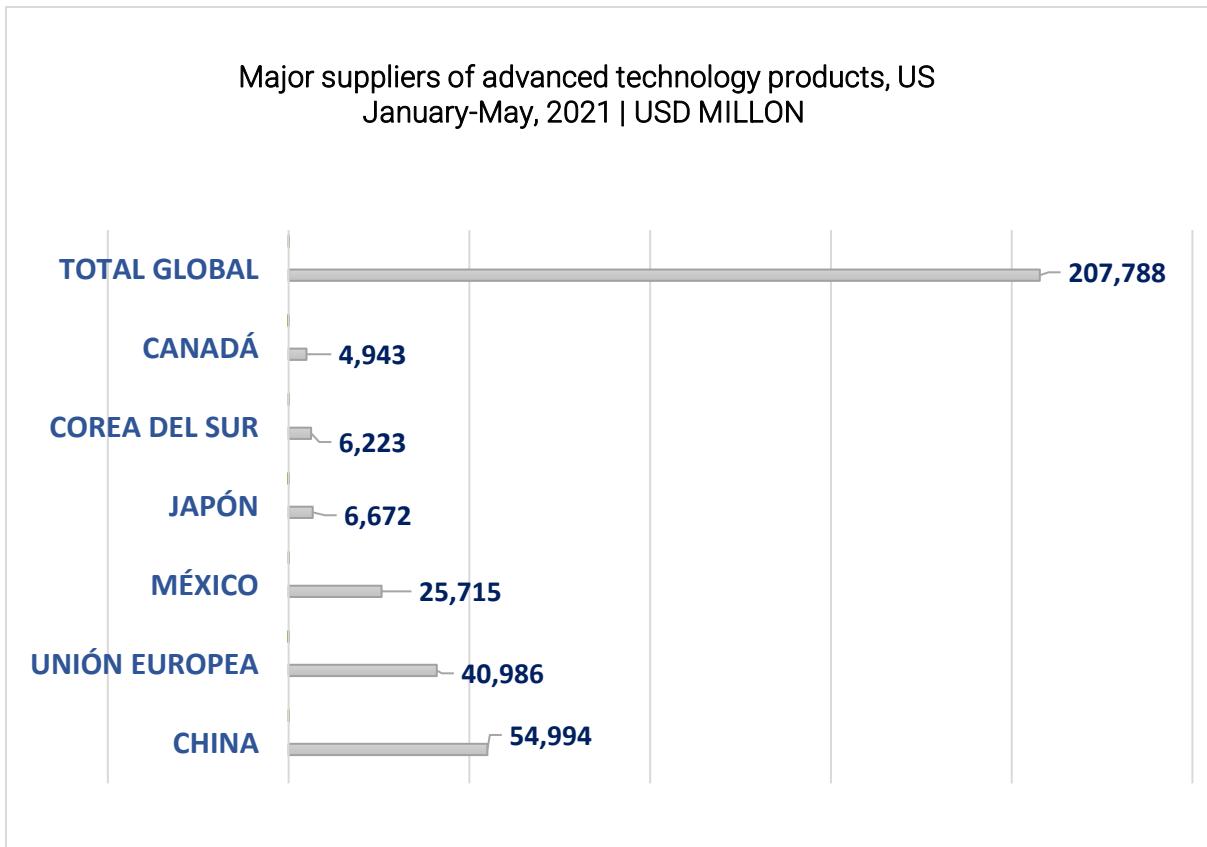
Mexico is a high-tech supplier for the United States due to its proximity and the cost of labour and investments that have been made in high-tech manufacturing (See Figure 7), being among the top five suppliers of the US. However, technological dependence as a supplier and not as a leading agent in innovation developments or participation in technological disruption makes it difficult for Mexico to position itself as a creative country capable of generating high-tech companies and promoting scientific and economic growth.²⁰⁷

Therefore, it is essential to encourage innovation, scientific-technological promotion, and its activity towards companies since there are areas of opportunity in educational policy to link large companies and thus promote the transfer of knowledge generated in the country's universities.

²⁰⁶ de la Cruz Rojas Erick, Ciencia y tecnología su impacto en el desarrollo de México, Accessed May 11, 2022, Referenced from <https://www.selectestrategia.net/reporte/ciencia-y-tecnologia-su-impacto-en-el-desarrollo-de-mexico>

²⁰⁷ Morales, Roberto, México se consolida como proveedor de alta tecnología de Estados Unidos, July 9, 2021 Accessed May 11, 2022, Referenced from <https://www.economista.com.mx/empresas/Mexico-se-consolida-como-proveedor-de-alta-tecnologia-de-EU-20210709-0016.html>

Graphic 1 Major suppliers of advanced technology products to the US January-May 2021 USD MILLION



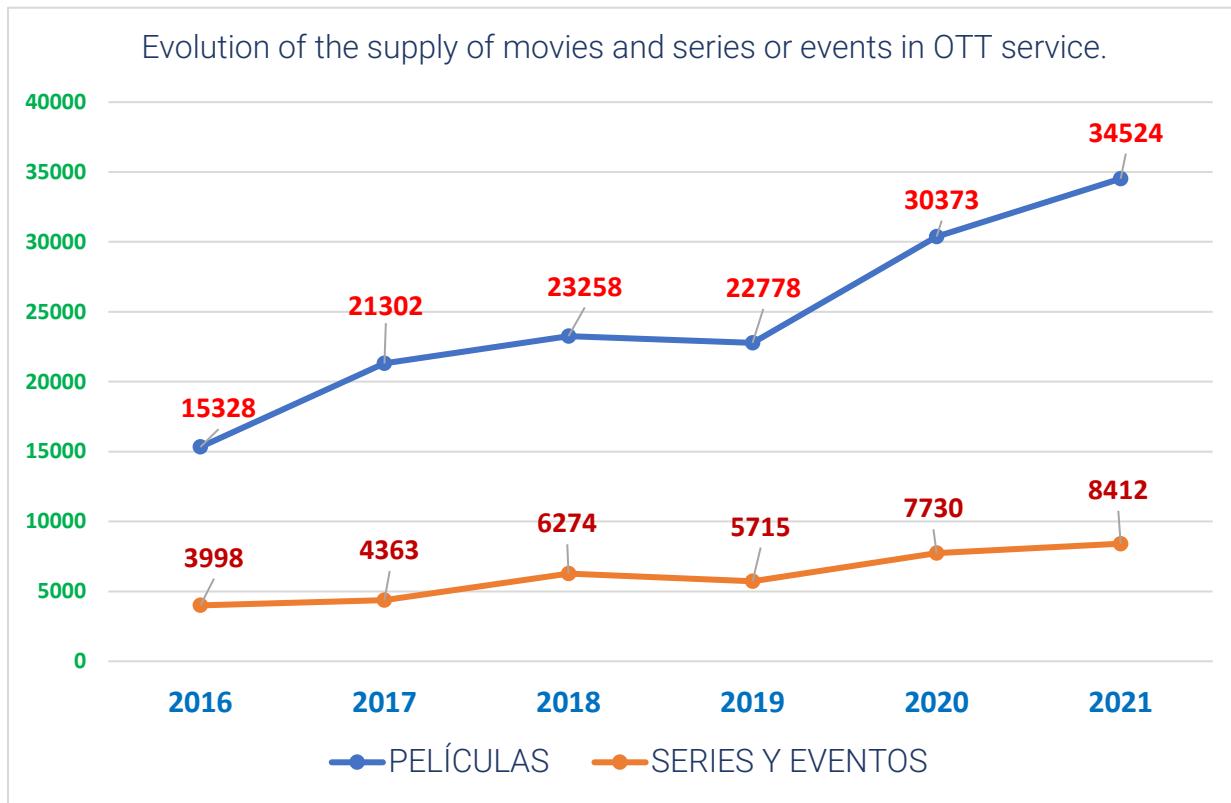
Source: United States Commerce Department

8.1 Video transmission

Video streaming is one of the fastest-growing digital and technological services in Mexico.

Its high demand requires infrastructure capable of supporting a concurrency, direction, and access to products immediately, giving the user the best experience and thus maintaining satisfied customers, permanent and profitable.

Graphic 2 Evolution of the supply of movies and series or events in OTT service.



Source: Federal Telecommunications Institute (IFT).

The pandemic in Mexico facilitated the incursion of new competitors; during the last year, entertainment catalogues from companies such as Disney+, HBO Max and Paramount + have been added.

A study conducted by the Federal Telecommunications Institute (IFT) called Supply and Demand of OTTs of Audiovisual Content in Mexico points out that in 2016 there were 71 streaming platforms in operation; in 2021, the offer grew to 89. It is worth mentioning that the catalogues have become quite diverse; in a matter of six years, the offer doubled, going from 15,328 movies available in 2016 to 24,454 in 2021, while the series offered by these platforms went from 3,998 in 2016 to 8,412 in 2021.²⁰⁸

The technology, also known as Over-The-Top (OTT) or on-demand services, is changing the audiovisual entertainment industry. The supply of movies and series or

²⁰⁸ Instituto Federal de Telecomunicaciones, Oferta y demandas de OTTs de contenidos audiovisuales en México, 2021 Accessed May 9, 2022, Referenced from: <http://www.ift.org.mx/industria/umca/estudios-y-reportes-de-analisis-de-medios-y-contenidos-audiovisuales>

events on streaming platforms operating in Mexico has doubled in the last six years. The streaming subscription model has tripled in four years, going from annual revenues of 621 billion dollars in 2018 to 1.9 billion dollars in 2021.²⁰⁹

According to the Ibero-American Telecommunications Organization (OTI)²¹⁰, the Latin American countries that consume the most content via streaming are Argentina, Brazil, Chile, Colombia, Mexico, and Peru. In addition, OTI notes that by 2019 a total of 59 million Latin households occupied their internet service to watch videos.

In March 2021, EMI Research Solutions²¹¹ conducted a survey for Penthera²¹², in which 87.8% of Internet users in Latin America affirmed watching videos through SVOD (Subscription Video on Demand) platforms, those such as Netflix or Amazon Prime. While 70.4% of users prefer platforms with free content in exchange for advertising, known as AVOD (Advertising Video on Demand), similar to Pluto²¹³ or Vix.²¹⁴

Business Bureau highlights that in Mexico, 29% of streaming users still contract pay TV and at the same time consume content from OTT platforms, while 19% only watch OTT content. For its part, Statista points out that by the end of 2020, Brazil was the leader of SVOP subscribers with 20 million and followed by Mexico with 15 million subscriptions to SVOD platforms.²¹⁵

Another study conducted by the World Intellectual Property Organization (WIPO), entitled "Audiovisual OTT business model in Latin America: recent trends and future", highlights that, by 2023, the advertising-based OTT model will be the second

²⁰⁹ Quiroga Ricardo, Arte e ideas, Streaming no para de ganar terreno, pero diversifica sus modelos, April 5, 2022, El Economista Accessed May 9, 2022, Referenced from:

<https://www.eleconomista.com.mx/arteseideas/Streaming-no-para-de-ganar-terreno-pero-diversifica-sus-modelos-20220405-0170.html>

²¹⁰ <https://otitelecom.org/>

²¹¹ <https://emi-rs.com/>

²¹² <https://www.penthera.com/>

²¹³ <https://pluto.tv/es/live-tv/pluto-tv-cine-estelar-1>

²¹⁴ <https://www.vix.com/es-es/canales>

²¹⁵ El economista, Industria OTT, México, en el Top 5 en consumo de streaming en Latinoamérica, January 26, 2022, Accessed May 9, 2022, Referenced from: <https://www.eleconomista.com.mx/arteseideas/Mexico-en-el-Top-5-en-consumo-de-streaming-en-Latinoamerica-20220126-0112.html>

most relevant in Latin America, driven by broadband penetration and the fact that younger consumers will switch from free-to-air TV to OTT.²¹⁶

Mexico is the third country worldwide that watches more videos on YouTube; 47% of these users are millennials. Youtube Mexico has registered 16.99 million visitors per month. Youtube's primary use is to search for information about a topic, product or service or to learn something. One out of three Mexican reviews information on YouTube before making a purchase.²¹⁷

Despite the exponential growth of streaming or video transmission in Mexico, it is important to remember that there is still a significant and imminent digital divide in the country.

8.2 Digitalization of companies

Digitization became a necessary and mandatory process in 2022, derived from the COVID-19 pandemic and the rethinking it had on businesses to determine a new disposition of how they operate. Just for 2021, it was anticipated that 75% of companies in Latin America could digitize their internal work processes due to new adoptions of hybrid work, said the firm specializing in digitization, Kodak Alaris²¹⁸. In addition, the firm considered that large companies worldwide would invest about 460 million dollars in new technologies.

Nowadays, every organization must have technological elements in which their employees find support to perform the tasks through mobile or portable devices with only internet access, avoiding a physical environment. Before the pandemic, it was linked to an office; this digitization process has benefited organizations to face challenges and take advantage of opportunities, whereas the traditional work model has become a hybrid one.

²¹⁶ Katz Raul, Study on the audiovisual legal framework in Latin America, Part 1 Accessed May 9, 2022, Referenced from https://www.wipo.int/export/sites/www/ip-development/en/agenda/pdf/1_paper_ott_audiovisual.pdf

²¹⁷ Spinel Rodrigo, Producción de video digital, 18 datos sobre el consumo de Youtube en México, Produccionaudiovisual.August 15, 2017, Accessed May 9, 2022, Referenced from: <https://produccionaudiovisual.com/produccion-video-digital/consumo-youtube-mexico/>

²¹⁸ Segundo Luis Pablo., Negocios, Buscan digitalizarse 75% de las empresas de América Latina en 2021: Kodak Alaris, Milenio August 17, 2021, Accessed May 2, 2022, Referenced from: <https://www.milenio.com/negocios/buscan-digitalizarse-75-empresas-america-latina-2021-ko>

Several trends have marked the concept of digitization in Mexican companies, such as:

- Personalization or experience management companies now invest in eCommerce technology, service, marketing, and everything that allows for improving the customer experience.
- Automatization of sourcing and supply chain process. The pandemic showed that all companies need to strengthen supply chains.
- Advanced data management corresponds to data analysis and the opportunities that can be obtained from its correct use.²¹⁹

In 2021 Mexico's Technology adoption growth represented 40%, including an estimated 50 million dollars in eCommerce. Therefore, digitalization has signified as an ideal tool to collaborate remotely, automate corporate processes and improve processes with all employees of the companies.²²⁰

According to IAB (Interactive Advertising Bureau), in its "Study of Media Consumption and Devices among Mexican Internet users", more than 60% of respondents said they use social networks to investigate the reputation of brands and companies before buying. The study also reveals users' concerns about Internet security, so at least 60% of respondents said it is essential that the sites where they make purchases have security certificates, 36% researched information that seemed unreliable, and 28% reported emails of dubious origin.²²¹

Another essential aspect of generating more significant attraction in consumers and linked to digitalization were the discounts through the Internet since it is easier to find and compare prices of items in which there is a specific interest.

Despite the pandemic's digital acceleration, in a recent study by the Institute for Management Development, based in Switzerland, Mexico has a bleak outlook. The World Digital Competitiveness Ranking places Mexico in 56th place out of 64 nations, highlighting shortcomings, the lack of tax incentives for using information technology, and the precarious scientific concentration in the field. Another

²¹⁹ El financiero, Empresas, 3 tendencias de digitalización de las empresas en México, September 9, 2021, Accessed May 2, 2022, Referenced from: <https://www.elfinanciero.com.mx/empresas/2021/09/09/3-tendencias-de-digitalizacion-de-las-empresas-en-mexico/>

²²⁰ IDEM

²²¹ El mundo, La digitalización del consumo en México, November 30, 2021, Accessed May 2, 2022, Referenced from: <https://www.diarioelmundo.com.mx/index.php/2021/11/30/la-digitalizacion-del-consumo-en-mexico/>

argument that reinforces the previous postulate is the United Nations Conference on Trade and Development, which warns of Mexico's lag in achieving sustainable development and adequate preparation for the new world technological scenario.²²²

Therefore, Mexico should consider what was suggested by the United Nations at the end of the first year of the pandemic (2021), which was to emphasise encouraging digital literacy and familiarity with technology. Companies and society must adapt to a world of constant transformation while maintaining business competitiveness. And in general, all companies must adopt agile methodologies in their business areas, allowing them to innovate and make their processes efficient.

8.2 Virtual reality

The metaverse, or virtual reality, has existed since 2003; in the future, we will be immersed as a participating public in a new form of virtual interaction.

Companies such as Facebook and others worldwide are involved in technology development to create or design a series of technological products in which innovation interacts and gives life to this digital possibility of coexistence.

In a forecast mentioned by Bloomberg, the metaverse will have investment figures of around 700 billion dollars in 2024, of which half will be in the world of video games and the rest in other markets such as culture or sports²²³.

The economic impact in Mexico of Virtual Reality (VR) and Augmented Reality (AR) technology in 2020 was 15.6 billion dollars, according to Statista.

In Mexico in 2019, more than 120 thousand primary education students from 400 private schools tested a new pedagogical model called "Augmented Learning," in which students and teachers used devices such as iPads, drones, and virtual reality glasses to be part of unique and so far, different experiences in terms of learning.

²²²Institute of Management Development, Word Digital Competitiveness Ranking 2021 Accessed May 2, 2022, Referenced from <https://www.imd.org/centres/world-competitiveness-centre/rankings/world-digital-competitiveness/>

²²³Forbes México, Forbes Life, Metaverso: La nueva realidad virtual y social que llama a tu puerta, April 9, 2022, Accessed May 10, 2022, Referenced from: <https://www.forbes.com.mx/forbes-life/tecnologia-metaverso-realidad-virtual/>

Santillana(Grupo Editorial), through its company UNOi, presented this educational model as an alliance with Google and Apple.²²⁴

An example of virtual reality used in Mexico is real estate; this sector allows buyers to know how their new home will be in the pre-sale stage while the development is being built. For this type of virtual development, those involved in Mexico are companies like CoDesign,²²⁵ Plus interactive²²⁶ and VRMx Studios.²²⁷

Virtuelle²²⁸ is a Mexican startup that has developed a more specialized solution called DriVR, a virtual reality simulator to assess the risk of drivers behind the wheel through simulated situations in a digital environment. This system allows companies to select their personnel, evaluate them and train them to improve their driving skills, which helps reduce the number of accidents and their severity.²²⁹

Although virtual reality involves creativity to excel in competitive developments and provide exciting experiences for people, companies must consider practical IT issues such as cost, security, infrastructure, and ownership.

Grandview Research mentions that half of the 18% compound annual growth in virtual reality sales expected through 2028 will occur in retail stores, auto showrooms, and real estate offices.²³⁰

8.3 Big Data Analysis

Big Data analysis is the processing of massive amounts of data to extract business insights or relevant information on a specific topic. According to a study by IDC and InterSystems, 75% of organizations lose business opportunities by not being able to analyze large amounts of data in real time.

²²⁴ Milenio, Negocios, Realidad virtual y drones llegarán a la educación básica en México, October 16, 2019, Accessed April 22, 2022, Referenced from: <https://www.milenio.com/negocios/realidad-virtual-drones-llegaran-educacion-basica-mexico>

²²⁵ <https://www.codesign.mx/>

²²⁶ <https://plusinteractive.mx/pl/index.html>

²²⁷ <https://vrmx.net/>

²²⁸ <https://virtuelle.com.mx/>

²²⁹ Palomera Ivan, Realidad virtual, se acabaron los límites, Forbes MÉXICO, Red Forbes May 15, 2020, Accessed April 27, 2022, Referenced from: <https://www.forbes.com.mx/realidad-virtual-se-acabaron-los-limites/>

²³⁰ <https://www.grandviewresearch.com/>

In addition, for the fourth consecutive year, NewVantage Partners' 2022 Big Data and AI Executive Survey²³¹ report shows that 90% of executives prioritize investments that involve improved data analytics capabilities. The advantages and benefits cited by executives about Big Data are.²³²

- Make more effective business decisions.
- Know customers, competitors, and the overall market better.
- Detect more secure investment opportunities.
- Improve internal business processes and enhance service delivery.
- Design more robust and cost-effective business strategies.
- Increase business scalability.
- Provide clarity and predictability to management.

The Mexican Big Data market had a record growth of 7.5% in 2021, bringing investments of more than 1.8 billion dollars, revealed the analyst firm IDC, who also considers that this market represents one of the segments with the most significant activity strategic emphasis in Latin America.

In Latin America, the Big Data and analytics market represented an investment of more than US\$8 billion in 2021, which translated into a growth of 9% in Latin America compared to 2020. IDC also considers that by 2025, the Big Data market in Latin America will be 10.5%, while in Mexico, it will be 11%.²³³

The research firm IDC estimates that in 2021 the world Investment in Big Data and data analytics was 215.7 billion dollars, 10.1% more than in 2020. IDC also foresees a strengthening panorama during the next five years as the world economy recovers from the COVID-19 pandemic.

Among the obstacles that Mexican companies encounter regarding the adoption of Big Data we find:

²³¹ Bloomberg, Noticias, NewVantage Partners Releases 2022 Data And AI Executive Survey, January 3, 2022, Accessed April 22, 2022, Referenced from: <https://www.bloomberg.com/press-releases/2022-01-03/newvantage-partners-releases-2022-data-and-ai-executive-survey>

²³² Lemontech Blog, Estrategia, Análisis Big Data en negocios tradicionales: ¿Cómo aplicarlo?, October 31, 2019, Accessed April 22, 2022, Referenced from: <https://blog.lemontech.com/analisis-big-data/>

²³³ Segundo Luis Pablo, Negocios, Inversiones en 'big data' superarán los mil 800 mdd en México al cierre de 2021: IDC. Milenio, November 11, 2021, Accessed April 22, 2022, Referenced from: <https://www.milenio.com/negocios/inversiones-big-data-superaran-mil-800-mdd-mexico-idc>

- The cost of infrastructure
- Security costs
- Operational costs
- Lack of management support
- Lack of technical skills

Despite the popularity of Big Data, 63% of Mexican companies do not know how to approach the technology, and 11% consider it irrelevant to their business. Only 26% of companies say they understand the benefits of the technology. This figure contrasts with 28% for the Latin American region, 39% for North America, and far from the leading region, the Asia Pacific, with 49%.

8.4 Artificial Intelligence in data centres

Artificial Intelligence (AI) represents one of the most significant opportunities and challenges to improve data centre processes and efficiency.

Using AI in Mexico is a meaningful way to benefit public and private organizations. However, Mexico has a lack of professionals and knowledge that limits the transformation of AI.

In 2018 the British Embassy in Mexico and financed by the Prosperity Fund, carried out an analysis called "Towards an AI Strategy in Mexico"²³⁴, it mentions that 19% of jobs in Mexico (9.8 million jobs) will be affected by automation in the next two decades. The two sectors with the most significant impact in Mexico will be manufacturing and construction.²³⁵

The same analysis also points out that according to the Oxford Insights AI Government Readiness Index, Mexico ranks 22nd out of 35 OECD countries. The country's good rating is due to its digital infrastructure and open data policies, but it scores poorly in technology skills, digitization, and innovation in the public sector. Conditions that are important to implement AI successfully.

²³⁴ Bristish Embassy Mexico City, Oxford Insights, CMinds, Hacia una Estrategia de IA en México, June 2018, Accessed April 23, 2022, Referenced from <https://ia-latam.com/portfolio/hacia-una-estrategia-de-ia-en-mexico-aprovechando-la-revolucion-de-la-ia/>

²³⁵ Ruiz Belem, Inteligencia Artificial en México: avances, retos y oportunidades, My Press, noticias y negocios, February 13, 2021, Accessed April 23, 2022, Referenced from: <https://www.mypress.mx/tecnologia/inteligencia-artificial-mexico-avances-retos-oportunidades-4670>

Some examples of the adoption of AI in Mexico are in federal agencies, such as the Secretariat of Tax Administration (SAT), whose function allows identifying fraudulent transactions. The Ministry of the Interior (SEGOB) to know the incidence of aggression against journalists and human rights defenders and the Ministry of Health for patient monitoring and care. Other uses or implementations of AI include the one used in Mobility System 1 in Mexico City, which, together with the British firm Datank, used GPS data from buses to create a more efficient departure system. Similarly, the Metro Collective Transportation System (STC) sought to make the flow of passengers 10 to 15% more efficient through AI, so large sets of data were analyzed and based on computer systems, it was possible to reduce boarding alighting times in train cars.²³⁶

In Mexico, there are initiatives such as the Mexican Society of Artificial Intelligence (SMIAS for its acronym in Spanish)²³⁷, a scientific society whose mission is to promote the cultivation and application of AI in Mexico.

The group has professionals as academics in the area, to whom the community offers an organizational and management framework to share and disseminate their research projects, teaching, liaison, or dissemination of the discipline. SMIA is in charge of several publications and annually organizes the Mexican International Congress on Artificial Intelligence (MICAI), which allows disseminating the production of its members in the field of research and development.

A survey by Morning Consult at the request of IBM indicates three main barriers that Mexican firms consider to AI adoption:

- Limited AI experience or knowledge.
- Lack of tools or platforms to develop AI models
- Data complexity and data silos

Only 14% of Mexican companies have already implemented AI as part of their business operations.²³⁸

²³⁶ Ruiz Belem, Inteligencia Artificial en México: avances, retos y oportunidades, My Press, noticias y negocios, February 13, 2021, Accessed April 23, 2022, Referenced from: <https://www.mypress.mx/tecnologia/inteligencia-artificial-mexico-avances-retos-oportunidades-4670>

²³⁷ <http://smia.mx/>

²³⁸ Expansión, tecnología, Estas son las barreras para la adopción de la Inteligencia Artificial en México, september 10, 2021, Accessed April 23, 2022, Referenced from: <https://expansion.mx/tecnologia/2021/09/10/estas-son-las-barreras-en-la-adopcion-de-inteligencia-artificial-en-mexico>

As today's networks become more complex and distributed, and the metaverse demands of augmented and virtual reality become more critical, real-time computing and decision-making will become more critical. This real-time need is sensitive to latencies and, under an increasingly common hybrid model of enterprise, public and private clouds, communications, and network edge, full-time manual management becomes impractical, if not impossible. Artificial intelligence (AI) and machine learning will be critical to optimizing the performance of these networks. The availability of AI hardware from established vendors, cloud options for AI, a simplified toolchain and an educational focus on data science have put AI in place for even the smallest companies. All adds to speed up the adoption of AI.²³⁹

8.5 Implementation of automation

In Mexico, organizations have envisioned and set in motion a new stage in which the production system works in a hybrid way, fully verified and operational, thanks to the challenges that arose due to the pandemic of COVID-19. These were faced by the benefits of automation, digitization, cloud, and others granted to perform operations remotely in the same efficient and effective way that were carried out in the classic work office.

According to Deloitte, the industrial sector seeks to transform itself more profoundly among all productive activities. Industry 4.0 promises a new revolution that combines advanced production and operations techniques with intelligent technologies that will be integrated into organizations, people, and assets.

Despite the global growth of industry 4.0, there are factors that industries depend on to accelerate automation: new technologies implemented in production lines and industrial manufacturing processes, such as intelligent sensors.²⁴⁰

Mexico's manufacturing industry in 2022 will invest 3.5 billion dollars in technology; the investment will bring the manufacturing sector where it was before the

²³⁹ Vertiv, Las tendencias del centro de datos de 2022, Accessed May 13, 2022, Referenced https://www.vertiv.com/es-latam/about/news-and-insights/articles/pr-campaigns-reports/vertiv-2022-data-center-trends/?utm_source=datacenterdynamics&utm_medium=paid-display&utm_campaign=architects-of-continuity&utm_term=branding&utm_content=es_300x250_image-ad_news-release-page

²⁴⁰ HANNOVER MESSE, Industrial Transformation MEXICO, October, 2021, Accessed May 13, 2022, Referenced from: <https://industrialtransformation.mx/industria-en-mexico-aprovecha-automatizacion-para-ir-hacia-la-industria-4-0/>

pandemic. The industries are interested in adopting Industry 4.0, using robotics, IA, big data, virtual reality and IoT, but the adoption rate is slow.²⁴¹

Mexico annually consumes nearly 750 million dollars in automated systems with inspection, welding, and assembly robots. However, there is a number close to 70 billion dollars that require updating and replacing robots and automation, given the industrial composition of Mexico, which requires a high investment.

One of Mexico's biggest challenges for automation is the lack of qualified engineers and technical staff. The engineers available have skills below the average in other countries, as stated by the World Bank digital skills measurement that rated Mexican's skills with 3.8 points, below Costa Rica, Argentina and Chile. ²⁴²

²⁴¹ SDI, Industria manufacturera invertirá 3,500 millones de dólares en tecnología 2022, February 2022; Accessed May 13, 2022, Referenced from: <https://sdindustrial.com.mx/blog/industria-manufacturera-en-mexico-invertira-3500-millones-de-dolares-en-tecnologia-en-2022/>

²⁴² Arena Publica, ¿A qué se enfrentan las empresas mexicanas para implementar la automatización? January 30, 2022 Accessed May 3, 2022, Referenced from <https://www.arenapublica.com/negocios/que-se-enfrentan-las-empresas-mexicanas-para-implementar-la-automatizacion>

9 New data centre projects in Mexico

The Mexican state Queretaro is an important location for establishing data centres. The geographic location is a bridge between the United States and Latam. The state has invested in fibre optic infrastructure and assuring energy supply.²⁴³ 20 new data centres are planned to be in Queretaro, including Amazon Webs and Asenti.²⁴⁴

The International Computer Room Experts Association (ICREA) recently showed that at least five mega data centre projects are to be developed in the next few years in Mexico, representing an investment of 300 million dollars.²⁴⁵

2019-2020 Data Centre market trends in Mexico, large companies have already realized that Mexico has all the cards to become the following Data Centre Hub in Latin America. Proof of this has been the creation of new technological facilities in Mexican cities, such as the recent inauguration of Schneider Electric's²⁴⁶ new intelligent plant last July in Monterrey. Also, the Spanish multinational cloud services company Gigas has announced that it expects to close acquisition agreements with local cloud companies. The company ASCENTY (Subsidiary in Latam of Digital Realty Trust) is also looking at Mexico as the next destination for its investments in the Datacentre.²⁴⁷

The cloud computing company, Nutanix, announced that it would continue to expand its business in Mexico with a new global support centre in Mexico City and new team members in Monterrey to expand services in the country's northern region.

²⁴³ Estrella, Vivian, Querétaro se perfila como núcleo de centros de datos: Sedesu; June 20, 2022

Accessed August 8, 2022, El Economista Referenced from

<https://www.economista.com.mx/estados/Queretaro-se-perfila-como-nucleo-de-centros-de-datos-Sedesu-20220620-0097.html>

²⁴⁴ Ruiz, Hayde, Entre los 20 data centers en querétaro, se está a la espera de la confirmación de la instalación de Google, AM Queretaro May 15, 2022 Accessed August 8, 2022, Referenced from <https://amqueretaro.com/queretaro/estado/2022/05/15/se-instalaran-20-data-centers-en-queretaro/>

²⁴⁵ Riquelme Rodrigo, México, a punto de convertirse en el segundo hub de centros de datos de América Latina: Panduit, , El economista, centros de datos, March 24, 2022, Accessed May 3, 2022, Referenced from: <https://www.economista.com.mx/tecnologia/Mexico-a-punto-de-convertirse-en-el-segundo-hub-de-centros-de-datos-de-America-Latina-Panduit-20220324-0064.html>

²⁴⁶ <https://www.se.com/mx/es/work/campaign/planta-6-monterrey/>

²⁴⁷ Prensario TI LantiAmerica; Tendencias del mercado de Centros de Datos en México: ¿Nuevo Hub latinoamericano? July 14, 2021 Accessed May 3, 2022, Referenced from [Tendencias del mercado de Centros de Datos en México: ¿Nuevo Hub latinoamericano? - Prensario Tila](https://prensariotila.com/tendencias-del-mercado-de-centros-de-datos-en-mexico-¿nuevo-hub-latinoamericano?)

ODATA, a Brazilian origin, the leader in Data Centre infrastructure in Latin America, with four data centres already in operation in Brazil and Colombia and two more new projects in Santiago de Chile and Rio de Janeiro (Brazil). Odata Has invested in its first data centre in Mexico. The centre offers neutral connectivity and colocation solutions, i.e., hosting of privately owned servers and network equipment in IT rooms, adapted to the requirements of any market sector, with high standards of security and operational excellence. The centre is located in Parque Industrial Queretaro.

Zoom Video Communications announced the start of operations of its Mexican Data Centre, located in Quintana Roo. This is Zoom's first co-located data centre in the country, with 21 co-located data centres worldwide and in the public cloud. Zoom's co-located data centres are currently hosted in these regions: Canada, China, Europe, India, Japan/Hong Kong, Latin America, and the United States.²⁴⁸

Bloomberg reports Amazon is nearing a deal with the Mexican federal government to open a new data centre in the central state of Queretaro. An announcement is reportedly expected soon, although no date has been set. AWS already has two CloudFront Edge locations in Querétaro.²⁴⁹

Oracle announced opening a new cloud region in the state of Querétaro, its first in the country. The new Querétaro region is Oracle's 39th worldwide cloud region and will offer customers OCI and Oracle Fusion Cloud Applications services. The Oracle general manager mentioned, "The Oracle Cloud Querétaro region offers organizations a wide range of services, including access to emerging technologies, to help improve the customer experience and positively impact the country's innovation ecosystem."²⁵⁰

Mexico, an emerging market in the data centre industry

Mexico is an emerging market in the data centre industry; the growth it has experienced has been to the flexibility of the regulatory standard that allows the

²⁴⁸ TecnoEmpresa, Zoom anuncia Data Centre en México, June 2, 2021 Accessed May 3, 2022, Referenced from <https://tecnoempresa.mx/index.php/2021/06/02/zoom-anuncia-data-centre/>

²⁴⁹ DataCenter Dynamics Report: AWS planning data center region in Queretaro, Mexico December 10, 2021 Accessed May 3, 2022, Referenced from <https://www.datacenterdynamics.com/en/news/report-aws-planning-data-center-region-in-queretaro-mexico/>

²⁵⁰ Swinhoe Dan, Oracle opens Mexico cloud region in Querétaro, June 30, 2022, Accessed July 3, 2022, Referenced from <https://www.datacenterdynamics.com/en/news/oracle-opens-mexico-cloud-region-in-quer%C3%A9taro/>

construction of specific facilities according to the organisations' needs and the world's current dynamics.

Mexico played a leading role in recent years, thanks to its data centre construction standard. The only one in the world endorsed by the International Computer Room Experts Association (ICREA), which seeks the correct and continuous operation of data centres in the various market segments (financial institutions, telecommunications companies, among others).

According to Market Watch, by 2023, the global data centre market will reach a value of more than 174 billion dollars; in the case of Mexico -the second-largest market in the region, only behind Brazil.

Therefore, companies such as ABB, IBM, and Schneider Electric have positioned themselves in the country as leaders in integrated physical infrastructure solutions for data centres. In addition to modernizing, optimize their performance, space, and availability to make them scalable, resilient, sustainable and able to support the growing demands of digital life.²⁵¹

The National Autonomous University of Mexico (UNAM) is worth mentioning within the Mexican data centre, which has the most extensive scientific data storage in Mexico, thanks to the incorporation of a data centre and high-performance computing at the Institute of Nuclear Sciences (ICN).

9.1 Key players

In the following section, we present a list of the data centre in Mexico and the services they provide.

9.1.1 Data centres

9.1.1.1 Ascenty

[Ascenty Data Centres Mexico](#)

Queretaro, Queretaro.

The two Data Centres in Mexico today have 52MW of available energy and 44,000m² of total area. In addition to high quality and redundancy in the infrastructure, the Data Centres offer excellent

²⁵¹ Heraldo de Mexico, México, mercado emergente en la industria del data center, January 7, 2021, Accessed May 3, 2022, Referenced from <https://heraldodemexico.com.mx/tecnologia/2021/1/7/mexico-mercado-emergente-en-la-industria-del-data-centre-242623.html>

connectivity through their fiber-optic network or connections with different companies in the market.

9.1.1.2 Digital Realty

Digital Realty

Querétaro, Queretaro.

Fast-growing industrial and hight-tech-centre

Dedicated electrical substation Uptime Institute Level III design, direct connection to Mexico IX, utility power capacity 31.000 kW

Total building size 258.000 ft², UPS redundancy N+1, 2N

Cooling plant redundancy N+1.

9.1.1.3 Disaster Recovery

SDR México

Mexico City, CDMX.

ICREA level III certified Data Centre.

High availability is located 30 miles from Mexico City. located in Metepec, State of Mexico Facilities are designed and built based on world-class requirements. Alternate on-site and off-site vaulting workstations.

9.1.1.4 Equinix

Equinix

Queretaro, Queretaro.

Equinix has two data centres in Mexico. One in Queretaro City and the other location in Monterrey.

9.1.1.5 HostDime Mexico

HostDime Mexico

Guadalajara, Jalisco.

Approximately 3,000 square feet.

2-story building with concrete perimeter walls.

Work desk and client lounge. Meeting room.

9.1.1.6 KIO Networks

KIO Networks

They offer SaaS, PaaS and IaaS services, Data Analytics, Cyber Security.

40 data centre distributed in Mexico, Central America, Caribbean and Europe

9.1.1.7 Nabiax

Nabiax

Ixtlahuaca, State of Mexico.

The Ixtlahuaca Data Centre is located near the Toluca International Airport (Mexico) and less than 90 km from Mexico City. A 2.2 MW IT power supply, 1,800 square meters of IT floor space built in a 100% Carrier Neutral ecosystem. Tier III certified.

9.1.1.8 NGX Networks DC01

NGX Networks

Nogales, Sonora.

Data Centre in Mexico just across the border from the United States. Data centre with multiple carriers, A+B power protected by Vertiv UPS, dual generac generators, and Vertiv N+1 precision cooling systems, Honeywell fire suppression system using 3M Novec agent, 24x7 CCTV system, and world-class security.

9.1.1.9 Odata

Odata

Queretaro, Queretaro.

The Data centre in Queretaro is the first one Odata built in Mexico. Odata has seven more data centres located in South America.

9.1.1.10 redIT.DataPark, redit Santa fe, red it interlomas and Monterrey

redIT

Mexico City, CDMX.

The first phase is two neutral data centres of 11625 square feet each, operating in 2012 for wholesale data centre services and retail colo, cloud services, virtualization, DRP, business continuity, and information security, among other benefits.

redIT.DataPark is the new redIT concept to offer complete sales services in a highly reliable POD (Power Optimized Data Centre) idea, seeking an efficient operation under LEED standards and physical security for critical functions for customers.

It is located near the Mexico City area American Tower Telecommunications Company.

9.1.1.11 Triara

Triara

Queretaro, Queretaro.

Triara is the brand name for TELMEX data centres. Triara has two centres, one in Queretaro and the second in Monterrey. Both centres have ICRC level 5 certification. Providing cloud services for private and public organizations. SAP Hosting Services; SAP in Cloud Services.

9.1.1.12 Web Hosting Dedicated Servers

Web Hosting and Dedicated Servers

Manzanillo, Colima.

Web Hosting and Dedicated Servers. The services include Hosting, Domains, Virtual and Dedicated Servers, MX Backup, Ftp Backup, Audio, and Video Streaming.

9.1.1.13 Zoom Video Communications

<https://explore.zoom.us/es/>

Quintana Roo.

Zoon announced the start of operations of its Mexican Data Centre, located in Quintana Roo. Due to the increasing demand in the Mexican market.

9.1.2 Cloud Services

9.1.2.1 Alestra

Alestra - Data Centres

Queretaro, Monterrey y Guadalajara.

Cloud services, Big Data, mobility, high availability, mission-critical services, and geographic redundancy in multi-Tier (different levels of certification and redundancy) and multi-density (different energy levels per rack) environments.

9.1.2.2 AWS (Amazon Web Services)

Amazon Web Services

Querétaro, México.

AWS already has two CloudFront Edge locations in Querétaro Zone Cloud platform, offering everything from infrastructure technologies such as compute, storage, and databases to emerging technologies such as machine learning and artificial intelligence, data lakes and analytics, and the Internet of Things.

9.1.2.3 Axity

[IT and Communications Services](#)

Mexico City, CDMX.

Integrates a portfolio of services with solutions in cybersecurity, IT management, applications, digital transformation, and technology in which Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) stand out.

9.1.2.4 Azure Mexico

[Microsoft Azure](#)

Mexico City, CDMX.

Azure provide services in Mexico.

9.1.2.5 Bestel.

[Bestel](#)

Mexico City, CDMX.

Offers SaaS cloud services with CenturyLink, Rackspace, Limelight; public cloud with Century Link; IaaS with Rackspace and Data Centre Services (Data Centre Design Awareness).

9.1.2.6 Cisco

[Cisco – Mexico](#)

Mexico City, CDMX.

Integrations with container and cloud solutions offer options when running applications on-premises and in the cloud. Cisco Umbrella, a cloud-native security service accessible anytime, anywhere.

9.1.2.7 C3ntro Telecom

[C3ntro Telecomm](#)

Mexico City, CDMX.

Telecommunications service provider We design customized managed solutions with the best support and infrastructure.

SaaS, PaaS and IaaS cloud services.

9.1.2.8 Computing Centre of the Mexico Development

Centre of the Autonomous University of Nuevo Leon

[Mexico Development Centre of the Autonomous University of Nuevo Leon Data Centre](#)

Monterrey, Nuevo León.

9.1.2.9 Equinix

[Mexico Customer Resource Centre](#)

Queretaro, Mexico.

Monterrey, Nuevo Leon

Offers SaaS, PaaS and IaaS services.

9.1.2.10 Fujitsu

[Fujitsu Global:](#)

Cloud solutions such as IaaS (public, private, and local cloud services) and SaaS (subscription services, including applications for office productivity enhancement, customer relationship management).

9.1.2.11 HPE (Hewlett Packard Enterprise)

[Hewlett Packard Enterprise \(HPE\) | Mexico](#)

Mexico City, CDMX.

Cloud services, Network connectivity, SAP, storage, security risk compliance, virtualizations.

9.1.2.12 Huawei Cloud

[HUAWEI Mobile Cloud](#)

Hybrid cloud solutions

Media and entertainment

HPC in the cloud

9.1.2.13 IBM

[IBM Cloud for VMware Solutions - México](#)

Mexico City, CDMX.

IBM Cloud® for VMware Solutions.

9.1.2.14 IPXON

[IPXON Mexico](#)

Guadalajara, Jalisco.

Infrastructure as a Service (IaaS) provider.

9.1.2.15 Level 3 Mexico, S. de R.L. de C.V.

[Level 3 Mexico](#)

Ciudad de México, CDMX.

SaaS, PaaS, and IaaS services Level 3's submarine cable, called "Pan-American Crossing (PAC)", connects Mazatlán with the western United States, Costa Rica, and Panama, thus becoming

an outlet for business traffic on the Pacific side and an alternative to the cables of, for example, AT&T and América Móvil that connect the country via the Atlantic.

9.1.2.16 NexoIT

[NexoIT](#)

Naucalpan, Estado de México

Multichannel services B2C (Business to Consumer) and B2B (Business to Business) modalities.

9.1.3 Data Centre Providers

9.1.3.1 Altan Redes Shared network

<https://www.altanredes.com/>

Placement services. Design, and operate network infrastructure.

9.1.3.2 Cyxtera

[Cyxtera Bare Metal](#)

Cyxtera Enterprise Bare Metal offers the security, control, and performance of dedicated colocation infrastructure in an on-demand model.

9.1.3.3 Data Evolution

[Data Evolution](#)

[Consulting and Design \(dataevolution.com.mx\)](#)

Tlalnepantla de Baz, State of Mexico.

Services Design, development and data centre certification.

ANSI/TIA-942, LEED.

9.1.3.4 Dell Technologies

[Dell Technologies](#)

Mexico City, CDMX

Cloud infrastructure provider across public and private clouds for a hybrid cloud experience.

9.1.3.5 Equinix

[Equinix](#)

[Mexico City Data Centres and Internet Exchange Point: Equinix Interconnection Services](#)

Querétaro, México.

Virtual services through their data centres industry-leading level of computing services and networking and security.

9.1.3.6 Gold Data

[Gold Data - Our Network](#)

Tijuana, Baja California

Strategic points of presence, submarine capacity, and last-mile access. Connectivity solutions such as Cloud Connection, Broadcasting Solutions, and Network Security.

9.1.3.7 Google Cloud

[Google Cloud](#)

Mexico City, CDMX.

Data Centre services, as well as IaaS, SaaS, and PaaS services.

9.1.3.8 HostDime

[Host Dime](#)

Guadalajara, Jalisco.

These data centres provide various cloud services, include cloud servers, colocation services, and bare-metal servers.

9.1.3.9 Insys

[Insys](#)

Mexico City, CDMX.

Data Quality. Profiling. Data cleaning. Intelligence and data analysis. Intelligent data analysis. Information generation for decision making. Design and Development of dashboards. Definition of KPI's and Metrics.

9.1.3.10 Iron mountain

[Iron Mountain](#)

Network and data centre interconnection services low-latency, high-capacity connections. From a cross-connect to a global MPLS deployment with hundreds of Gbps Internet capacity, peering, connections, and hundreds of cross-connects.

9.1.3.11 ITW Technology

[ITW Technology](#)

Mexico City, CDMX.

Infrastructure automation engine, drives IT collaboration, and increases the speed and flexibility of IT service delivery.

9.1.3.12 Nexoit

[Nexo IT](#)

Naucalpan de Juárez, State of Mexico.

Serveris

[Serveris - Data Centre](#)

Mexico City, CDMX.

IT Infrastructure as a Service (IAS) services, dedicated servers, private clouds, data storage, and backup services, among other services.

9.1.3.13 Telmex

[Telmex](#)

Mexico City, CDMX.

Comprehensive solutions that include hosting and managing infrastructure High Availability Data Centre Services / ICREA Level V (99.999%) ICREA Level III (99.90%).

9.1.4 Government and regulatory bodies

9.1.4.1 Energy Control Centre (CENACE)

<https://www.gob.mx/cenace/>

9.1.4.2 Energy Regulatory Commission (CRE)

<https://www.gob.mx/cre>

9.1.4.3 Federal Electricity Commission (CFE)

<https://www.cfe.mx/>

9.1.4.4 Federal Telecommunications Institute

<http://www.ift.org.mx/>

9.1.4.5 Federal Commission for Regulatory

Improvement (COFEMER)

<https://www.gob.mx/conamer>

- 9.1.4.6 National Commission for the Efficient Use of Energy (CONUEE)
<https://www.gob.mx/conuee>
- 9.1.4.7 National Institute of Electricity and Clean Energies (INEEL)
<https://www.gob.mx/ineel>
- 9.1.4.8 Secretariat of Communications and Transportation (SCT)
<https://www.sct.gob.mx/>
- 9.1.4.9 Secretariat of Energy (SENER)
<https://www.gob.mx/sener>
- 9.1.4.10 Secretariat of Economy
<https://www.gob.mx/se>

10 Challenges and Opportunities for the Establishment of Data Centres

10.1 Challenges

10.1.1 Key challenges for data centres in Mexico

The main challenges for data centres in Mexico are energy and water availability.

The New Energy Reform was rejected in April 2022, but the Federal government has blocked private investments and caused chaos and uncertainty. The investment in transmission infrastructure has been reduced, and under Mexican law, this is an area where only the government can invest.

To attract investment, Private players' conditions and policies for energy generation should be clear and legal.

Mexican states are playing a vital role in driving renewable energy sources through their Energy Agencies that promote energy efficiency in their states.

The state of Queretaro signed last June, a strategic alliance with the Canadian company Solfium to increase the use of solar energy in the state. The project involved solar power for housing and business, including large projects.²⁵²

Water is needed to help in the cooling process of data centres. The water problem in Mexico has been caused for over-exploitation of water resources, deforestation, contamination of bodies of water and climate change.

This year has mainly been complicated in the northern states of Mexico, with a severe drought affecting the states of Nuevo León, Coahuila, Chihuahua, Sonora and Baja California. ²⁵³

The Mexican government recently implemented an Official Mexican Standard (NOM) NOM-001-SEMARNAT-2021 that establishes the permissible limits for pollutants in wastewater discharged into state-owned bodies of water requiring additional treatment for the discharge of wastewater by industrial companies. The new standard is a way to diminish contamination of water bodies.

²⁵² Estrella, Viviana, Solfium y Querétaro crean alianza para impulsar el uso de energía solar, El Economista June 21, 2022, Accessed August 9, 2022, Referenced from: <https://www.eleconomista.com.mx/estados/Solfium-y-Queretaro-crean-alianza-para-impulsar-el-uso-de-energia-solar-20220621-0026.html>

²⁵³ Expansión, Estados con sequía en México en 2022: ¿dónde no hay agua?, Junio 25, 2022, Accessed August 9, 2022, Referenced from <https://politica.expansion.mx/estados/2022/06/25/estados-sequia-en-mexico-2022>

10.1.2 Security challenges facing data centres²⁵⁴

Data centres are one of the main objectives of cyberattacks; security is critical; some of the aspects to consider are:

- I. Physical security, protection against intruders and measurements in case of a disaster such as water leaks, fire and cooling system failure.
- II. Data recovery, outages, ransomware, and corrupted data can affect digital content and information.
- III. Power outages, backup power supplies.
- IV. Real-time site monitoring, who's in and who's out.
- V. Social engineering is malicious activities accomplished through human interactions. The employees must be trained to prevent it and have an internal policy of cybersecurity, detection of corrupted sites, emails, phishing etc.

10.1.3 IoT: the big challenge for data centres²⁵⁵

Today, a large volume of data and information is coming from all the devices connected to the cloud, which will increase in the coming years. The number of intelligent house devices in Latam in 2018 reached 76 million, and it is expected that the number will be 280 million by 2023 and more than 93 million only in Mexico. For optimal operation of IoT connectivity, quality and speed are factors to consider. In 2018 the average speed in Latam was 11.7 Mbps. It is expected that by 2023 will be 30.1Mbps, and for Mexico, 33.5Mbps.²⁵⁶

Data centres need to be prepared to cover the IoT demand and guarantee the process of the big growing data, besides considering security, privacy, storage, network, and bandwidth.

²⁵⁴ González Encarna, Los 5 principales desafíos de seguridad que deben afrontar los centros de datos. Bitl Life Media, April 5, 2022 Accessed May 3, 2022, Referenced from <https://bitlifemedia.com/2022/04/centros-de-datos-desafios-seguridad/>

²⁵⁵ Actions Data, IoT el gran desafío de los centros de datos, June 18, 2022 Accessed July 3, 2022, Referenced from <https://www.actionsdata.com/blog/iot-el-gran-desafio-de-los-centros-de-datos>

²⁵⁶ Hernández Mauricio, Internet de las Cosas: una oportunidad de negocio de casi 6 mil mdd en México, Forbes Mexico December 20, 2019 Accessed July 3, 2022, Referenced from <https://www.forbes.com.mx/internet-de-las-cosas-una-oportunidad-de-negocio-de-casi-6-mil-mdd-en-mexico/#:~:text=Otro%20dato%20que%20confirma%20el.millones%20tan%20s%C3%B3lo%20en%20M%C3%A9xico>

10.1.4 Key points of the new approach to be considered by data centre managers in the new normal.²⁵⁷

During the Pandemic, data centres were the key to continuing countless activities worldwide. The new normal is continuity in business operations. Today is critical given that the digital channel has become the main (and in many cases the only) means of contact between employees, partners, or customers and the organization's data.

And to guarantee an optimum level of operations data centre must comply with the respective industry procedures, standards, and certifications.

A vital factor to consider is energy: the information and communication technology (ICT) predicts that by 2025 electronic products will use 20% of global electricity and emit 5.5% of all carbon emissions, which could reach 14% by 2040, from internet-connected devices, high-resolution photos, emails, streaming videos, cell phones, etc. In addition, global energy consumption is expected to triple in the next five years.

Data centres today consume more than 2% of all global electricity and will also see exponential growth. At the current growth rate, data centres could consume 6% of the world's energy by 2025.

Mexico leads Latin America in the efficient use of energy. The National Commission for the Efficient Use of Energy (Conuee), has 32 Mexican Official Standards (NOM)²⁵⁸ on the subject and has played a fundamental role in achieving this leadership.²⁵⁹

10.2 Opportunities

10.2.1 Opportunities for Data Centers

The increase in data volumes, driven mainly through connected devices, has caused companies to re-evaluate their IT infrastructures to meet ever-increasing consumer demands, IT managers are choosing to move their facilities closer to the end-user or the Edge.

The main opportunities for supplying data and edge centres in Mexico in the coming times will be in:

²⁵⁷ Technio, Nuevos desafíos para los centros de datos, November 1, 2022, Accessed May 3, 2022, Referenced from <https://technocio.com/nuevos-desafios-para-los-centros-de-datos/>

²⁵⁸ Mexican Standards Energy efficiency <https://www.gob.mx/conuee/acciones-y-programas/normas-oficiales-mexicanas-en-eficiencia-energetica-vigentes>

²⁵⁹ Serrano Raúl, México encabeza la eficiencia energética en Latinoamérica, September 20, 2019, Iluminet Accessed May 3, 2022, Referenced from <https://www.iluminet.com/mexico-encabeza-eficiencia-energetica-latinoamerica/#:~:text=M%C3%A9xico%20encabeza%20en%20Latinoam%C3%A9rica%20el%20uso%20eficiente%20de,su%20creaci%C3%B3n%20el%2028%20de%20septiembre%20de%202019>.

1. Infrastructure:
 - i.Fiber optic
 - ii.Thermic efficiency to control the temperature, saving energy.
 - iii.Cables Standard 6, copper and Rj45 connectors.
 - iv.Power over Ethernet (PoE)
 - v.Interconnection Core points
 - vi.Multiple access connectivity
 - vii.Redundancy in the electric system
 - viii.Last generation equipment
 - ix.Modular and scalable

2. Cybersecurity
 - i.Distance virtual filters
 - ii.Access control to data centres
 - iii.Remote monitoring
the Edge Centers

The Edge data centres are one of the most significant opportunities. In Mexico, Edge data centres have been designed and implemented agilely in different cities, all with designs and availability comparable to those currently operating in other regions of the United States and Europe. However, one of their challenges is the speed at which connectivity is growing in the country. Despite this aspect, the opportunity lies in the ability to implement reliable facilities throughout the country. States such as Baja California, Sonora, Sinaloa, and Chihuahua have joined the Edge developments.²⁶⁰

Currently, in Mexico, there are nearly 100 Edge data centres. In 2019, the Edge market in Mexico was worth 5.2 billion, with a growth rate of 23% by 2026. The 5G and the use of IoT will increase the use of the edge.

Edge Data centres can be deployed in medium cities where budgets are tight for the infrastructure of large data centres, and Edge centres can be used to connect and provide better services.²⁶¹

²⁶⁰ DCD, La transformación del negocio tradicional de centros de datos a través del Edge Computing ¿Qué tiene que hacer México para estar preparado ante la demanda creciente de infraestructura Edge?, September 7, 2021, Accessed March 31, 2022, Referenced from: <https://www.datacentredynamics.com/es/features/la-transformaci%C3%B3n-del-negocio-tradicional-de-centros-de-datos-a-trav%C3%A9s-del-edge-computing/>

²⁶¹ Payan Diana, ¿Qué esperar del Edge Data Center en México?, Info Channel, September 13, 2021 Accessed June 31, 2022, Referenced from <https://infochannel.info/que-esperar-del-edge-data-center-en-mexico/#~:text=Los%20Edge%20Data%20Centers%20pueden.a%20los%20servicios%20de%20streaming%20>

10.2.2 New technologies are being deployed globally

10.2.2.1 Mobile Virtual Network Operators

Mobile virtual network operators are expanding their participation in Mexico, and a new wave of value and innovation is emerging.

Mexico registered 130.36 million mobile clients between January and March 2022, a figure that surpassed the 122.9 million recorded in the same period of 2020, when the world was entering the pandemic, according to a report by Teleconomy. This growth is mainly explained by the advance of the prepaid segment, the most profoundly rooted modality in the region.

There were 108.8 million prepaid customers and 21.1 million postpaid customers in this first quarter, compared to 101.9 million and 21 million, respectively, in the same period of 2020. In this period, Telcel gained 3.4 per cent more customers in the year-on-year comparison.

AT&T grew 8 per cent in subscribers compared to the first quarter of 2021 by adding a base of 20.5 million lines, or 1.8 million more customers. Movistar, meanwhile, gained 536,188 subscriptions, 2.2 per cent more than in the first quarter of 2021, which allowed it to close the first quarter with 25.3 million customers, according to figures cited by Telconomía.²⁶²

However, the ones that grew the most were the Mobile Virtual Network Operators (MVNOs), which advanced 32 per cent between January and March of 2022 against the same period of 2021. This represents a 2.7 per cent share of the total market, up from 2.2 per cent in the first quarter of 2021.

MVNOs play an essential role in reducing the digital divide; they can serve places without coverage, are a low-cost option and brings competition in mobile services.

10.2.2.2 IoT

²⁶² Catalano Andrea, Los operadores móviles virtuales amplían su participación en México y se advierte una nueva ola de valor e innovación, *TeleSemana*, May, 2022 Accessed June 31, 2022, Referenced from <https://www.telesemana.com/blog/2022/05/18/los-operadores-moviles-virtuales-amplian-su-participacion-en-mexico-y-se-advierte-una-nueva-ola-de-valor-e-innovacion/>

The market of internet-connected objects such as televisions, washing machines, watches and even cars was worth in 2019 around one billion dollars in Mexico, and is estimated to quadruple in 2022.²⁶³

IoT is one of the fastest-growing trends in Mexico. By 2025 the market will reach profits of up to 1.6 billion dollars.²⁶⁴

Some of these advances that are in use in Mexico include all activities and contexts, from industries, retail businesses, the education system and cities' mobility.²⁶⁵

Optimizing processes with IoT in manufacturing and production industries facilitates the work of the human team and reduces risks. One example is SensorGO,²⁶⁶ which has a line of seismic sensors that will send an alarm and perform actions such as closing the gas or water pipes.²⁶⁷

Another successful application is in companies with a direct relationship with the consumer (B2C), such as convenience stores and other retail stores, which integrate IoT in their stores for tasks such as geolocation of products in the warehouse and inventory registration stock control, and others.²⁶⁸

10.2.2.3 Content distribution

A CDN (Content Delivery Network) is a global distribution network of servers that deliver content to website visitors based on where they are located.

Content delivery networks use a network of servers spread across multiple geographic locations. Requests are automatically redirected to the nearest servers, accelerating page loads, maximizing bandwidth, and providing identical content regardless of Internet or site traffic peaks.

Social networking is one of the activities that internet users do more in Mexico; figure 8 shows the networks that are more commonly used in Mexico.

²⁶³ Castañares Itzel, Valor de mercado IoT en México se cuadruplicará en 2022, January 18, 2018 Accessed June 31, 2022, Referenced from <https://www.elfinanciero.com.mx/empresas/valor-de-mercado-iot-en-mexico-se-cuadruplicara-en-2022/>

²⁶⁴ Forbes, Negocios de impacto: el IoT en México y su aceleración, Janaury 16, 2020 Accessed June 31, 2022, Referenced from <https://www.forbes.com.mx/neogocios-de-impacto-el-iot-en-mexico-y-su-aceleracion/>

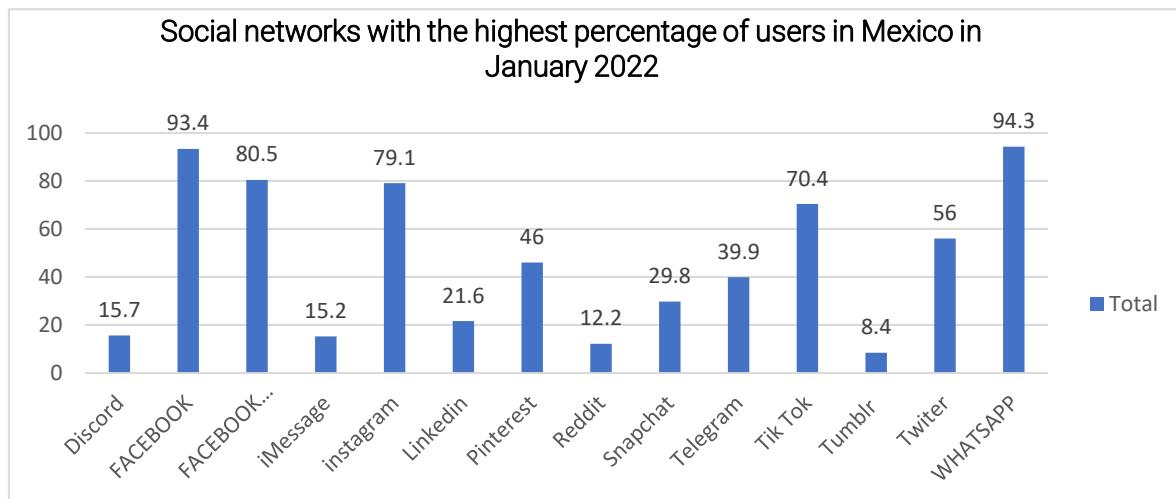
²⁶⁵ Sensors Mkt, IoT En México. Iniciativas Que Ya Son Una Realidad, July 2020, Accessed June 31, 2022, Referenced from <https://sensors.mx/iot-en-mexico/#:~:text=La%20tecnolog%C3%ADa%20IoT%20en%20M%C3%A9xico%20%28Internet%20de%20las,planes%20y%20estrategias%20de%20crecimiento%20sostenible%20del%20pa%C3%ADs.>

266 <https://sensorqo.mx/>

267 IDEM

²⁶⁸ Censys, IoT e Industria 4.0 – Realidad y tendencias en México, September 21, 2021, 2020 Accessed June 31, 2022, Referenced from [IoT e Industria 4.0 – Realidad y tendencias en México - Censystems](#)

Figure 6 Social networks with the highest percentage of users in Mexico in January 2022.



Source: Statista.com²⁶⁹

Since the pandemic, more activities have been done online, but still are differences due to social-economic levels. 56% of households in Mexico considered that the price service for pay content is high for them.²⁷⁰

In the section on video transmission, it was discussed the over-the-top platform's market in Mexico.

10.2.2.4 Smart Cities

Four cities in Mexico are considered Smart Cities by the Inter-American Development Bank (IDB). The international organization declared Ciudad Maderas in Querétaro; Ciudad Creativa and Tequila in Jalisco; and Smart, in Puebla, as intelligent zones. In addition, Mexico City has several characteristics that put it on the road to this category.²⁷¹

- Smart cities are using the IoT and 5G for the following services.
- Traffic management: 5G bandwidth to perform real-time analysis of flows in cities.

²⁶⁹ <https://es.statista.com/estadisticas/1035031/mexico-porcentaje-de-usuarios-por-red-social/>

²⁷⁰ Instituto Federal de Comunicaciones, Encuesta Nacional de Consumo de Contenidos Audiovisuales 2020-2021, Accessed June 31, 2022, Referenced from <https://www.sinembargo.mx/wp-content/uploads/2021/12/01Reporte-final-ENCCA2020-2021vp2.pdf>

²⁷¹ Ayala Guillermina, Estas son las ciudades inteligentes que hay en México, December 4, 2019, Milenio Accessed June 31, 2022, Referenced from <https://www.milenio.com/negocios/estas-son-las-ciudades-inteligentes-que-hay-en-mexico>

- Public Services: Power generation, where reliable connectivity can be provided to synchronize power and avoid future outages.
- Public Safety: Devices cameras and speed control to help public safety.
- Smart buildings: Sensor data streams (lighting, climate, etc.)
- Vehicles: 5G technology will impact power distribution and enable communication between electric and autonomous vehicles.²⁷²

Mexico City has implemented a mobility program that uses apps to increase it. The users with one rechargeable card can use the city's bus, metro and bike system. Also, the city is promoting the construction of green and sustainable buildings.

10.2.2.5 Robotics

The sectors that most robotic automation is the automotive and auto parts industry with 2,628 units, followed by semiconductors and electronics, with a growth of 180%, and the medical sciences and pharmaceutical industries, with an increase of 220%. Mexico is the world's fourth largest importer of robots, only behind China, Germany, and the US. This trend continues; in the first half of 2019 in the North American region, the market grew 7.2% with the import of 16,488 robots valued at 869 million dollars, of which 3,676 were acquired by Mexico, a fact that represents a growth of 81.6% compared to 2010.²⁷³

10.2.2.6 Shared Network of Mexico

The Altán consortium made of a group of investment funds (Morgan Stanley) and operators such as Axtel and Megacable; and will operate under the name of Altán Redes.

The company Altán Redes, S.A.P.I. de CV. has been granted by the Federal Telecommunications Institute (FIT) the concession for the commercial use of the Wholesale Shared Network in Mexico. The network will be constructed and

²⁷² Forbes, El futuro de las ciudades digitales comienza por una conectividad aumentada, April 28,2022 Accessed June 31, 2022, Referenced from [El futuro de las ciudades digitales comienza por una conectividad aumentada • Red Forbes • Forbes México](https://www.forbes.com/sites/redforbes/2022/04/28/el-futuro-de-las-ciudades-digitales-comienza-por-una-conectividad-aumentada/)

²⁷³ Prometal, El boom de la robótica en México 2020, Accessed June 31, 2022, Referenced from <https://www.prometal.com.mx/noticias/el-boom-de-la-robotica-en-mexico>

operated by Altán for 20 years to provide connectivity and improve social services such as national security, telemedicine and distance learning.²⁷⁴

The shared network of mobile bandwidth of voice and data of 4.5 G, with its infrastructure and connectivity, has allowed the transformation of the 700 Mhz spectrum into a more extensive coverage and capacity at a lower cost.

The Altan network has helped in the digital divide reaching regions that did not have connectivity. The coverage plan is to take internet to 7.2% of settlements located in 115 thousand of communities.

This network is a service available for all types of operators, MVNOs, and even social operators.²⁷⁵

Even though the network has reached new areas, it has been difficult for Altan to sustain the service. The company has received financial support from private stockholders (50,5 Million USD) and Mexican Development Bank (161 million USD).

The FIT established coverage goals of 70% by November 2022, 85% by January 2027 and 92.2% by January 2028.²⁷⁶

10.3 Difficulties

Energy is an important issue for companies because it represents one of their most significant expenses, approximately one-third of the total cost of operations, and a critical factor in determining their long-term profitability. In recent years, the cost of energy in Mexico has increased between 40% and 120% within the industrial sector, being the highest in Latin America and raising companies' operating costs.²⁷⁷

Mexico faced uncertainty regarding the energy reform approved on 2015, derived from the existing opposition, the current government and its opponents. On April 18, 2022, the modification of the electric reform presented by President Andres Manuel

²⁷⁴ Lucas Nicolas, Altán gana la licitación de la Red Compartida; promete operación en 2018, November 17, 2016 Accessed July 3, 2022, Referenced from <https://www.economista.com.mx/empresas/Altan-gana-la-licitacion-de-la-Red-Compartida-promete-operacion-en-2018-20161117-0325.html>

²⁷⁵<https://www.altanredes.com/>

²⁷⁶ Saldaña Steve, El rescate de Altán Redes es aprobado por el IFT: gobierno de México tomará control de la directiva solo de forma temporal, June 21, 2022 Accessed July 3, 2022, Referenced from <https://www.xataka.com.mx/telecomunicaciones/rescate-altan-redes-aprobado-ift-gobierno-mexico-tomara-control-directiva-solo-forma-temporal>

²⁷⁷ Periodismo y ambiente, El costo de la energía en México incrementó entre un 40% y un 120% según estudio de Enlight Accessed June 28, 2022, Referenced from <http://www.periodismoyambiente.com.mx/2021/08/03/el-costo-de-la-energia-en-mexico-incremento-entre-un-40-y-un-120-segun-estudio-de-enlight/>

Lopez Obrador (AMLO) was rejected. However, the current administration has continued to bet on the use of fossil fuels and the concentration of the energy markets in PEMEX (Mexico Petroleum Company) and Federal Electric Commission (CFE) and limiting the operation of private operators with operation in Mexico.

However, AMLO, on July 17, 2022, mentioned that the investment in removable energy would continue in Mexico only if the planning is in charge by the Ministry of Energy and the leading partner will be CFE with the participation of private investment.

United Nations Sustainable Development Agenda 2030 promotes the adoption of intelligent and sustainable solutions that support digital transformation while preserving and caring for the environment. Data centres have the challenge of reducing and efficiency of energy consumption.²⁷⁸

²⁷⁸ Boletín de la computación, Innovación reduciría 40% el consumo eléctrico de Centros de datos: Panduit;may 17,2022. Accessed June 28, 2022, Referenced from <https://boletin.com.mx/industrial/empresas/innovacion-reduciria-40-el-consumo-electrico-de-centros-de-datos-panduit/>

11 Conclusions and comments

The present document analyses several sources of information, including internet media, government and non-government institutions, and studies. The paper intends to present the situation of the data centre market in Mexico, comparing it with Latam, trends, challenges and opportunities that potential investors and suppliers need to consider if they want to participate in Mexico.

The COVID-19 pandemic had an important impact on Mexican society, accelerating digital transformation, increasing the number of internet users and migration from an office environment to home office, and the increasing number of activities online.

Mexico, with a vast territory and large population (11th in the world), is constantly growing; the technology development and data centre is booming in some states of Mexico.

Querétaro stands out for its impact in terms of infrastructure and companies that have settled in the state (KIO Networks, Equinix and Ascenty), among others. Where they have created suitable spaces, the federal entities and the state have benefited, growing their local and regional economy. Other locations such as Mexico City, Nuevo Leon, Jalisco, and Aguascalientes are also home to other data centres.

These investments have allowed Mexico to be a leader in Latin America and positioned as a reference in the field of international data centres, given its characteristics (infrastructure, security, certifications, personnel).

It is necessary to highlight the capacity and performance of the leading players in the country, such as KIO Networks, Amazon, and Google, and the benefits of economic growth they have achieved by being located in Mexico.

However, the competition in Latin America (mainly Brazil, Chile, and Mexico) on data centre development involves a technological race to have the best infrastructure, faster broadband speed connection, 5G network, greater coverage, use and understanding of IoT, Big Data application for decision making, implementation of cloud services, artificial intelligence in process automation. All these elements are a part of the digital transformation in which data centres are critical and promote the digital business transformation and economic growth of the regions potentializing such investments.

Some of the factors that have boosted data centres development in Mexico are

- Trained professionals that participated and operated the data centres at a competitive labour cost.
- Security elements are backup by certifications and standards that data centres located in Mexico have.
- Infrastructure (developed in these large technology centres) is comparable and fully competitive with any other region (Latin America).
- Domestic and foreign investors, suppliers and Mexican companies within the technology industry are participating in the development of the infrastructure—companies looking for opportunities in Cloud Computing, Edge Computing, Energy Efficiency, etc.
- Today's technology trend to develop AI, IoT, Cloud Computing, Edge Computing, and Big Data, which depend on the development and growth of data centres.
- Strategic geographic location and proximity to the US market.

Although Mexico has vital aspects that influence technology development, some elements make it difficult to turn the country into a technological power. A key component is the digital divide that affects part of the population by the lack of Internet access accompanied by digital literacy (which, despite the growth of Internet users derived from the pandemic, has not yet decreased). The above goes in hand with Mexico's education system, which faces significant backwardness in basic levels; Mexican children attending school do not reach basic proficiency levels in mathematics, which is very similar in other areas such as science and history.

The actual political and social environment in Mexico has restricted the operation of foreign investors in the energy sector. The rejection of the modification of the electric reform presented by President Andres Manuel Lopez Obrador (AMLO) has created uncertainty and decreased foreign investment.

The telecommunications sector led FIT, and related organizations promote new investment to increase internet access for the population. At the same time, the FIT ensures that investors comply with regulations and operations procedures and monitor and balance the competition.

Figures Index

Figure 1 Location of the main data centres in Mexico.	12
Figure 2 Employed population by State with High Probability of Automation.....	24
Figure 3 Edge Data Centres in Mexico, KIO Networks.	28
Figure 4 Contracts in Mexico for connecting power plants with less than 0.5 MW capacity.	33
Figure 5 Technologies in contracts and installed capacity in Mexico.	34
Figure 6 Social networks with the highest percentage of users in Mexico in January 2022.	97

Tables Index

Table 1 Demographic Indicators	4
Table 2 Growth indicators in Mexico's economy	6
Table 3. ICREA certifications for data centres in Mexico during 2020 and 2021.....	49

Graphic Index

Graphic 1 Major suppliers of advanced technology products to the US January-May 2021 USD MILLION	67
Graphic 2 Evolution of the supply of movies and series or events in OTT service. ..	68