Gap Analysis and Opportunities for Innovation in the Energy Sector In Latin America and the Caribbean

Cataloging-in-Publication data provided by the
Inter-American Development Bank
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Gap analysis and opportunities for innovation in the energy sector in Latin America and the Caribbean / Gavin Rennie, Brad K. Hartnett, Victoria Reyes, Dafna Siegert, Daniel Sandoval, Maria Banda.
p. cm. — (IDB Monograph ; 846)

Includes bibliographic references.
1. Energy industries-Technological innovations-Latin America. 2. Energy industries-Technological innovations-Caribbean Area. 3. Electric power production-Technological innovations-Latin America. 4. Electric power production-Technological innovations-Caribbean Area. 5. Renewable energy sources-Latin America. 6. Renewable energy sources-Caribbean Area. I. Rennie, Gavin. II. Hartnett, Brad K.. III. Reyes, Victoria. IV. Siegert, Dafna. V. Sandoval, Daniel. VI. Banda, Maria. VII. Inter-American Development Bank. Infrastructure and Energy Sector. VIII. Series.
IDB-MG-846

JEL Codes: O3, O33, Q40

Keywords: Technological innovation, energy industry, renewable resources, Digital revolution, Science and technology

Contents

List of abbreviations

The following table shows the main abbreviations used throughout the document.

Abbreviation	Definition
AAP	Peruvian Automotive Association (Asociación Automotriz del Perú)
AAVEA	Argentine Association of Electric and Alternative Vehicles (Asociación Argentina de Vehículos Eléctricos y Alternativos)
ACSC	Australian Cyber Security Centre
ADAZ	Application for Diagnosis, Analysis, and Status Monitoring
AEMO	Australian Energy Market Operator
AESCSF	Australian Energy Sector Cyber Security Framework
AI	Artificial Intelligence
ALAMOS	Latin American Association for Sustainable Mobility (Asociación Latinoamericana de Movilidad Sostenible)
AMI	Advanced Metering Infrastructure
AN	Andean
ANCAP	National Administration of Portland Alcohol Fuels (Administración Nacional de Combustibles Alcohol Portland)
ANFIS	Adaptive Neuro Fuzzy Inference System
ANU	Australian National University
AR	Argentina
ASEP	National Public Services Authority (Autoridad Nacional de Servicios Públicos)
AU	Australia
BA	Barbados
BE	Benchmark Countries
BEV	Battery Electric Vehicle
BI	Business Intelligence
BR	Brazil
BREA	Barbados Renewable Energy Association
CA	Central America
CAES	Almacenamiento de energía de aire comprimido (Compressed-air energy storage)
CB	Caribbean
CDEEE	The Dominican Corporation of State Electric Companies (Corporación Dominicana de Empresas Eléctricas Estatales)
CEPM	Cana-Macao Energy Consortium (Consorcio Energético Punta Cana-Macao)
CERT	National Center for Responses to Computer Security Incidents (Centro Nacional de Respuestas a Incidentes de Seguridad Informática)
CESER	Office of Cybersecurity, Energy Security, and Emergency Response
CFE	Federal Electricity Commission (Comisión Federal de Electricidad)
CIC	Critical Infrastructure Centre
CL	Chile
CNE	National Energy Commission (Comisión Nacional de Energía)

CNEL EP	National Electricity Corporation (Corporación Nacional de Electricidad)
CO	Colombia
CPO	Charge Point Operator
CRE	Rural Electrification Cooperative (Cooperativa Rural de Electrificación)
CREG	The Energy and Gas Regulation Commission of Colombia (Comisión de Regulación de Energía y Gas)
CSIWG	Cyber Security Industry Working Group
DE	Germany
DECC	Department of Energy and Climate Change
DEIP	Distributed Energy Integration Program
DER	Distributed Energy Resource
DG	Distributed Electricity Generation
DO	Dominican Republic
DOE OE	U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability
E4E	Evolution for the Energy
EC	Ecuador
EECoin	Energy Efficiency Coin
EEP	Pereira Energy Company (Empresa de Energía de Pereira)
EMS	Energy Management system
EOM	Energy One Matrix
ESM	Energy Spend Management
ESS	Energy Storage System
ETESA	Panama Electric Transmission Company (Empresa de Transmisión Eléctrica de Panamá)
EV	Electric Vehicles
FCEV	Fuel Cell Electric Vehicle
FPL	Florida Power & Light
GB	United Kingdom
GDP	Gross Domestic Product
ICCT	International Council on Clean Transportation
ICE	Internal Combustion Engine
IDB	Interamerican Development Bank
IESS	Intelligence Energy Storage System
INDC	Intended Nationally Determined Contribution
INEEL	National Institute of Electricity and Clean Energy (Instituto Nacional de Electricidad y Energía Limpia)
IoT	Internet of things
IPN	National Polytechnic Institute (Instituto Politécnico Nacional)
KPI	Key Performance Indicators
LAC	Latin America and the Caribbean
LIDAR	Light Imaging, Detection, and Ranging
MEER	Ministry of Electricity and Renewable Energy (Ministerio de Electricidad y Energias Renovables)

MEM	Ministry of Energy and Mines of Peru (Ministerio de Energía y Minas de Perú)
MIEM	Ministry of Industry, Energy and Mining (Ministerio de Industria, Energía y Minería)
MIRRAT	Melbourne International RoRo and Auto Terminal
MOU	Memorandum of Understanding
MQTT	Message Queue Telemetry Transport
MX	Mexico
NEAR	Australia's National Energy Analytics Research Program
NN	Neural network
OEDI	Cutting Edge Open Data Initiative
OLADE	Latin American Energy Organization (Organización Latinoamericana de Energía)
P2P	Peer to Peer
PA	Panama
PDEE	Brazilian Energy Expansion Plan (Plano Decenal de Expansão de Energia)
PE	Peru
PFS	Proa Forecasting System
PHEV	Plug-in Hybrid Vehicle
PTI	Itaipu Technology Park (Fundación Parque Tecnológico Itaipú)
PV	Photovoltaic
PY	Paraguay
RECAI	Renewable Energy Country Attractiveness Index
REEEAC	Renewable Energy and Energy Efficiency Advisory Committee
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
RPA	Robotic Process Automation
RPMA	Random Phase Multiple Access
SC	The Southern Cone
SCADA	Supervisory Control and Data Acquisition
SEAL	Arequipa Electric Society (Sociedad Eléctrica de Arequipa)
SEIN	National Interconnected Electric System (Sistema Eléctrico Interconectado Nacional)
SEMARNAT	Mexican Secretariat of Environment (Secretaría de Medio Ambiente y Recursos Naturales)
SENI	National Electricity System (Sistema Eléctrico Nacional)
SGIG	Smart Grid Investment Grant
SIE	Ecuador Energy Information System (Sistema de Información energética de Ecuador)
SIGDE	Integrated System for Electricity Distribution Management (Sistema Integrado para la Gestión de la Distribución Eléctrica)
SIN	National Interconnected System (Sistema Nacional Interconectado)
SINEE	System of National Energy Efficiency Indicators (Sistema de Indicadores Nacionales de Eficiencia Energética)
SSB	Basic Solar Systems (Sistemas Solares Básicos)

TDS	Technical Drones Solutions
ToU	Time of use tariff
UAS	Unmanned aircraft systems
US	United States
UY	Uruguay
WB	World Bank
ZA	South Africa

1. Executive summary

1.1. Context and relevance of the project

In the last decade, the energy sector has experienced a shift toward disruptive trends such as decarbonization, decentralization, and digitalization, creating an energy transition that generates a major impact on the electricity industry worldwide.

As a result, the future of the electricity industry faces many uncertainties depending on consumer behavior, social and economic priorities, climate change commitments, political agendas, technological developments, competitive pressures and the availability of different generation resources, especially in developing countries. In Latin America and the Caribbean (LAC), most of the countries are categorized as developing countries.

The main objective of this project is to understand and analyze the innovation gap in the LAC region's power industry, using countries in Europe, Asia, and other regions as a benchmark. The goal is to identify these gaps across different dimensions of the industry. Based on a comparison with qualitative and quantitative data, with a comparable synthetic index which has been developed, in the scope of this project, to provide a detailed analysis, identifying the gaps and opportunities at a regional level in LAC.

The importance and relevance of the project are due to the publication and analysis of information from different technologies, used as well as a description of the actual scenario and scope of each country towards the innovative trends of the industry. With the use of this information, not only the government but the people of each country will be aware of the relevance of the advancement of new technologies helping on the use of these innovative technologies. Thanks to the report a new roadmap for each country can be made, using data from benchmark countries to determine the go-to.

Six dimensions across two scenarios

This report seeks to identify the innovation levels of the power industry in LAC countries, by gathering relevant data and calculating Key Performance Indicators (KPIs) that provide evidence of the degree of innovation along the sector's value chain. The theoretical framework of KPIs proposes two future scenarios led by innovation and disruptive technologies in the sector: a centralized and decentralized grid.

Table 1 KPI's and their respective dimensions

			Value Chain			
		Digital	G	T	D	R
SCG	Utility Scale Non-hydro Renewable Energy		X			
SDG	Distributed Solar PV		X		X	X
Support Both	Enabling Technologies (Cloud, Artificial Intelligence, P2P, Communication)	X	X	X	X	X
Support Both	AMI Deployment	X			X	X
Support Both	Electric mobility				X	X
Support Both	Utility Scale Storage		X		X	

SCG: Support Centralized Grid
SDG: Support Decentralized Grid
Qualitative information

G - Generation
T - Transmission
D - Distribution
R - Retail

Source: EY Power and utilities Innovation Lab

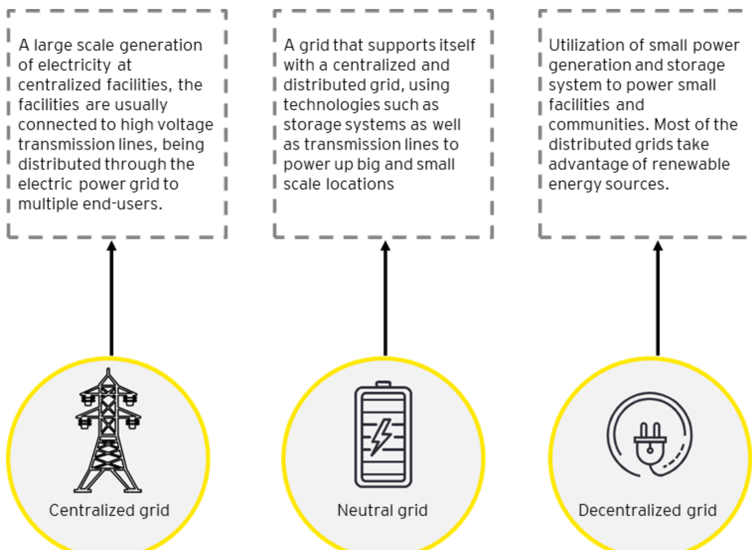
Table 1 shows the different KPIs that have been defined to show the relevant innovation levels per country (see Annex A for more detail about the benchmark methodology). These KPIs are grouped based on (i) the type of support to the grid which identifies the trend to the centralization or

decentralization of the grid and (ii) the segment of the industry value chain the KPI belongs to. The type of scenario will help to identify the degree of innovation each country has. Even though each scenario has an innovative quality, the technologies that have an involvement in the distributed grid tend to show more innovative characteristics due to the changes they bring to the industry.

Adopting technologies such as utility-scale renewable generation or utility-scale storage is indicative of a country looking to maintain a centralized grid scenario. While distributed energy technologies such as behind-the-meter storage, microgrids, and distributed solar photovoltaic (PV) are more suited for countries moving towards a more decentralized grid scenario.

Countries across the LAC region will reach a future state that will be somewhere in a spectrum between the centralized and decentralized scenario, these scenarios are described in the Figure 1. Each country's case will be determined by factors including generation profile, demand profile, utility resources and utility capabilities. The journey towards each future state can be enabled by the different technologies presented in this report. The illustration below describes each type of future state.

Figure 1 Future states for the grid



Source: EY Power and Utilities Innovation Lab

Technologies that support a centralized grid scenario (even though it is the most common one in the market) have helped and supported the large-scale use of renewable energy, especially with the hydro source, and giving the opportunity to different countries to shift their energy matrix into a more renewable and sustainable one. Also, centralized grids have offered the opportunity for countries to develop large scale storage plants to control intermittencies, faults, or energy supply issues that may compromise the daily energy usage of the users.

On the other hand, technologies that support distributed grids have become increasingly widespread with the growth and advancement in the research and appliance of renewable sources. Due to the recent use of renewable energy technology such as solar panels, wind turbines, small scale hydro and biomass plants, among others; both utilities and users have sought and applied new forms of energy usage, giving communities the opportunity to obtain a sustainable energy source that may improve energy efficiency and resiliency.

Lastly, neutral grid technologies are those that can support grid development under both a distributed and a centralized scenario. These technologies are enablers[1] to maintaining a sustainable and efficient energy usage across a community and the entire country.

All these types of grids are important, even though some types of technologies are more modern than others, the usage of each type of grid technologies is crucial and it demonstrates an innovative adoption of the country towards the improvement of the industry.

1.2. Main trends

Each country approaches differently the use of technologies in its energy matrix, however, it is clear that there are certainly general trends that will be explained when each case is exposed. It should be emphasized that, the pace of change and the combination of energy solutions in each geographical area requires the creation of unique and stable political and economic frameworks; that have a long-term vision. For this study there are benchmark countries and LAC countries, each country has a particular energy matrix, the main trends and technologies of each group of countries will be briefly announced and divided between qualitative and quantitative data to find the main differences between both markets.

1.2.1. Trends in the benchmark countries

- **Australia**

Australia is a benchmark country because the electricity market is undergoing a significant transition. Renewable energy and clean energy innovation, including emerging technologies play an increasingly important role in a modern and dynamic electricity market. Renewable technologies are deployed widely throughout Australia and include large-scale and residential solar PV, concentrated solar thermal, wind, hydro, biomass, wave energy, geothermal and battery storage technology [6]. Australia is currently not a leader in utility-scale storage; however, this is expected to improve soon, due to the reforms to support the increased roll-out of energy storage projects at residential, commercial and grid scales.

In the case of quantitative KPIs, Australia is not the most representative leader, however, according to the enabling technologies, it is evidenced that it has a high level of maturity in big data, blockchain, cloud services, peer to peer and RPA. As the costs of these technologies continue to fall, uptake is expected to increase, creating new ways to generate, store and distribute electricity.

- **Germany**

Germany is a benchmark country because the German power market is rapidly transforming from a system founded upon centralized coal and nuclear power plants into an electricity grid based predominantly on renewable energy, in 2016 the country covered 28 percent of its energy consumption from renewables. Germany uses specific technologies that are advancing energy operations around the world such as big data, machine learning, automation, and even drones that are used for inspection of

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[1] Enabling technologies are those technological advances of an innovative nature that drive disruptive changes in the performance and capabilities of users, either through combination with pre-established technologies or by themselves.

photovoltaic installations. Since 2000, global efforts have managed to manufacture photovoltaic (PV) cells and have become more efficient, while wind turbines have been repowered to soar to great heights and operate in inland areas previously considered unsuitable for wind power generation. Regarding quantitative KPIs, Germany is the leader in non-hydro renewable installed capacity [1]. According to the enabling technologies, it has a high level of maturity in blockchain adoption.

- **South Africa**

South Africa has a well-developed electricity network and one of the highest rates of electricity access in sub-Saharan Africa. The government is focusing on diversifying the power mix by introducing natural gas and renewables, including concentrating solar power. The role of coal in the South African industry and power generation is already decreasing, while that of gas and renewables is increasing [2]. Regarding enabling technologies, South Africa is the leader in chargers per EV. According to KPIs, this country is not the most representative leader in any of them.

- **United Kingdom**

In the UK, the energy system is changing rapidly. There are fundamental transformations in how energy is being generated and consumed. Renewable energy sources now account for around a quarter of UK electricity generation. Technological innovations and new business models are also starting to have an effect. Smart meters, electric vehicles and new types of storage are already affecting how consumers manage their energy and allowing more innovative approaches to managing supply and demand [3]. In specific, UK is the leader in drones that inspect transmission lines and cybersecurity, regarding enabling technologies, and it is the first country in EV per 10 thousand vehicles and non-hydro renewable generation.

- **United States**

The United States is a leader in the production, supply, and consumption of energy. U.S. energy companies transmit, distribute, and store energy through complex infrastructure networks that are supported by emerging products and services such as smart grid technologies. The United States accounts for 36 percent of the total global capacity for electrochemical energy storage, a fast-growing subsector that can help address intermittency from renewable energy sources like solar and wind. In many parts of the country, renewable energy technologies like wind and solar are cost-competitive or even cheaper than conventional energy sources [4]. Regarding quantitative KPIs, the U.S. is the leader in estimated smart meter penetration and distributed solar PV insertion. According to the enabling technologies, it has a high level of maturity in IoT, cybersecurity, augmented reality and advanced analytics adoption.

1.2.2. Trends in the LAC region

According to the International Renewable Energy Agency (IRENA), in the region, a quarter of total primary energy comes from renewable sources, mainly hydro conventional resources, which make Latin America one of the most dynamic markets in this sector. Countries such as Brazil, Chile, Mexico, Peru and others, members of the Energy and Climate Alliance of the Americas have already begun the shift towards a less energy-intensive economy, taking advantage of their abundant renewable resources and seeking to increase their economic efficiency while reducing their needs of investment in energy infrastructure [5].

The heterogeneity of the energy mix represents a challenge for the electricity markets that will need to pay attention to the dispatch of energy and ancillary services to counter the volatility due to the incorporation of renewable energy sources, but countries continue to make progress on this issue. Mexico has entered a period of expansion of its electrical system, as it is in a phase of diversification away from fossil fuels. Natural gas generators are the main source of electricity production in the country, with a dominant role in the electricity sector, but renewable energy has started to participate with the wind, solar and geothermal energy facilities. Mexico, regarding enabling technologies, has a high maturity level in cloud services adoption.

Brazil is a market that consumes twice as much energy as Argentina, Bolivia, Chile, and Uruguay together; approximately 70% of electricity is obtained from hydroelectric resources. And the wind, solar and natural gas are expected to have more participation by 2030, as the country needs to diversify to avoid energy shortages [6]. Regarding enabling technologies, Brazil has a high maturity level in advanced analytics, big data, blockchain, and RPA adoption.

Ecuador is a similar case to Brazil; its electrical system focuses on hydroelectric power. Compared with the previous countries, Ecuador has a high maturity level in cybersecurity. In Chile, the supply of electricity is mainly satisfied with fossil fuels, renewable energy is expected to grow, however, this country is the leader in storage coverage due to solar parks that have energy storage through the use of molten salt technology, in addition to the fact that the battery market has recently been boosted due to the decrease in prices of batteries, mainly lithium-ion.

In Paraguay, given the high capacities in hydroelectric generation, the electrical energy generated in Paraguay is almost exclusively hydraulic, this is thanks to the production of the binational hydroelectric power plants, mainly from Itaipú. Respecting enabling technologies this country has a high maturity level in advanced analytics. Whereas Peru leads in the adoption of cloud service compared to other LAC countries and its electrical system focuses mainly on hydroelectric power.

1.2.3. Differences between benchmark and LAC countries

There are some differences between the main technologies used in the benchmark countries and the LAC region. The gap between the benchmark countries and the LAC countries is evident in the use of disruptive technologies for physical technologies, where the data gathered is mainly quantitative. The only LAC country that leads is Chile with its utility-scale storage mainly due to the deployment of the molten salt energy storage systems.

Mostly LAC countries are not leaders in the adoption of enabling technologies. Colombia, Argentina, Barbados, Bolivia, Dominican Republic, Panama, and Uruguay do not have a high maturity level in the adoption of any enabling technology, however, there are some LAC countries at the same maturity level of the benchmark countries, as shown in the following examples:

There are two relevant cases; Brazil and Paraguay have the same level of maturity as the United States in the adoption of advanced analytics, which allows identifying that these LAC countries also implemented tools and methods drawn from statistics, computer science, econometrics, linguistics, and others in the data analytics process. Similarly, Mexico and Peru have the same level of maturity as

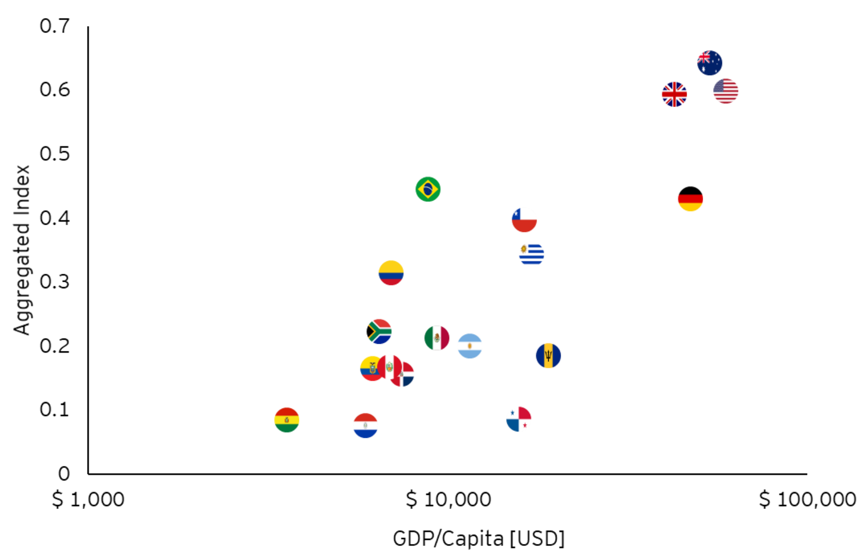
Australia in the adoption of cloud services, so it is evident that these countries use computing services such as servers, storage, databases, networking, software, analytics, and intelligence over the internet.

1.3. Main results

The main objective of this project is to understand and analyze the innovation gap in the LAC region's power industry, using countries in Europe, Asia, and other regions as a benchmark, based on a comparable synthetic index that has been developed, in the scope of this project, to provide a detailed analysis, identifying the gaps and opportunities at a regional level in LAC. The composition of the aggregated index took the average of each normalized result and calculated the index on a scale from 0-1 making the score of 1 a very innovative country and the score near to 0 a poor innovative country (see Annex B for more detail about the index methodology). Each aggregated index represents the general position each country is towards the different enabling and disruptive technologies presented previously. Even though some countries have a low aggregated index it is important to review each indicator to notice their strengths and weakness in the industry, understanding that some countries don't have enough budget to invest in all the new technologies offered in the industry.

In the Figure 2, the aggregated index of each country is presented against the GDP/Capita (Gross Domestic Product per capita). The graph shows two sets of clusters that can represent a clear gap between them, the first cluster is divided by the aggregated index in which countries such as the UK, Australia, and the US have a greater innovation index than the rest of the countries, leaving all the LAC countries in the same cluster. The other cluster is the economic division between the countries showing a great gap between Australia, UK, the US, and Germany against the rest of the countries, this gap shows a clear barrier for the innovation growth of the LAC countries. In the cluster of the LAC countries, it can be identified that the aggregated index varies between 0,2 and 0,45 showing a close difference between them. Countries such as Paraguay and Panama show a very low index meanwhile countries such as Chile and Brazil demonstrate a more innovative index, demonstrating a higher interest in the growth of the industry (For more detail on the results, see Annex G and Annex H).

Figure 2 Index summary



Source: EY Power and utilities Innovation Lab

As stated previously, the results presented are divided between qualitative and quantitative data. The qualitative data represents the enabling technologies which mainly supports both centralized and decentralized grids; with technologies such as RPA, augmented reality (AR), blockchain, cloud services, among others. This data is measured through a maturity level that helps to identify the level of the project, replacing qualitative data into a quantitative result. Meanwhile, the quantitative data are the disruptive technologies that are from both the distributed and the centralized grid, presenting results such as renewable energy variety, storage level, AMI deployment, and EV penetration. These two types of information brought some interesting insights that helped to understand the general scope of each country as well as the trend towards the growth of the industry in the LAC countries and the benchmark countries (for a detailed explanation of this KPIs see Annex E and Annex F). To understand the general scope of the results, the main insights will be listed to understand what the results demonstrated towards the presence of innovation in the electricity industry in the LAC countries:

- **Low electric vehicle penetration in LAC countries:**

The EV market in the LAC region demonstrates a slow growth compared to the benchmark countries. With the results normalized with EV per 10,000 vehicles, it can be noticed that countries such as the UK and the US have high penetration levels, demonstrating a good EV infrastructure with a charging station ratio that demonstrates the interest of growing the market and giving access to the users that want to start using electricity as a mobility resource. Also, the penetration of the market for these two markets demonstrates a high impact leaving behind all the LAC countries. Barbados demonstrates the highest implementation in the electric mobility industry, being ahead of other LAC countries with 33.1 EVs per 10,000 vehicles.

- **The AMI deployment is growing at a small pace:**

Due to the growth in the investigation of different technologies, the industry has taken advantage of this growth, utilizing different types of an information system to promote energy efficiency and letting the users understand and monitor the current energy use. Due to the accessibility given by the AMI, the energy industry of each country has shown an interest to implement this technology to enclose the utility user relation, supporting effective energy use. The benchmark countries such as the US and the UK, demonstrate a high AMI deployment showing an interest in filling the grid with this technology. Even though the LAC countries are behind the innovative markets, most of all the countries from this region are demonstrating an impact on the use of smart meters. Barbados has the highest value from the countries in the LAC region demonstrating interest in this technology and is expected to increase the percentage of smart meters in the next years.

- **Chile has higher storage than the US as a % of coverage of the peak demand:**

Towards the storage coverage of the different countries, unlike the other disruptive technologies, in the storage coverage indicator, Chile demonstrates an outstanding indicator being above innovative countries such as the UK and the US. This indicator demonstrates a good level of planning and infrastructure towards the storage for future events in the energy industry in Chile. Chiles storage coverage is due to a growth in thermal molten salt technology with projects such as: Atacama - Cerro Dominador Solar Plant, Pedro de Valdivia Solar Plant, SolarReserve- Copiapo Project, SolarReserve-Likana Project and SolarReserve- Tamarugal Project; which has helped to create some storage stations that cover a part of the maximum demand.

- **Most of the countries are working towards projects with advanced analytics:**

The advanced analytics projects gather different types of processes such as data mining, machine learning, forecasting among others. Due to the advantages, these processes added to the services given by the utilities have helped on the innovation of the sector enabling new methods to implement projects and offer solutions to the electricity sector. Regarding the interest of the advanced analytics in the projects, many LAC countries have adapted new innovative trends in the business, this can be seen given the high indicator that Paraguay and Brazil show, demonstrating and adoption of advanced analytics near the trends demonstrated by the benchmark countries[2].

- **Peru has a high Cloud service adoption compared to the benchmark countries:**

The cloud services are becoming a more accessible technology to different countries due to the internet capacity that has increased through the previous years. Cloud services have also helped in the access and saving of key information that can be shared between different companies. In the energy industry, Peru (alongside Mexico and Brazil) has been pioneering on cloud services projects, utilizing the cloud service to create a more effective and secure system that manages the data of the user. This country has a higher indicator than some benchmark countries, demonstrating the high maturity level of the projects implemented from this topic.

- **RPA usage is becoming a trend in the energy industry:**

The Robotic process is a recent enabling technology that has supported the automation of different industries, helping some processes to become more effective. RPA technology in the industry has become one of the most fast-growing technologies, making several countries invest in this technology. Due to this growth, benchmark countries like Australia have RPA projects with a high maturity level given the budget they implement on the R&D divisions. Even though the benchmark countries have a better adoption of these technologies, LAC countries have invested to grow this trend, Brazil has shown a mature implementation of robotics in the industry supporting the innovative growth of the LAC region.

1.4. Opportunities

Given the results presented previously in the aggregated index summary, the LAC region in the innovative characteristics is behind some main innovative markets such as Germany, Australia, the UK, and the US, this generates a key opportunity for LAC countries to execute deployments of innovative technology by referencing best practices in benchmark countries. Due to the short term of adoption of these technologies from the LAC countries, the gap can be recognizable, but given the fast growth of the industry towards these technologies and theories such as the countdown clock, it is important for all these countries to start creating long term plans for the adoption of new technologies that may improve and support the energy industry.

In recent years countries have been stating the plans to reduce the carbon emission to help with a sustainable environment. Given this political trend industries have supported on decarbonization and uses of clean energy. The best way to decrease emissions is by implementing new technologies such

[2] Paraguay presents this level of maturity in advanced analytics due exclusively to the production of the binational power plant together with Brazil, Itaipu.

as renewable generation, electric vehicles, and even storage systems, in this way there can be a short-term growth on the sustainable use of energy. This environmental growth awareness will make LAC countries want to not only adopt low emission technologies but also use them at a mature level, increasing their use at a customer level and discouraging the use of sources that affect the environment.

The industry value chain which is composed of the generation, transmission, distribution, and retail (G, T, D, R) is currently changing and giving the end-user the opportunity to not only be aware but also be part of the generation stage, decreasing the dependency or avoiding the transmission and distribution and becoming a prosumer in a distributed grid. These changes have made utilities look for strategies to enclose the end-use and have better communication on their energy consumption. In the LAC region, this is one of the most urgent changes, making utilities look for technologies such as smart meters and automation of the grids, to look for a way to inform and manage the user relation, giving opportunities of energy consumption, reduction and understanding of the amount of energy used for generation. LAC utilities not only need to be aware of how to connect with their centralized grid users but also how to support and implement services in the distributed grid, with communities and off-grid sectors.

The change in the industry and the investigation and application of pilots made in the different countries have helped in the fast-paced growth of the different technologies in the region. To reach a better growth and be capable to outstand the challenges the industry is having, the LAC region can take advantage of all the process and projects the benchmark countries are implementing, to improve and even discover new applications of the technology, cooperating in the growth and incrementing their innovative index, also decreasing the size of the innovative gap that can be seen today.

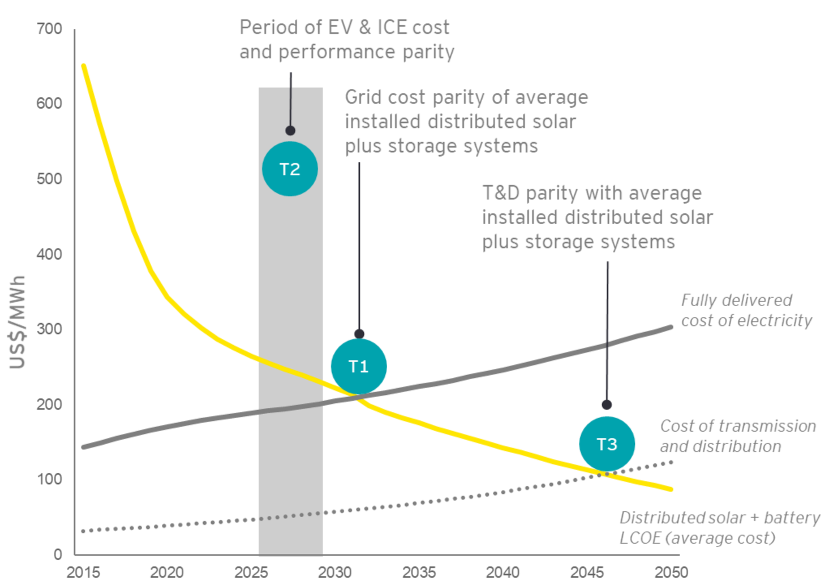
2. Results construction

2.1. Technologies

The power industry is going through a significant transformation that is pushing different utilities to adopt innovative technologies to use as enablers to prepare for the future. One model that analyzes how technological and consumer-led changes will result is EY's Countdown Clock, which can be seen in the Figure 3. The countdown clock presents three disruptive tipping points in consumer behavior that will deeply disrupt the way the power industry operates.

The first tipping point indicates when the cost and performance of an average installed distributed solar system plus storage will be competitive with the centralized grid, making it a viable option for consumers to operate independently from the grid. The second tipping point presents cost and performance parity between electric vehicles and the internal combustion engine. Lastly, the third tipping point shows when a solar PV unit and a battery can compete with the cost and performance of the transmission and distribution services (without generation or retail fees). These consumer-led changes predicted by the countdown clock need to be considered due to the growth of new technologies and changes made by the utilities.

Figure 3 Countdown clock

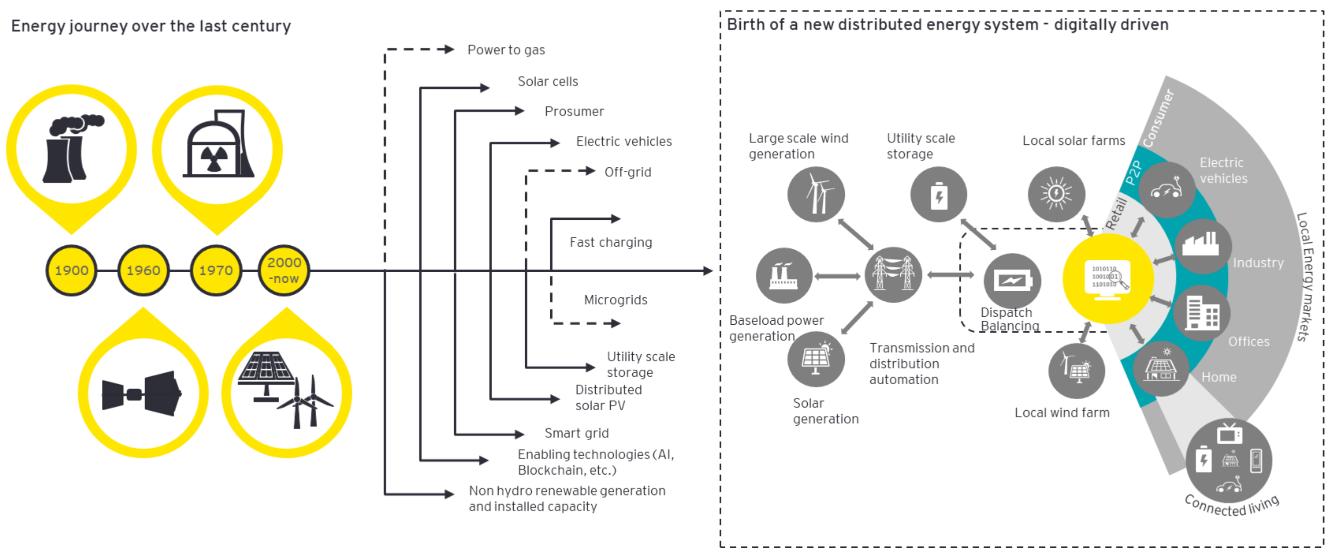


Source: EY Power and utilities Innovation Lab

Utilities are at the core of this transformation towards a new energy system. These changes in consumer behavior will push grids to their limit, Figure 4 shows the main changes in this transformation. The large-scale introduction of Distributed Energy Resources (DER) will strain local distribution networks and will require network controls, analytics and capabilities that are currently not widely adopted. The adoption of innovative technology is a key enabler to prepare utilities for these upcoming challenges. These technologies will transform both the digital and physical environments in which utilities operate.

On a global level, the energy system will need to react towards consumer demand for distributed generation. Some consumers will seek to become prosumers to take advantage of DERs generation. This last will become a complex challenge for networks to maintain the status quo without smarter solutions. Utilities in LAC will need to transform their structure and services to meet the new expectations of their clients. This response may focus on optimizing the centralized grid, developing distributed grid capabilities, or a mixture of both. But in any case, utilities will need to prepare for changes in consumer expectations.

Figure 4 New distributed energy system



Source: EY Power and utilities Innovation Lab

As a result, new business models, utility capabilities and consumer capabilities in the energy sector will be enable by the emerging technologies which are listed below.

- **Infraestructura de medición avanzada (AMI)**

Advanced metering infrastructure is a term that contemplates electricity meters that measure and record usage data at hourly intervals (at a minimum) and provide access to the data to both consumers and utilities at least once a day. For this report, the meters that are installed and about to be installed (in stock) as of the cut-off date of the end of 2018 are taken into account.

- **Non-hydro renewable energy**

Non-hydro renewable energy considers renewable energy sources excepting hydroelectric plants with reservoirs, since this technology has been established since the 19th century and is not considered innovative. The technologies that are considered in this indicator are: solar, wind, small hydroelectric plants (without reservoirs), biomass, geothermal and tidal.

- **Distributed Solar PV**

For this indicator, those systems that use photovoltaic solar panel technology on a distributed scale were considered (solar parks are not considered), instead the systems that are installed in residential, commercial and small industrial clients.

- **Utility-scale storage**

Energy storage systems are those systems that have the capacity to store electrical energy for later use over time. For this indicator, the systems connected to the network are considered and excluding hydro pump storage technologies and systems installed in distributed-scale, considering only utility-scale systems. The technologies considered for the indicator are advanced lead-acid, compressed air (CAES), flow battery, flywheels, lead-acid, Li-ion, metal-air, Na-ion, NaS, nickel, power-to-gas, sodium-metal halide, superconductor, thermal and zinc.

- **Electric Vehicles (EV)**

They are those vehicles that work by means of electrical energy, either through a partial or total use of this energy. For this report, vehicles that work only with electricity and those hybrids (that work with electricity but also have an additional system that uses another source of energy) were considered.

- **EV charging infrastructure**

They are those systems that allow the transfer of electrical energy from the network to the EV batteries, for the report those chargers of a private and public nature are considered.

- **Advanced Analytics**

Advanced analytics is a group of capabilities to manage and analyze data, typically going further than the capabilities of the traditional Business Intelligence (BI). While BI encompasses a set of tools and techniques to acquire, store, and present data, Advanced Analytics is the examination of a set of data using algorithms and other sophisticated modeling and statistical analysis techniques to produce insights from this data. It implements a wide range of tools and methods drawn from statistics, computer science, econometrics, linguistics, and others in the data analytics process [7].

The capabilities included within Advanced Analytics are:

– Analytics-as-a-service
– Artificial intelligence
– Machine learning
– Deep learning
– Power generation forecasts
– Predictive analytics
– Prescriptive analytics
– Real-time analytics
– Unstructured data analytics
– Data mining

Some use case examples in the Power & Utilities sector are:

– BeeBryte (France): leverages AI to do the arbitrage for the trilemma: sell, store or consume energy generated by the prosumers
– Verdigris (US): smart sensors and AI cloud solution collect data about the buildings to make a better decision, reduce costs and automate the response
– DeepMind (UK): a leading actor in artificial intelligence research and machine learning algorithms that can predict the load on data centers

- Enertech (Australia): lets customers manage their performance through a customized energy data analytics strategy by properly assessing, managing and reporting energy consumption, thereby, helping increase energy/resource productivity

- **Blockchain**

Blockchain is a set of technologies that act a decentralized ledger for information that can be widely accessed, updated, monitored and verified. Information is stored and processed in a decentralized manner, so no single user or data center controls all information in the blockchain.

In most of its applications, blockchain is an openly accessible network and database that records transactions between two parties efficiently and in a verifiable and permanent way. It can also be programmed to trigger transactions automatically. Transactions are stored in virtual blocks, which are connected in a chain, creating a complete history of all transactions that have ever occurred within a network.

Blockchain will integrate information and process within and across enterprise boundaries and has the potential to streamline and accelerate business processes, increase protection against cyberattacks and reduce or eliminate the roles of intermediaries. Blockchain is a new architecture that increases the opportunities for peer to peer transactions, green certification, and asset tracking with no middleman [7]. Here are some examples:

- Oslo to Rome (Europe): public and private e-charging infra-structure connected across Europe on a "Decentral Mobility Network" to enable direct, cross-country e-charging as the basis for future mobility
- Block charge (Germany): allows users to easily share their private Electric Vehicle charging stations with the intentions of easily share or rent their mobility assets, including energy, parking spots, and eventually even the vehicles themselves [8]
- Blockchain is also an enabler for the development of smart energy contracts. These smart contracts can be administered and executed in a decentralized manner among energy market participants. Since they are digitally operated, they can be configured to automatically disburse payments or execute power dispatch orders once specified conditions are met. The benefits of smart contracts (as opposed to traditional contracts) is a higher level of transparency, integration of the contract with power markets and operations, and the elimination of costs imposed by middlemen (such as brokers, market operators, fiduciaries, financial entities, among others).

- **Peer-to-peer (P2P)**

Peer-to-Peer (P2P) energy trading consists of exchanges between peers in the power grid. The energy that is generated from small-scale DERs located in houses, buildings, offices, and factories is traded between energy prosumers and consumers connected to the same grid. The last is possible because power generation by the DERs systems usually have a storage system incorporated, and the prosumer can decide to sell its surplus energy to other consumers [9]. Around the world some projects and trial have been deployed, here are some examples [10]:

- Piclo (UK): collaboration between an innovative technology company called "Open Utility" and a renewable energy supplier "Good Energy", where business consumers could buy electricity directly from the local renewables

- Vandebron (Netherlands): links consumers and generators, and balances the whole market by enabling energy consumers to buy electricity directly from independent producers (such as farmers with wind turbines in their fields)
- PeerEnergyCloud (Germany): cloud-based technologies for a local electronic trading platform for dealing with local excessive production through a virtual Marketplace
- Smart Watts (Germany): optimization of energy supply using modern information and communication technologies (ICT)
- Yeloha and Mosaic (US): apartment owners and others who do not own solar systems can pay for a portion of the solar energy generated by the host's solar system
- SonnenCommunity (Germany): a community of sonnenBatterie (storage systems) owners who can share self-produced energy with others
- Lichtblick Swarm Energy (Germany): IT platform that optimized customers' local power plants and storage systems, allowing interactions between distributed and renewable energy sources
- Community First! Village (US): a community that provides affordable and permanent housing with energy supply funded by donations
- TransActive Grid (US): community energy market, and a combination of software and hardware that enables members to buy and sell energy from each other securely and automatically, using smart contracts and the blockchain
- Electron (UK): a platform for gas and electricity metering and billing systems through a completely secure, transparent, decentralized platform that runs on a blockchain

- **Internet of Things (IoT)**

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, and even device-enabled people or animals, that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction [7].

IoT will enable the connection of assets across the utility creating a digital gateway to the network and consumers increasing the speed and breadth of capabilities available. Some examples of IoT use cases are:

- Advanced Metering Infrastructure (AMI): One of the most prominent IoT applications for utilities. AMI allows utilities to equip users with meters with digital capabilities and that can remotely connect to the utility through a communications network. This allows the utility to develop a variety of use cases, such as the development of power services tailored to each individual user, remote connection/disconnection, the development of home/enterprise energy monitoring and control services, accurate billing that does not depend on a field force or on estimations, and a granular view on grid status that can optimize grid operations. AMI has been deployed is several countries around the world, including most EU countries, the United States, and a variety of initial phase projects in Latin America.
- Zaphiro (Switzerland): a real-time monitoring and automation system that enhances the reliability, efficiency, and profitability of grid operation
- Nordic Automation Systems (Estonia): an industrial automation company creating sensor technologies, data analysis, and monitoring solutions

- Sensolus (Belgium): care-free & low power tracking of your valuable non-powered assets directly from the cloud
- Hexoskin (Canada): smart clothing laced with sensors which monitors body activity and can be connected to chosen or custom
- Enlighted (US): technology platform for smart buildings providing sensor technology and scalable network to real-time data collection and high-value applications

- **Big Data**

The basic idea behind the phrase 'Big Data' is that everything we do is increasingly leaving a digital trace (or data), which we can use for analysis for future interpretations [7]. The four V's of Big Data are:

- Volume: The amount of data that we have for analysis is huge and it keeps increasing day by day and the information that can be retrieved from it will be of great use
- Variety: The different types of data that are made available for analysis. It can be either Structured, Unstructured or Semi-Structured
- Veracity: The trustworthiness of the data. Whether the data being generated is reliable or not
- Velocity: It is the speed at which the data gets generated. Eg: Data generated from Streaming applications like Twitter and Facebook

The Power & Utilities sector generates enormous amounts of data that can be processed to optimize power planning generation by estimating customers demand and DERs generation profiles. Big Data can also be leveraged to develop applications for the large amounts of data generated by Advanced Metering Infrastructure. Further, Big data has the capability of process data to make energy consumption decisions on the user side.

- **Cloud Services**

Cloud services or cloud computing is the delivery of computing services such as servers, storage, databases, networking, software, analytics, and intelligence over the Internet ("the cloud"). Instead of storing and processing data in a server inside the utility's offices, data can be sent, stored and processed in servers operated by a cloud service provider. Cloud services offer faster innovation, flexible resources, and economies of scale [7]. Utilities can leverage the cloud to reduce the costs for their technology infrastructure, to develop agile and cost-efficient applications, and to facilitate a rapid increase scale of data operations. This last point is particularly valuable for the introduction of Advanced Metering Infrastructure and DER, which enormously increase the amount of data that utilities need to process.

Regulatory specifications for cloud applications for government entities or critical national infrastructure can be an important consideration for cloud adoption in utilities. Many governments prohibit utilities from sending data to servers outside of national territories to mitigate privacy and cybersecurity concerns or due to mercantilist reasons.

This is a particular challenge for Latin American utilities, as cloud service providers do not operate servers in all countries in the LAC region. Utilities may need to work with service providers and/or policy makers in order to develop effective, compliant and secure cloud applications.

- **Drones**

Drones are unmanned aerial vehicles (UAVs) piloted actively or remotely. Drones can easily access areas that are dangerous for humans to enter, site surveys that would have taken two or three weeks for humans can be completed in a matter of hours using a drone equipped with image capture software. This technology will decrease surveying costs and length of time while simultaneously improving accuracy [11].

Some use cases are:

- Drones can remotely monitor vegetation growth near power lines. This can significantly reduce costs to utilities by optimizing the deployment of vegetation management field teams. This application can also help to identify potential hazards to the power line, therefore contributing to mitigate operational risk.
- Drones aid in aerial surveying & assessment, including hazard map creation, natural disaster monitoring, infrastructure inspections
- Drones can improve reporting, reduce the processing times of insurance claims, and deliver tangible aspects, such as payment cards
- Drones can access areas that are risky for humans (e.g., areas that have been through natural disasters)

- **Cybersecurity**

Cybersecurity helps to detect, resist and react to cyber-crime by assessing operations, priorities, and vulnerabilities. It helps organizations navigate the innovative and transformative changes in their business strategy and operating model that pose cybersecurity implications. Protecting the information channels from cyber-attacks will play a major role in the utility data infrastructure by protecting the electrical grid systems of cyberattacks [7].

Cybersecurity is a key consideration across all digital and physical technology developments in a utility. As a utility develops new applications, data sources, and access points, it also develops new cybersecurity vulnerabilities. Utilities must therefore consider Cybersecurity along with all other technology initiatives.

- **Robotic Process Automation (RPA)**

Robotics, or robot process automation (RPA), is the use of a software “robot” (a program) that replicates the actions of a human interacting with the user interface of a computer system. RPA connects multiple systems through automation without changing the existing IT landscape. It is a rule-based system that executes processes without the need for constant human supervision.

When applied to the right tasks, RPA can provide significant time and money savings. It can also help mitigate the risk of human error. Some of the key applications of RPA include back-office tasks in finance, supply chain management, accounting, customer service and human resources, such as data entry and purchase order issuing.

RPA enables process improvement to go far beyond process re-engineering/optimization or labor arbitrage. The efficiency of existing robotic solutions outperforms any employee: they do not make mistakes, work 24/7 and can be ramped up in an instance to match volatile demand. RPA also provides full audit trails and process compliance [7]. Some RPA trial projects are:

- EDF/Amazon (France): Amazon Echo voice-controlled energy. Alexa will then answer questions about your energy account
- Agent.ai (US): Artificial intelligence that answers customers questions in seconds

- **Augmented Reality (AR)**

Virtual Reality (VR) focuses on creating a virtual world while Augmented Reality (AR) provides an immersive experience allowing the user to have interactions with the real world. Interactions with real and virtual worlds along with spatial mapping features are supported by Mixed Reality [7]. Some uses for these technologies in the Power & Utilities sector are:

- Connecting with customers, record continuous feedbacks, develop easy prototypes to be tested by customers
- Identify technical issues, locating assets, capturing data
- Within the company to improve collaboration between teams working remotely, visualize trends and data, etc
- Potential applications of next realities devices as a training tool for every field of play, from customers and field workers to corporates

Some examples of use cases for AR are:

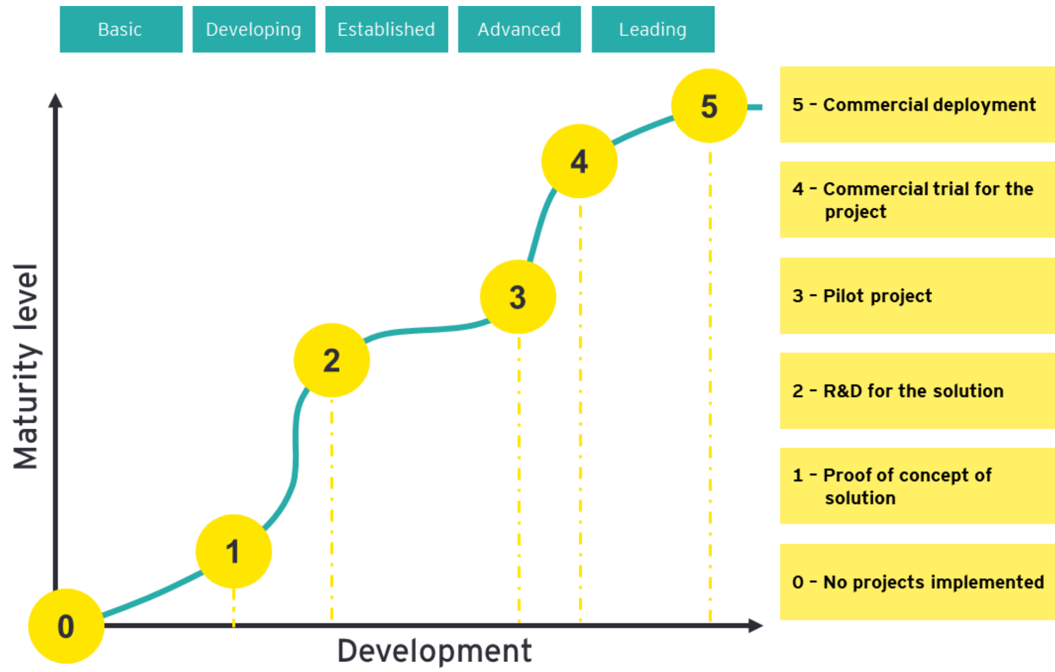
- Utility AR (Ireland): it works with innovators in Utilities to unlock the potential of Augmented Reality applications tailored for their needs
- Microsoft Hololens (US): is the first self-contained, holographic computer, enabling their users to engage with digital content and interact with holograms in the world around them
- Viu More (Belgium): real-time remote support based on Augmented Reality technology
- Ansys (US): using ANSYS physics-based simulation in conjunction with analytics, companies can make confident predictions about future product performance, reduce the cost and risk of unplanned downtime & improve future product development processes
- Carbon (US): The Carbon SpeedCell™ is a system of connected manufacturing unit operations that enables repeatable production of end-use parts at any scale

2.2. Information treatment

To use the information gathered, Key Performance Indicators (KPIs) have been defined together with the parameters required to calculate them. For each of the parameters, the relevant data was collected and used to calculate the related KPI. Annex C shows a description and measurement unit of the identified KPIs, and whether it is a qualitative or quantitative indicator.

In the Figure 5, the maturity level is measured with six different stages that evaluate the status of the project the utilities are developing. The maturity level is also measured regarding the time the project has been developing, identifying the efforts the utility has made to reach a commercial level with the offered technology. The maturity model helps to indicates the state in which the projects are, and let comparisons be made between different projects to differentiate the efforts made by the utilities analyzed in this study. Therefore, the maturity model is used to classify the maturity level of the enabling technologies for each country.

Figure 5 Maturity level for the enabling technologies



Source: EY Power and utilities Innovation Lab

Each maturity level will be explained as follows:

0 – No project implemented: currently there are no projects developed for the enabling technology and the country has no long-run projection towards the implementation of the technology in the industry.

1 – Proof of concept solution: resumed implementation of the project with the aim of demonstrating feasibility and potential of the enabling technology, this project is still at the stage of being completed or not, demonstrating a high uncertainty towards the project's long run.

2 – Research and Development for the solution: the project has been already proved to show some feasibility but still is on the process of development at an early stage with limited functions but on the process of becoming a pilot project.

3 – Pilot project: initial roll-out stage of a technology, entering the production stage, targeting a limited scope of the intended final solution, with the possibility of big adjustments and re-imagination of the project.

4 – Commercial trial for the project: the project is closing the gaps between the company and the customers, reaching a commercial agreement but on a small scale, looking for improvements and expansion opportunities that could expand its market.

5 – Commercial deployment for the project: stage in which the new product is accepted in the market (widespread deployment and the market reaches saturation), demonstrating a good commercial run, having a good performance towards the customer and growing their own market.

The quantitative information gathered from the different databases is presented in a normalized form. The variables found where presented in different forms (Ratio, Percentage, whole numbers, decimal numbers among others). Due to the way some information was given all the results where normalized in a first instance by converting them all into percentages, this will help to see a common ratio that does not depend on the size of the market of each country. Indicators for the EV market were a proportion for 10,000 vehicles to identify a real distribution of the EV market, in other instances, the storage capacity was identified by dividing it with the total peak demand, this way it could be analyzed the percentage of coverage of the storage system.

Even though the first type of normalization helps that comparison between variables, not all the indicators are presented in a %, due to this a second normalization is made to leave all the results on a scale from 0-1. To obtain this scale all the results were converted with a *Min-Max* Formula just as presented below.

Figure 6 Min-max formula

$$\frac{X-\min(X)}{\mathrm{Max}(X)-\min(X)}$$

Source: EY Power and utilities Innovation Lab

For the normalization, the minimum and maximum indicator were from the same variable now that the normalization is being made for each variable apart, but now having all the variables from 0-1, the indicators may be comparable between countries.

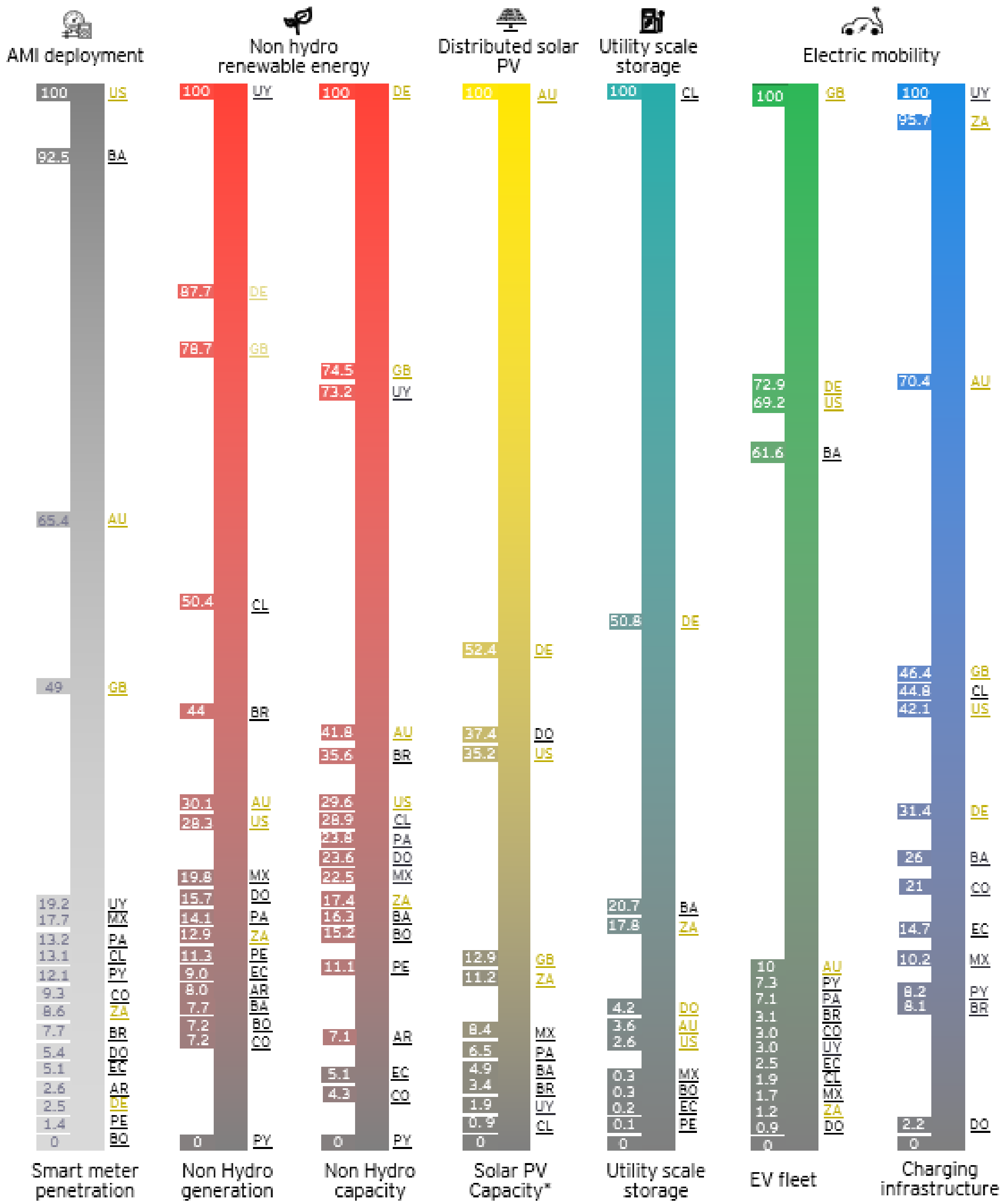
3. Results

3.1. Main results of the quantitative information

The following figures present a comparison of each country, divided by the dimensions studied. The graph shows normalized results of each KPI; the information from each KPI was standardized using a min-max formula, where the head country is rated with a score of 100, the tail is rated with a 0 and all the other results are mapped in the range of 0 to 100. The graph reflects the advantage of the US, Germany, the United Kingdom, and South Africa over the other countries on these topics, as well as Uruguay and Chile as the high performer among the LAC countries.

The Table 2 includes the results of the quantitative KPIs, highlighting the best indicator in the LAC region and the best indicator in the reference countries. In the benchmark countries, Germany leads the other countries by being the reference in two KPIs, Germany leads the in utility-scale storage penetration and non-hydro renewables. At the same time, the UK holds the leadership in EV fleet deployment, Australia leads the distributed solar PV penetration, the US is the most advanced in AMI deployment, and South Africa is the leader in EV chargers. From the LAC, countries leading its peers are Uruguay with the highest EV chargers and non-hydro renewables, and Barbados with AMI Deployment and EV fleet, the other two leaders are Chile (utility-scale storage penetration) and Dominican Republic (non-hydro renewables).

Figure 7 Rank of countries for the quantitative information[3]



Source: EY Power and utilities Innovation Lab

[3] Countries that are not shown in the graph have a KPI of 0

Table 2 Quantitative results

Country/Dimension	AMI deployment	Non-hydro Renewables*	Distributed Solar PV	Utility Scale Storage	EV Fleet	EV Chargers
Argentina	1.7%	4% / 3%	0.0%	0.0%	0.0	0.0
Barbados	55.6%	9% / 3%	2.4%	3.2%	33.1	0.6
Bolivia	0.1%	8% / 3%	0.0%	0.0%	0.0	0.0
Brazil	4.8%	19% / 17%	1.7%	0.0%	1.6	0.2
Chile	8.0%	15% / 20%	0.4%	15.6%	1.0	1.0
Colombia	5.7%	2% / 3%	0.0%	0.0%	1.6	0.5
Dominican Republic	3.4%	13% / 6%	18.3%	0.0%	0.5	0.1
Ecuador	3.2%	3% / 4%	0.0%	0.0%	1.3	0.3
Mexico	10.8%	12% / 8%	4.1%	0.0%	0.9	0.2
Panama	8.1%	13% / 6%	3.2%	0.0%	3.8	0.0
Paraguay	7.4%	0% / 0%	0.0%	0.0%	3.9	0.2
Peru	1.0%	6% / 4%	0.0%	0.0%	0.0	0.0
Uruguay	11.6%	39% / 39%	0.9%	0.0%	1.6	2.2
Australia	39.4%	22% / 12%	49.0%	0.6%	5.4	1.6
Germany	1.6%	53% / 34%	25.7%	7.9%	39.2	0.7
South Africa	5.3%	9% / 5%	5.5%	2.8%	0.7	2.1
United Kingdom	29.5%	40% / 31%	6.3%	0.7%	53.7	1.0
United States	60.1%	16% / 11%	17.3%	0.4%	37.2	0.9

Best LAC country

Best innovative market country

Source: EY Power and utilities Innovation Lab
*Non-hydro renewables has two KPIs: Installed capacity and Energy generation

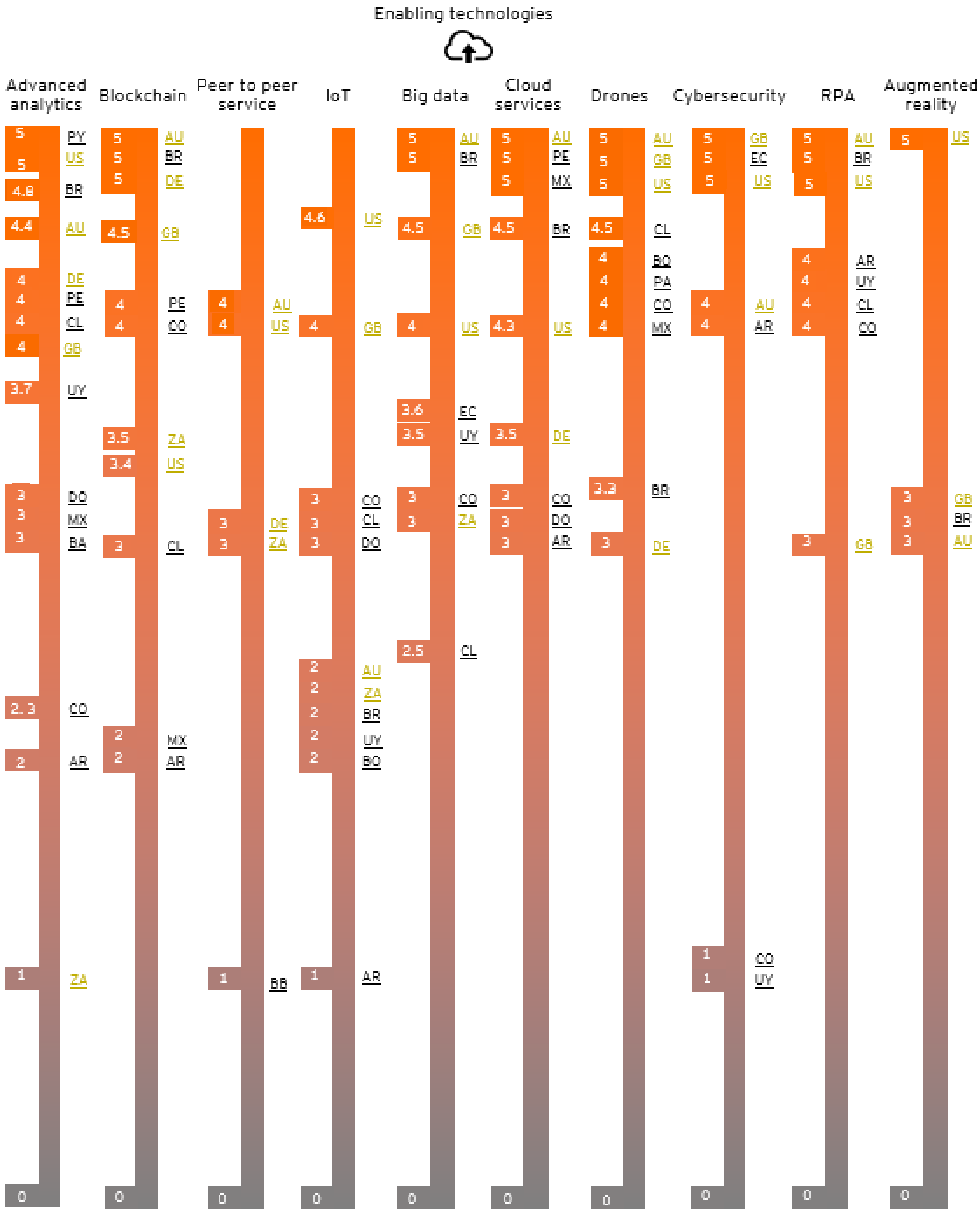
3.2. Main results of the qualitative information

The Figure 8 presents the status of each country towards the enabling technologies implemented in the industry. Unlike the graph from quantitative KPIs, this one does not have standardized results because they share an equivalent maturity level scale. Brazil has the highest maturity level degree for enabling technologies compared to the other LAC countries.

Table 3 shows the results of the qualitative KPIs, highlighting the best indicator in the LAC region and the best indicator in the innovative markets. In the innovative markets, the US and Australia lead the other countries by being each reference in six KPIs. From the LAC countries, the one leading its peers is Brazil with the highest level of adoption in four technologies: Blockchain, Big Data, RPA and Augmented Reality. Also, Chile is the most advanced in IoT and Drones. In terms of advanced analytics, Paraguay leads its peers[4], and Chile, Colombia, and the Dominican Republic are the most advanced in IoT projects. Mexico and Peru are the most advanced LAC countries in cloud services technology.

[4] Paraguay presents this level of maturity in advanced analytics due exclusively to the production of the binational power plant together with Brazil, Itaipu.

Figure 8 Rank of the countries for the qualitative information[5]



Source: EY Power and utilities Innovation Lab

[5] Countries that are not shown in the graph have a maturity level of 0

Table 3 Qualitative results

Country/Dimension	Advanced analytics	Blockchain	Peer to peer service	IoT	Big data	Cloud services	Drones	Cybersecurity	Robotic Process Automation	Augmented Reality
Argentina	2.0	2.0	0.0	1.0	0.0	3.0	0.0	4.0	4.0	0.0
Barbados	3.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bolivia	0.0	0.0	0.0	2.0	0.0	0.0	4.0	0.0	0.0	0.0
Brazil	4.8	5.0	0.0	2.0	5.0	4.5	3.3	0.0	5.0	3.0
Chile	4.0	3.0	0.0	3.0	2.5	0.0	4.5	0.0	4.0	0.0
Colombia	2.3	4.0	0.0	3.0	3.0	3.0	4.0	1.0	4.0	0.0
Dominican Republic	3.0	0.0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0
Ecuador	0.0	0.0	0.0	0.0	3.7	0.0	0.0	5.0	0.0	0.0
Mexico	3.0	2.0	0.0	0.0	0.0	5.0	4.0	0.0	0.0	0.0
Panama	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0
Paraguay	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Peru	4.0	4.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0
Uruguay	3.8	0.0	0.0	2.0	3.5	0.0	0.0	1.0	4.0	0.0
Australia	4.4	5.0	4.0	2.0	5.0	5.0	5.0	4.0	5.0	3.0
Germany	4.0	5.0	3.0	0.0	0.0	3.5	3.0	0.0	0.0	0.0
South Africa	1.0	3.5	3.0	2.0	3.0	0.0	0.0	0.0	0.0	0.0
United Kingdom	4.0	4.5	0.0	4.0	4.5	0.0	5.0	5.0	3.0	3.0
United States	5.0	3.5	4.0	4.7	4.0	4.3	5.0	4.3	5.0	5.0

Best LAC country

Best innovative market country

Source: EY Power and utilities Innovation Lab

3.3. Power BI results

The power BI results are divided into four main categories: (i) summary of the results, (ii) Country region scenario analysis, (iii) comparative matrix between regions and countries and (iv) a box plot analysis.

3.3.1. Summary of the results

The first category shows a summary of the main indexes calculated for each country. These results are divided into four main categories that show the index of each country in a general scope, in a centralized grid, in a distributed grid and a neutral grid. Each scenario is compared towards the GDP/ Capita of each country, which helps to understand and show the innovative situation of each country towards its economic context. Giving more insight on how each country is taking advantage of their current situation to gather new innovative technologies in the industry.

The legend of the countries presented in the graphs can be found in the Figure 9.

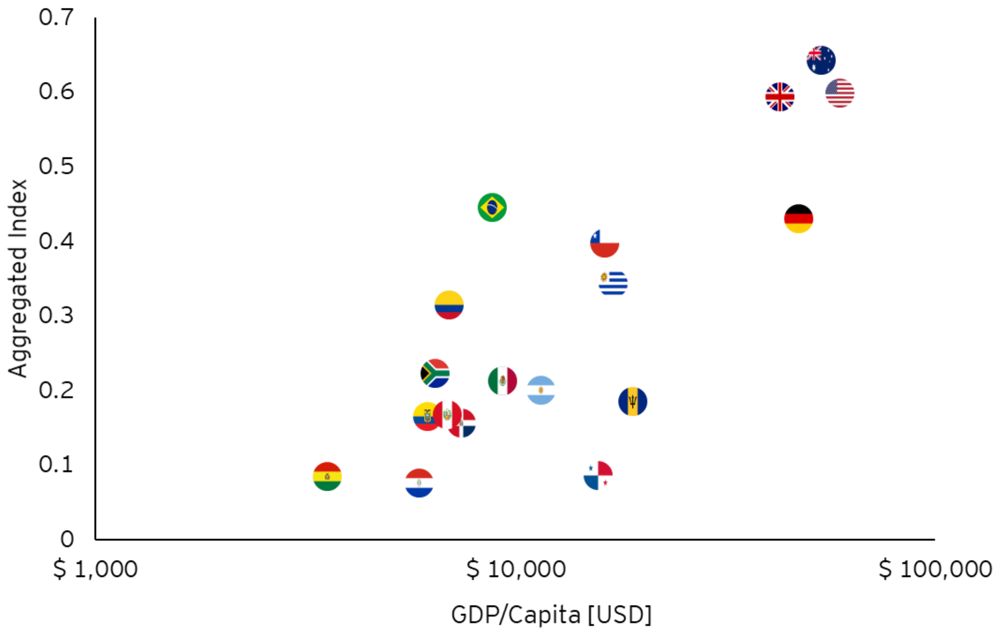
In the Figure 10, the aggregate index of each country is presented against the GDP/Capita. The graph shows two sets of clusters that can represent a clear gap between them, the first cluster is divided by the aggregated index in which countries such as the UK, Australia, and the US have a greater innovation index than the rest of the countries, leaving all the LAC countries in the same cluster. The other cluster is the economic division between the countries showing a great gap between Australia, UK, the US, and Germany against the rest of the countries, this gap shows a clear barrier for the innovation growth of the LAC countries. In the cluster of the LAC countries, it can be identified that the aggregated index do not surpasses a value of 0,45. Countries such as Paraguay, Panama and Bolivia show a very low index meanwhile countries such as Chile and Brazil demonstrate a more innovative index, demonstrating a higher interest in the growth of the industry.

Figure 9 Legend for the index graphs

Country	Flag
LAC Countries	
Argentina	
Barbados	
Bolivia	
Brazil	
Chile	
Colombia	
Dominican Republic	
Ecuador	
Mexico	
Panama	
Paraguay	
Peru	
Uruguay	
Benchmark Countries	
Australia	
Germany	
South Africa	
United Kingdom	
United States	

Source: EY Power and utilities Innovation Lab

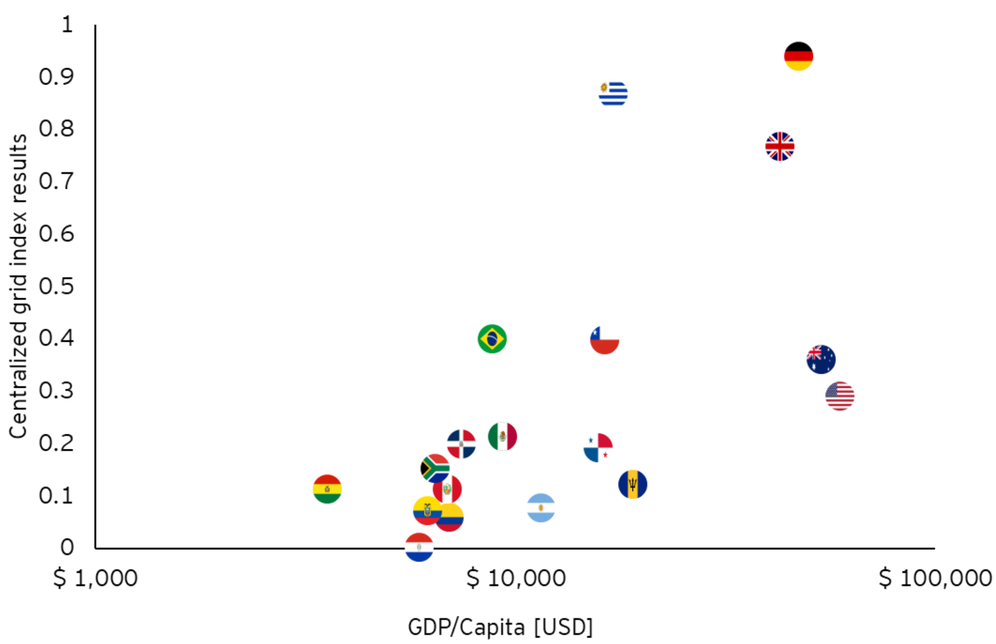
Figure 10 Aggregate index results



Source: EY Power and utility Innovation Lab

Towards the centralized results, as shown in the Figure 11, the countries that demonstrated a predominance in the aggregated index also demonstrate a high index in all the use of centralized grid technologies, especially Germany which due to its high use of non-hydro renewable sources both in its installed capacity as well as its generation. Uruguay demonstrates a high index due to the hi penetration of non-hydro renewables in the energy matrix.

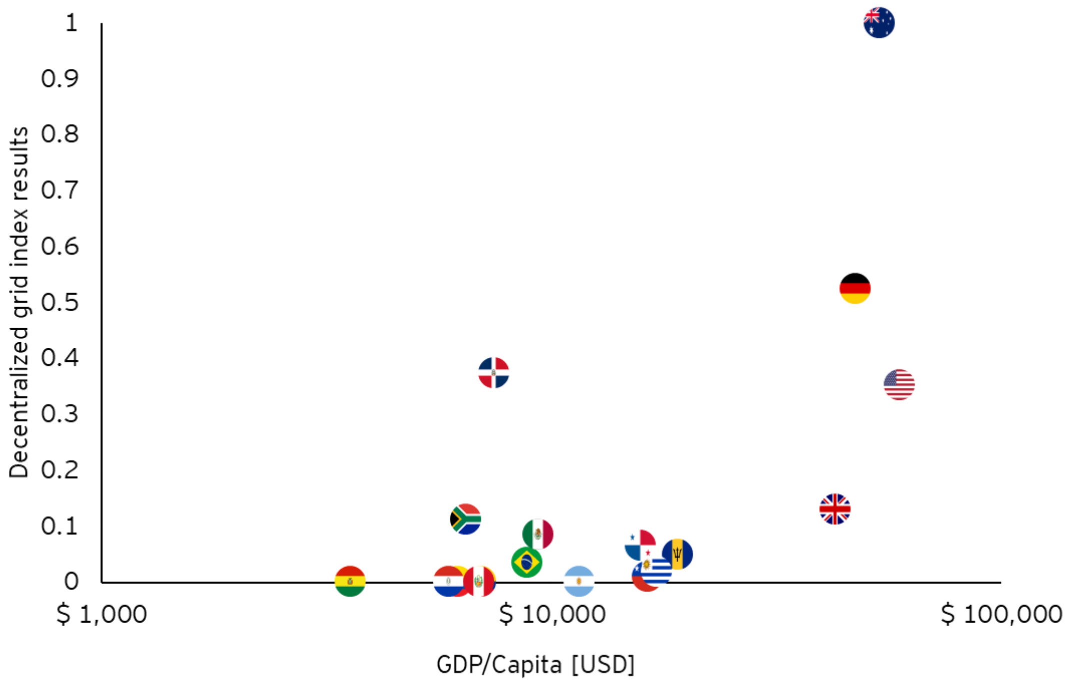
Figure 11 Centralized grid index results



Source: EY Power and utility Innovation Lab

For the distributed grid, as shown in the Figure 12, compared to the other graphs, the innovative index is very low, taking into account that the technology measured was distributed solar PV, some countries do not have valid information for this technology, that's why in the graph many countries can be seen with an aggregated result near or equal to 0. From the countries that do use distributed solar PV, Australia has a hi penetration of distributed solar PV.

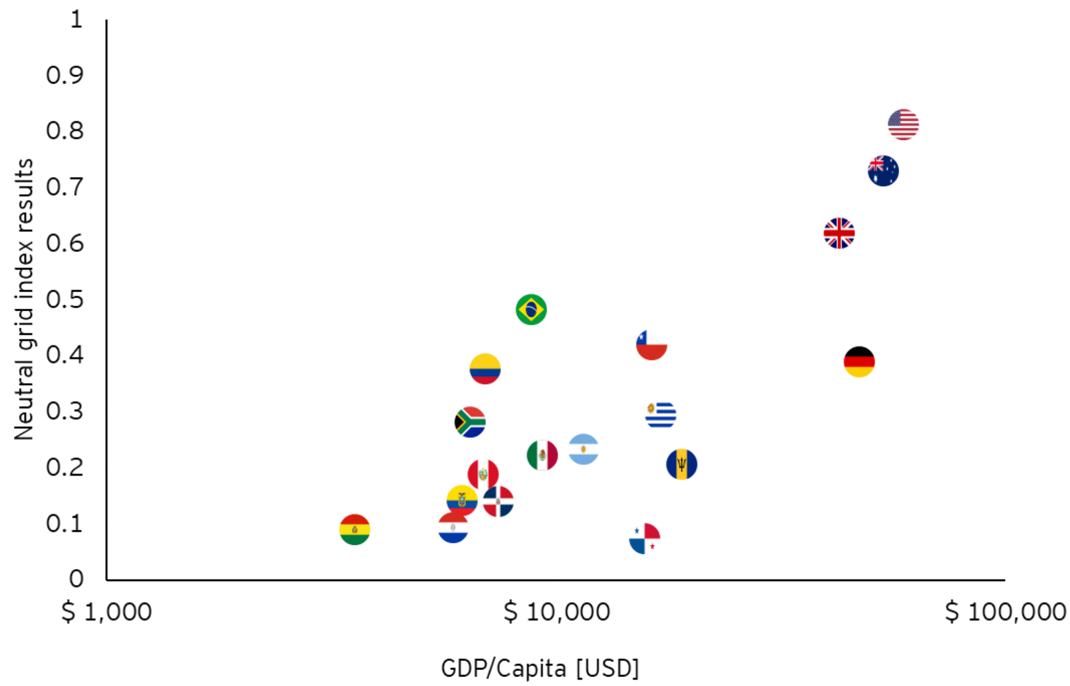
Figure 12 Decentralized grid index results



Source: EY Power and utilities Innovation Lab

The last type of grid presented is the neutral grid, as shown in the Figure 13, this one represents not only the different types of enabling technologies but also the use of EV's and AMI. The US, the UK and Australia, demonstrate a high adaption of the different technologies that support a neutral grid. As for the cluster of the LAC countries, Brazil, Chile, and Colombia do show high adoption of these technologies being above from the rest of the LAC countries, having countries such as Paraguay, Panama and Bolivia with a low index.

Figure 13 Neutral grid index results



Source: EY Power and utilities Innovation Lab

3.3.2. Country region scenario

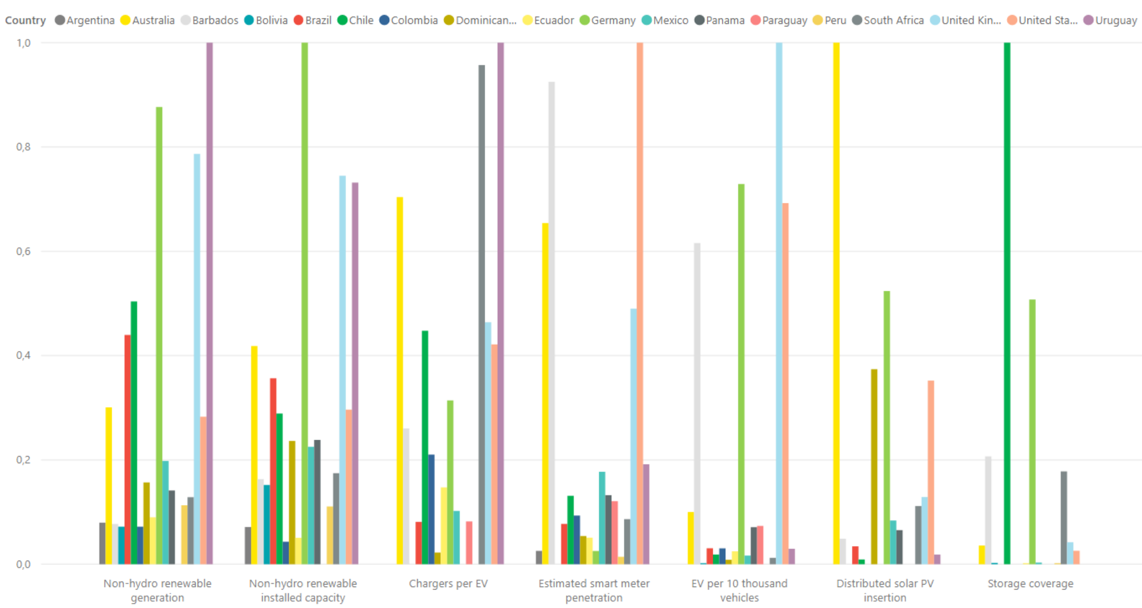
To have a better understanding of the results presented in the summary, the section of the country region scenario will help to determine and recognize the score that each country has towards each type of technology. To have a better understanding of each variable, they are divided into two types of graphs, the first graphs present the quantitative results, meanwhile, the second graph shows the qualitative variables (the enabling technologies). Due to the normalization of the results, the indicators are shown on a scale from 0-1. This normalization is made to make all the indicators comparable between countries.

In the Figure 14, the quantitative variables are presented for each country, showing the highest and lowest countries in each indicator. For the non-hydro installed capacity and generation, it can be seen how countries such as Germany and the UK have a very high advantage against most LAC countries. For the LAC countries, Uruguay has the highest non-hydro renewable usage, but still not being close to the innovative markets.

Towards the EV market, Countries like the UK and South Africa have a high market penetration as well as a usage on EV chargers. From the LAC countries, Barbados has the highest level of usage being near the innovative market and having an advantage towards the rest of the LAC countries.

For the estimated smart meter penetration, the US has a small advantage towards the highest LAC country which is Barbados. For the solar distributed power, Australia has the highest index in the category, in the usage of storage Chile and Germany have the higher indicator.

Figure 14 Quantitative information data



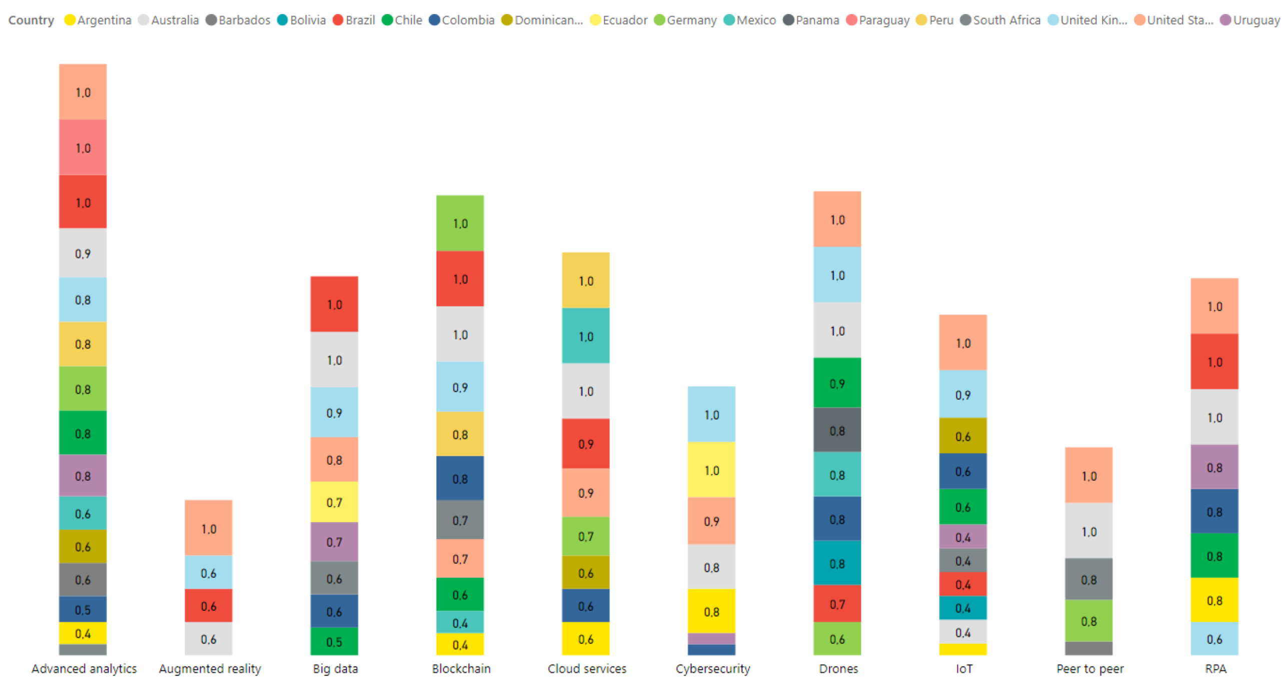
Source: EY Power and utilities Innovation Lab

For the enabling technologies, the results are presented in the Figure 15 from a scale from 0-1 having the highest country at the top of the graph and the lowest countries at the bottom. All the technologies presented are part of the neutral grid, also if the technology was not identified in a respective country then the country was not considered for that indicator.

For the advanced analytics, countries such as the US, Paraguay, and Brazil have a high adoption of advanced analytics having the LAC region and the innovative markets share a rather alike indicator. Towards the augmented reality, not many countries adopt this type of technology, but as seen in the graph, the US and Brazil do have a rather high adoption of this technology, showing a project with a commercial level.

For technologies such as Big Data, Blockchain and RPA, Brazil, Colombia and Chile show a predominance in the technology against other LAC countries, meanwhile for cloud services Mexico and Peru demonstrate a high maturity level due to its energy projects that include a structured cloud system. As for the other technologies, it can be seen in the graph that innovative markets such as the US have a high predominance in the use of these technologies with well-structured projects.

Figure 15 Qualitative information data



Source: EY Power and utilities Innovation Lab

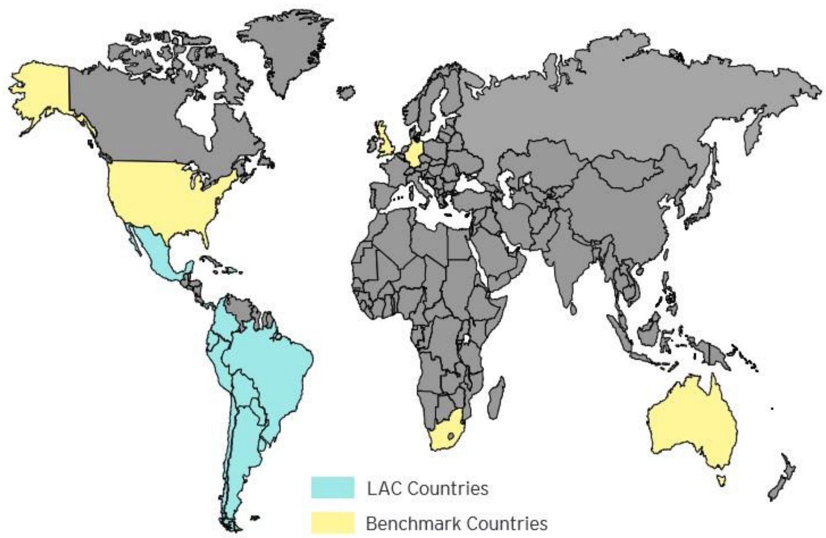
3.4. Index results summary

The Table 4 and Figure 16 show each country of the study with its respective flag and the scatter graphs below include the results of the quantitative KPIs, highlighting the countries with the best indicator and the countries that demonstrate a slow adoption towards technology, in both the LAC region and Innovative market countries. The scatter graphs also include the results of the qualitative KPIs, highlighting the countries that show a high level of adoption towards enabling technologies compared to the others and the countries that show a lower level.

Table 4 Country flags

Country	Flag
LAC Countries	
Argentina	
Barbados	
Bolivia	
Brazil	
Chile	
Colombia	
Dominican Republic	
Ecuador	
Mexico	
Panama	
Paraguay	
Peru	
Uruguay	
Benchmark Countries	
Australia	
Germany	
South Africa	
United Kingdom	
United States	

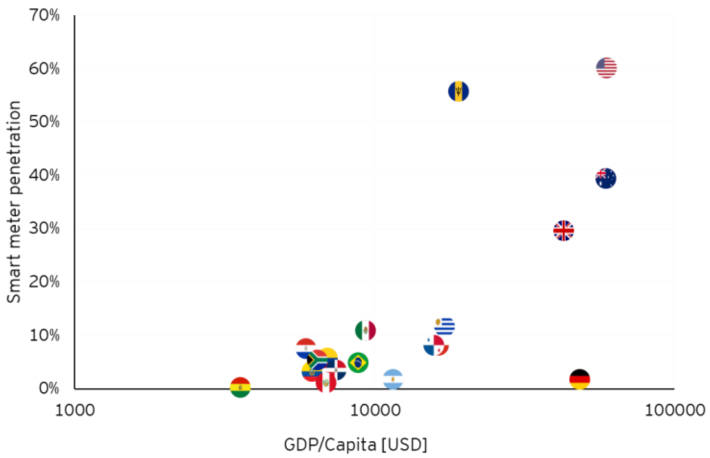
Figure 16 World map



Source: EY Power and utilities Innovation Lab

3.5. Quantitative information

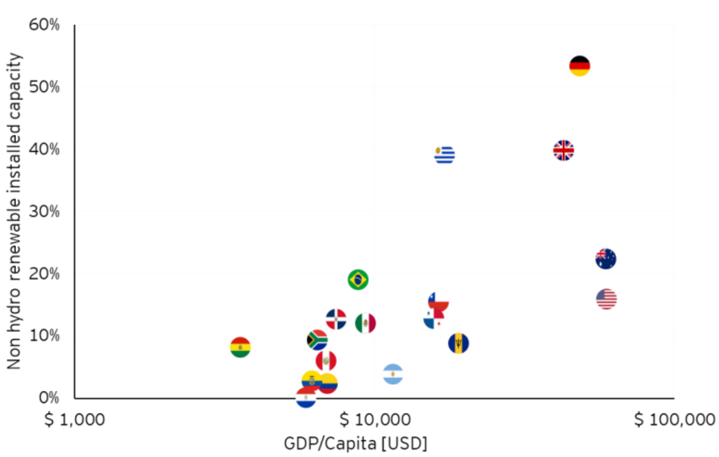
Figure 17 Smart meter penetration



Source: EY Power and utilities Innovation Lab

Bolivia and Peru show a lower smart meter penetration compared to the other countries. Mexico, Uruguay and Barbados are close to each other showing a higher degree of AMI deployment compared to the other four countries. The US followed by Australia and the UK show a great difference from the other countries (excepting Barbados) demonstrating a trend towards smart meters deployment.

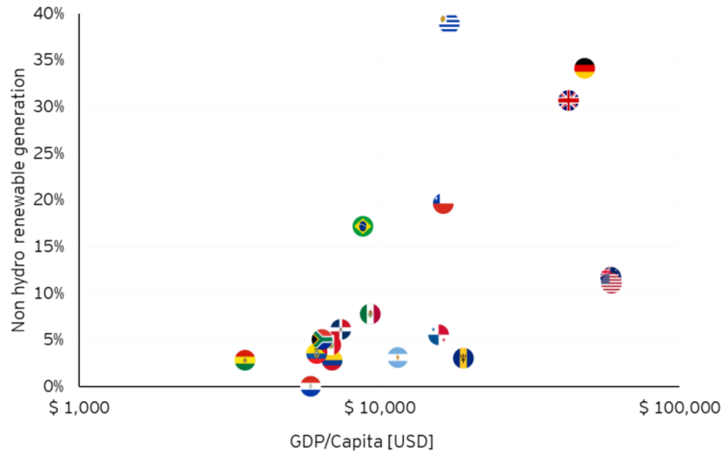
Figure 18 Non-hydro renewable installed capacity as a % of total generation capacity



Source: EY Power and utilities Innovation Lab

A country having a high percentage of non-hydro renewable installed capacity demonstrates an interest in new renewable resources to diversify or backup their generation matrix. In this case, Germany does not depend on hydro resources for its renewable installed capacity, showing dependency on other technologies such as wind, solar, among others. Uruguay and the United Kingdom show a balanced distribution between hydro and non-hydro renewables. Lastly, Paraguay, Colombia, and Ecuador have a high dependency on hydro resources.

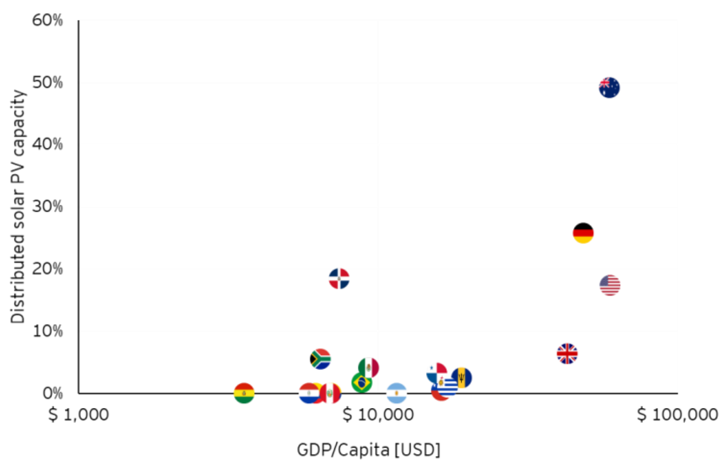
Figure 19 Non-hydro renewable generation



In this case, Uruguay, Germany and the UK do not depend on hydro sources for their renewable generation, showing dependency on other technologies such as wind, solar, among others. Paraguay has a complete dependency on hydro resources. Meanwhile, Brazil and Chile show a balanced distribution (almost 20% of non-hydro) in renewables.

Source: EY Power and utilities Innovation Lab

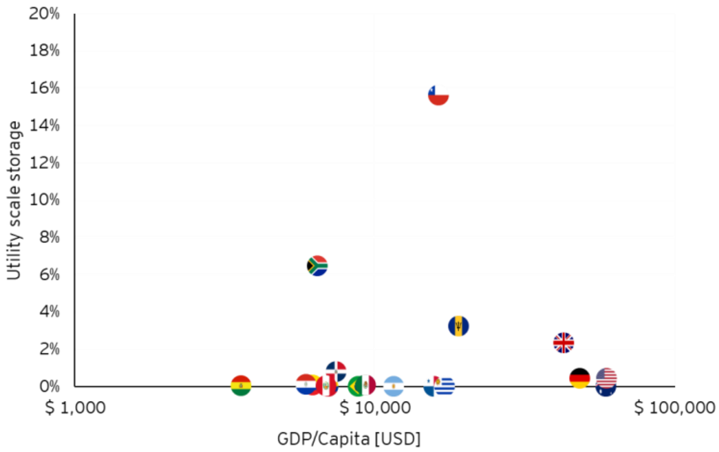
Figure 20 Distributed solar PV capacity



From the LAC countries, Argentina, Bolivia, Colombia, Ecuador, Paraguay, Peru do not have information available for distributed generation. Dominican Republic has the higher percentage of distributed generation among LAC, however it is lower than Germany and Australia, the last being far ahead form the other countries.

Source: EY Power and utilities Innovation Lab

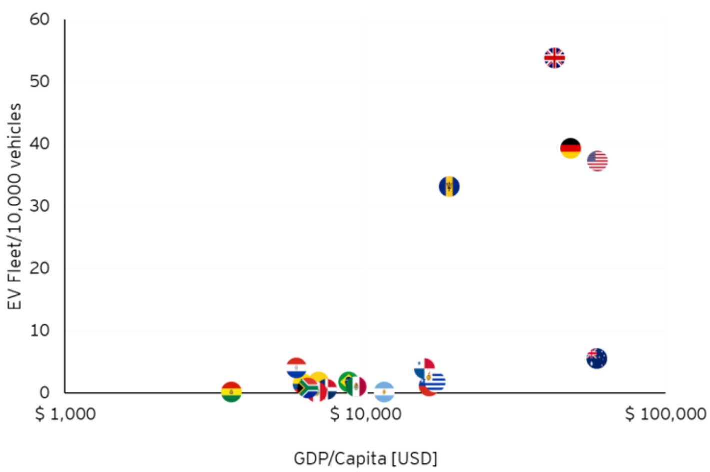
Figure 21 Utility scale storage



Source: EY Power and utilities Innovation Lab

Most of the LAC countries don't have any capacity of storage to cover their peak demand, despite their income level. Countries such as Peru, Bolivia, Mexico, Ecuador, Paraguay, and the Dominican Republic have a low capacity of storage to cover their peak demand. Meanwhile, Chile shows a high percentage of storage, covering 15% of its peak demand, mainly from molten salt storage installed in the facilities of 5 solar generation projects. The storage market in this country has been boosted recently due to the decreasing of the battery prices mainly of ion lithium. This increase in energy storage also gives a major entrance to the renewable generation. Barbados is the second highest country of the region in this KPI, meanwhile South Africa leads the benchmark countries, but it is far from the penetration of Chile.

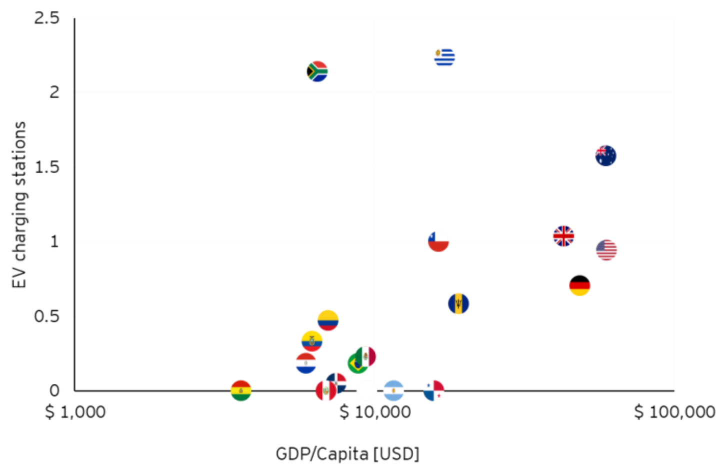
Figure 22 EV fleet/10,000 vehicles



Source: EY Power and utilities Innovation Lab

The UK has 54 EVs, Germany has 39 EVs and the US has 37 EVs per every ten thousand vehicles in the country. Barbados is the LAC country with the highest EV fleet compared to their total fleet, with 33 EVs per ten thousand vehicles. Countries such as Argentina and Peru don't have any electric vehicle at all and the rest have a low proportion of EV compared to their total fleet of vehicles, demonstrating a slow adaptation towards this technology.

Figure 23 EV charging stations

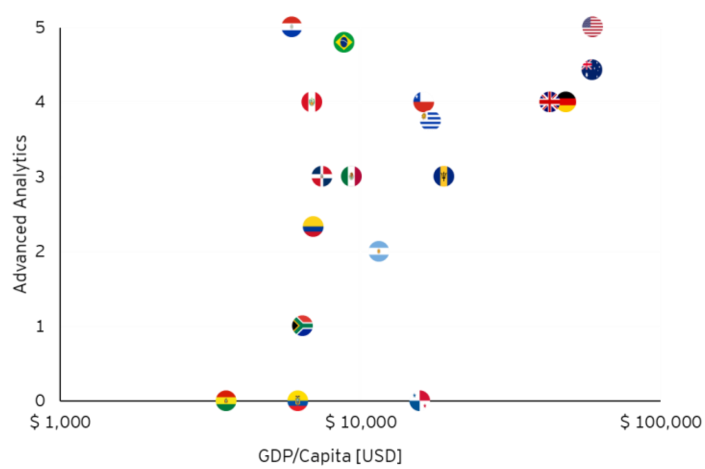


Source: EY Power and utilities Innovation Lab

Charging station infrastructure provides consumer confidence along with technicians to install, operate and maintain the new transportation technologies. In this case, EV charger's relation can reflect a complete private charging infrastructure, while a less than one relation not necessarily reflects an insufficient private infrastructure but the existence of a shared public infrastructure. Uruguay and Chile are the LAC countries with more EV chargers per EV, and South Africa is the benchmark country with the higher number.

3.6. Qualitative information

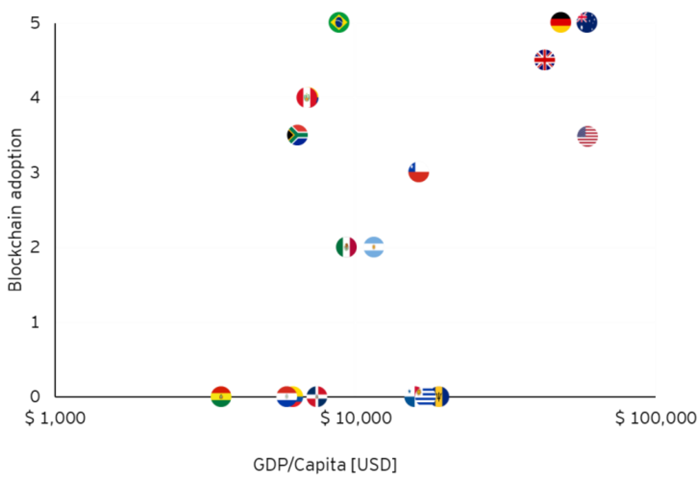
Figure 24 Advanced analytics



Source: EY Power and utilities Innovation Lab

15 countries studied have at least a proof of concept project in advanced analytics. Paraguay shows a higher experience on this topic, being the country with the highest maturity level in the LAC countries included in this report. The PTI in Paraguay and Brazil has implemented the automation and control innovation area, is a technical-scientific space, equipped with adequate facilities, hardware, software, and specialized professionals.
Peru, Chile, and Uruguay also show high adoption of advanced analytics. Meanwhile, countries such as Ecuador, Panama, and Bolivia do not have advanced analytics as an enabling technology.

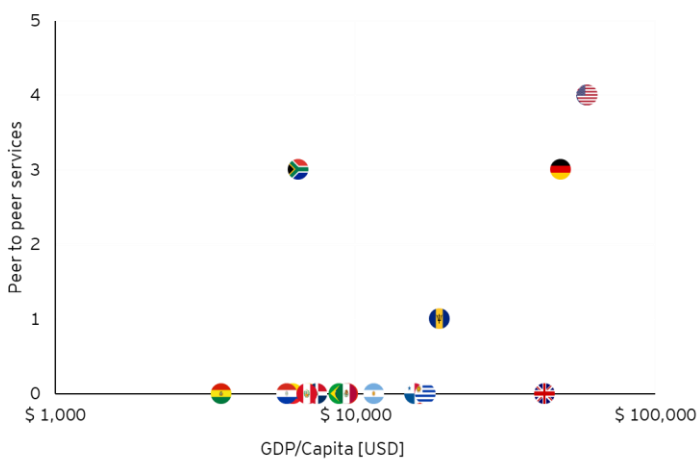
Figure 25 Blockchain adoption in the power sector



Source: EY Power and utilities Innovation Lab

Bolivia, Paraguay, Dominican Republic, Panama, Uruguay, and Barbados have not engaged in projects using blockchain in the energy sector. Brazil shows the highest maturity level in LAC countries.
In this country, Petrobras has launched machines for payment on time by credit card, as well as a free app that offers means of payment outside the network banking, smart management project, and blockchain solution. All the other LAC countries are in the stage of R&D, showing a greater interest in adopting blockchain for the energy sector or in the stage of commercial trial, like Colombia and Peru. Germany and Australia show the highest maturity level in the benchmark countries.

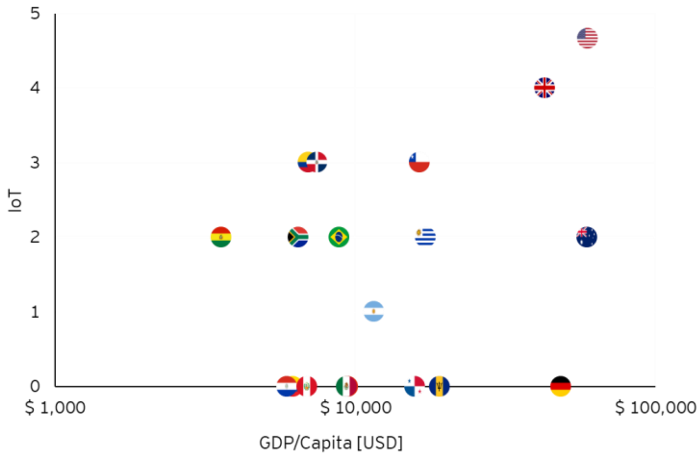
Figure 26 Peer to peer services



Source: EY Power and utilities Innovation Lab

For this enabling technology, the benchmark countries, USA and Australia (they overlap in the graph) are the countries with the highest maturity level, Barbados shows the highest maturity level in the LAC countries. Meanwhile, countries such as Bolivia, Paraguay, Mexico, Peru, Argentina, Panama, Uruguay, and Chile do not have P2P services as an enabling technology.

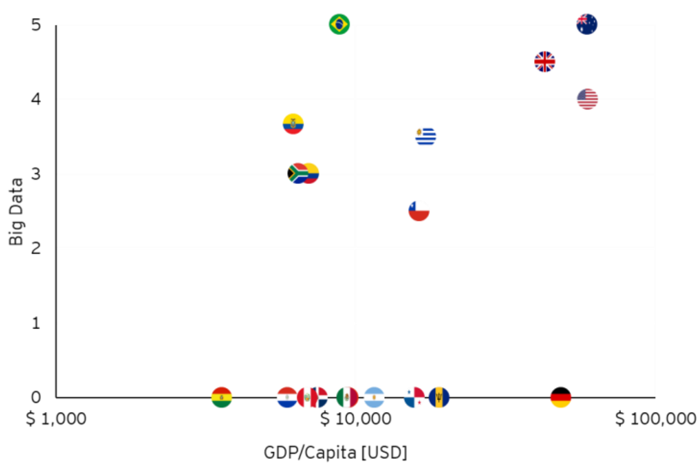
Figure 27 IoT



Source: EY Power and utilities Innovation Lab

All the LAC countries are in the stage of R&D, demonstrating an interest in the adoption of IoT for different practices in the industry. Colombia, the Dominican Republic, and Chile show the highest maturity level in the LAC countries. Meanwhile, countries such as Paraguay, Peru, Mexico, Panama, Barbados, Ecuador, and Germany do not have IoT services as an enabling technology. The United Kingdom and the United States are the benchmark countries with the highest maturity level.

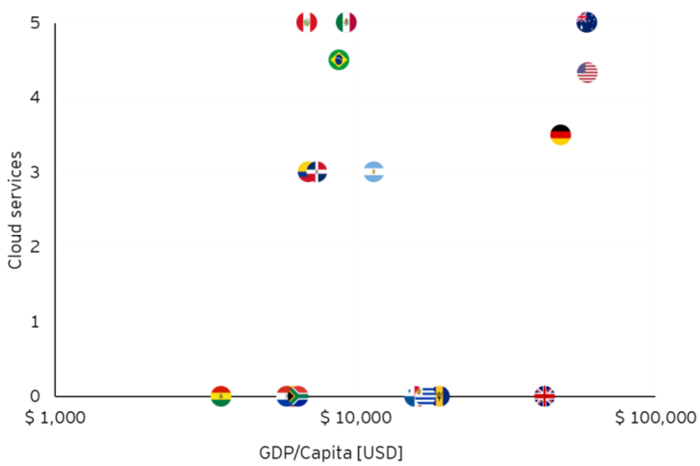
Figure 28 Big data



Source: EY Power and utilities Innovation Lab

Brazil shows the highest maturity level in LAC countries. In this country, Petrobras is working on the technological improvements in turbines and solar panels, whether in more advanced or efficient components or materials. These improvements expect to apply digital technologies that allow the use of real-time data and big data gains in maintenance, reduction of costs of O&M and energy lost in downtime. Australia, the UK and the US are the benchmark countries with the highest maturity level. Ecuador, Uruguay and Colombia are near the commercial trial stage for their projects of Big Data applications. The rest of the LAC countries are lagging in Big Data projects.

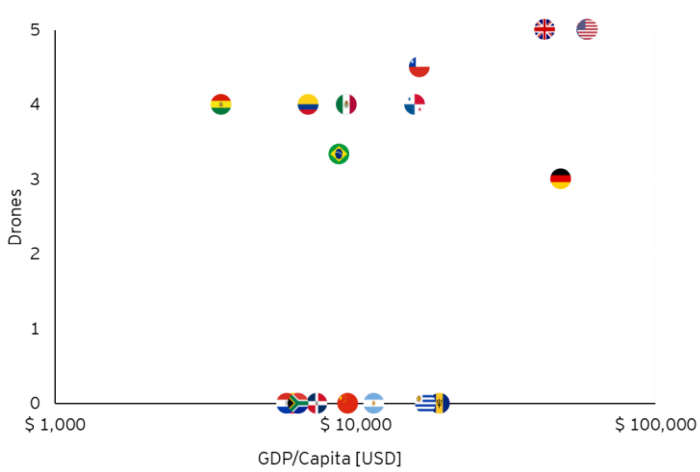
Figure 29 Cloud services



Source: EY Power and utilities Innovation Lab

Regarding cloud services, Peru and Mexico are the LAC countries with the highest maturity level. In Peru, Enel distribution carried out the digitalization of the electricity network with LIDAR (Light Imaging, Detection, and Ranging). In México, MVM engineer software has made the energy suite solution, offering resources for the compilation and analysis of large volumes of information, adding machine learning resources positioning the company as a worldwide work cloud.
Additionally, Colombia, Dominican Republic, and Argentina register an adoption of cloud services in the industry at a low maturity level. The rest of the LAC countries do not have Cloud services as an enabling technology.

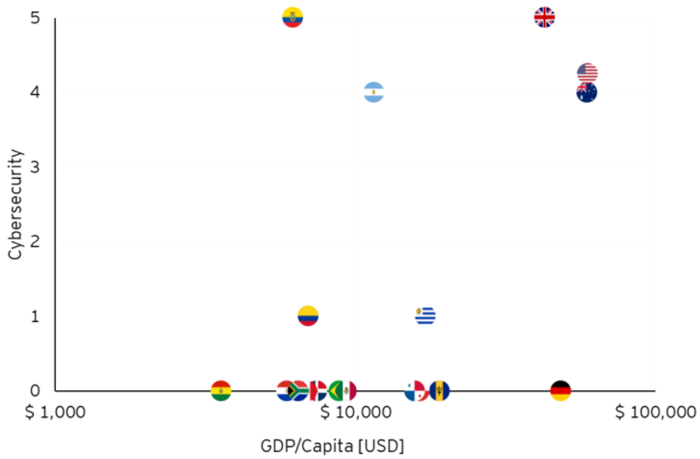
Figure 30 Drones



Source: EY Power and utilities Innovation Lab

Colombia, Bolivia, Panama, Chile and Mexico are adapting drone technology to oversee the infrastructure of their plants. Also, regarding drone adoption these countries show a similar maturity level as the UK and the US which are the benchmark countries with the highest maturity level. Brazil and Germany have a lower maturity level in the adoption of drones and the rest of the countries do not have Drones as an enabling technology.

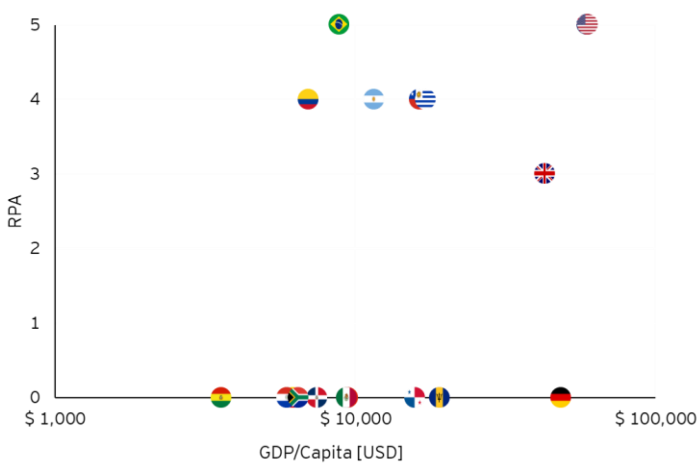
Figure 31 Cybersecurity



Source: EY Power and utilities Innovation Lab

Ecuador shows the highest maturity level in the LAC countries. In the first half of 2017, the Firewall-Checkpoint license renewal process was implemented in Empresa Electrica de Quito, as security equipment for the Las Casas Data Center, which has better access control to the company's systems. Argentina is positioned in a commercial trial stage, with a cybersecurity project carried out in EDENOR. Colombia and Uruguay are adapting cybersecurity primarily for generation data and have a low maturity level, being well behind the maturity level of Ecuador, the UK, and the USA projects. The rest of the LAC countries do not have Cybersecurity as an enabling technology.

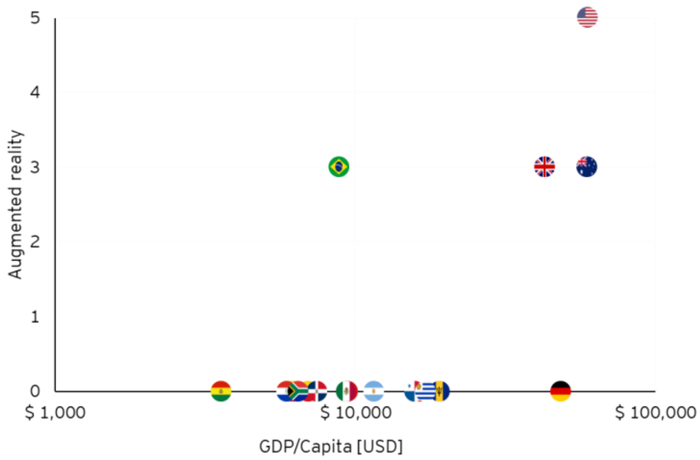
Figure 32 RPA



Source: EY Power and utilities Innovation Lab

Brazil shows the highest maturity level in LAC countries. Chile, Argentina, Uruguay and Colombia have RPA projects at a lower maturity level, demonstrating an innovative degree deploying robotic projects. The rest of the LAC countries do not have RPA as an enabling technology. At last, Australia and the US (overlapping in the graph) are the benchmark countries with the highest maturity level.

Figure 33 Augmented reality



Source: EY Power and utilities Innovation Lab

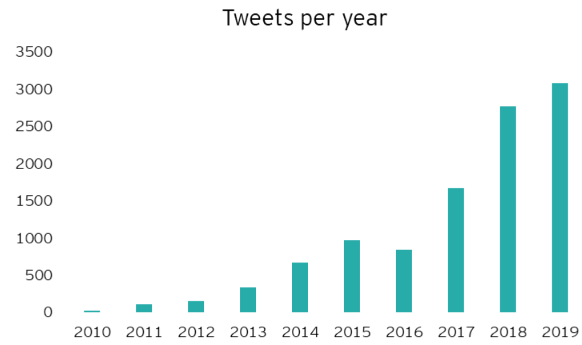
United States is the most advanced country in the development of AR projects. Apart from the US the countries that has adapted augmented reality for the industry are Brazil, United Kingdom and Australia. This shows a gap in the countries related to this type of technology because the rest of countries do not have AR as an enabling technology.

3.7. Twitter social media mining results

The Twitter social media mining process considers the tweets of 358 accounts from 2010 until November 30, 2019. The results obtained from the process gave as a result 10,400 tweets with mentions of disruptive or enabling technologies key words. For an in-depth explanation of the methodology used for this process see Annex D.

There is a clear growth in the use of keywords by the different Twitter accounts over the last ten years, excepting the difference between 2015 and 2016.

Figure 34 Tweets per year

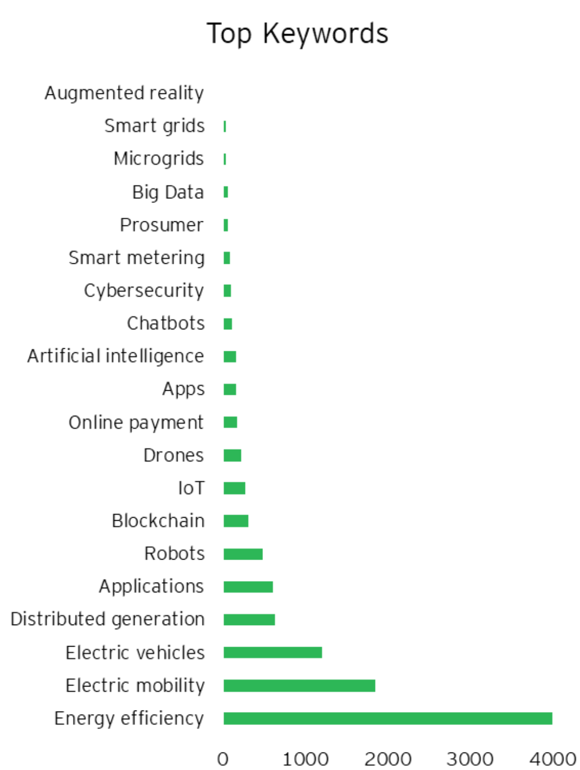


Source: EY Power and utilities Innovation Lab

From the 41 keywords searched in the tweets, 31 are mentioned at least once, with “Energy efficiency” being the one most used by the Twitter accounts, with almost 4000 mentions. The next most-used key term is electric mobility and electric vehicles followed by distributed generation.

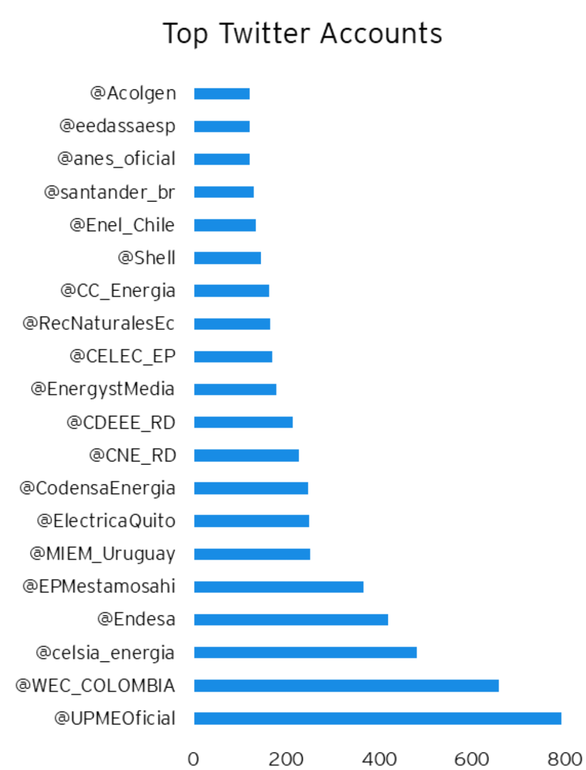
From the 358 Twitter accounts, 206 mentioned one of the keywords at least once. The account of the Energy Mining Planning Unit of Colombia is the one with most mentions of keywords with almost 800 tweets in these topics, followed by the World Energy Council of Colombia. The next with most mentions is Celsia (Panama, Honduras, Costa Rica and Colombia) followed by Endesa (Chile), EPM (Colombia), the Ministry of Industry, Energy and Mining (Peru) and Empresa Electrica de Quito (Ecuador).

Figure 35 Top 20 Keywords



Source: EY Power and utilities Innovation Lab

Figure 36 Top 20 Twitter Accounts



Source: EY Power and utilities Innovation Lab

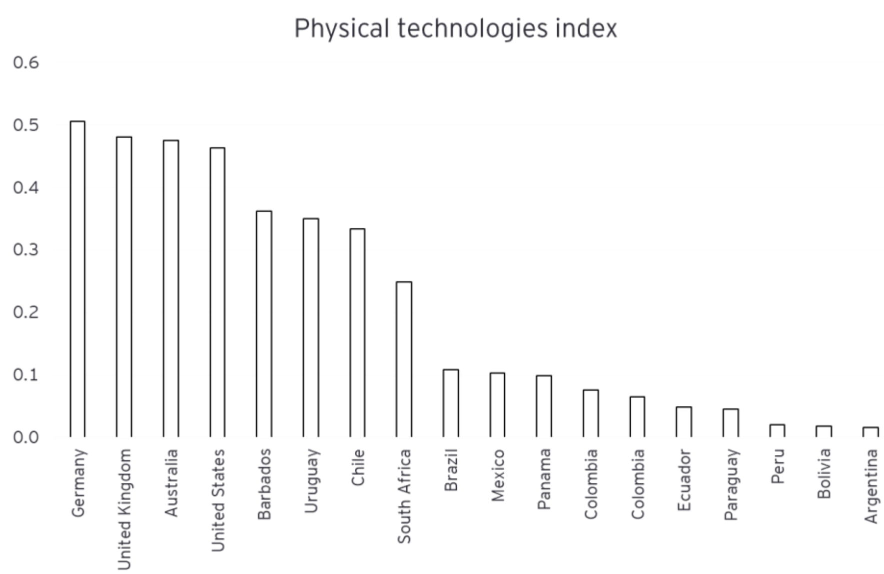
4. Conclusions

There are significant innovation gaps in the power utility sector within the LAC region. For example, Barbados, Chile, and Uruguay have a high level of adoption of specific physical technologies and countries like Brazil, Colombia and Chile have adopted enabling technologies to a high level, but Barbados and Panama lag in the matter of enabling technologies and Peru, Argentina and Bolivia lag in the adoption of physical technologies. This highlights an opportunity for sharing best practices among different countries and regions. International utilities can provide an excellent mechanism for transferring best practices into LAC countries.

4.1. Physical technologies

This report shows that for each of the physical technologies listed below there is leading and lagging countries for the LAC region. An aggregated index for the physical technologies is presented, the figure shows that the benchmark countries are on average over the average of the LAC countries. The benchmark countries that lead the other countries in the implementation of physical technologies are Germany, the UK, Australia, and the US. The three LAC countries that lead the region are Barbados, Uruguay, and Chile, while Argentina, Bolivia, and Peru are the lagging ones.

Figure 37 Aggregated index for the physical technologies

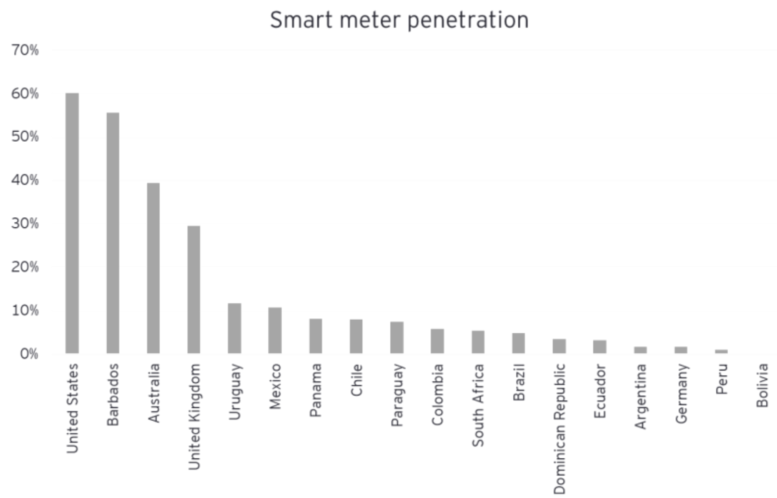


Source: EY Power and utilities Innovation Lab

Smart meter penetration

For AMI Deployment, the most developed LAC country is Barbados, with a share of 56% smart meters deployed which is equivalent to more than 75,000 meters. While the country with the lowest deployment level is Bolivia little more than 3,000 meters. In comparison to the benchmark countries, most LAC countries lag. The UK shows an AMI penetration of almost 30% corresponding to 8.4 million smart meters and the US has a deployment of 60% equivalent to 78 million smart meters installed.

Figure 38 Smart meter penetration

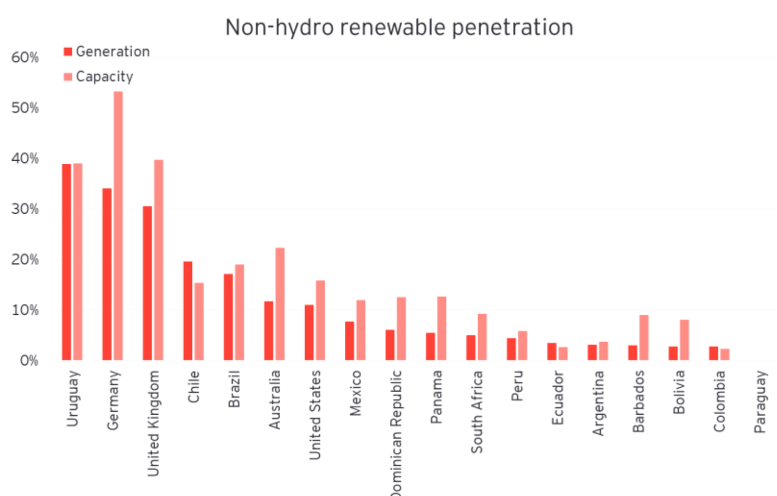


Source: EY Power and utilities innovation lab

Non-hydro renewable generation

With regards to the inclusion of non-hydro renewables in the renewable energy mix, Uruguay leads in the LAC region with a share of 41.2% in non-hydro renewable energy generation from the total of the energy matrix. The lowest level is found in Paraguay, which does not have non-hydro renewable capacity installed. From the benchmark, Germany has a share of 53.3% and the UK of 39.7% of the entire renewable matrix installed, but the energy generated from non-hydro renewable sources in 2018 is lower that the share of installed capacity.

Figure 39 Non-hydro renewable generation



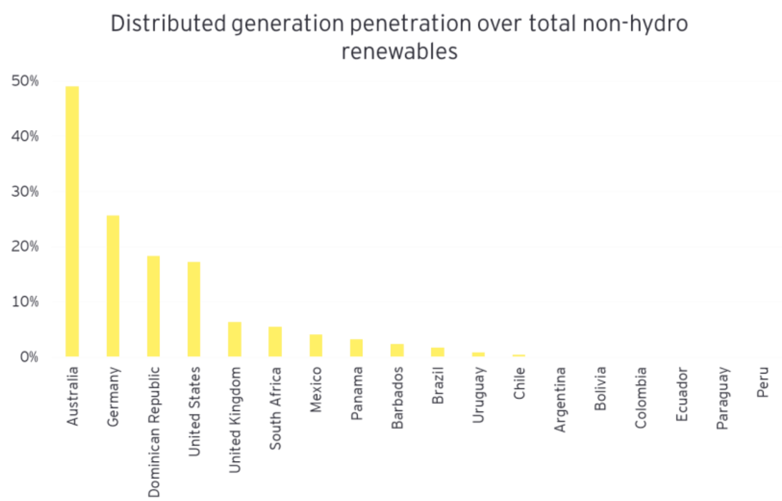
Source: EY Power and utilities innovation lab

Distributed solar PV capacity

From the information gathered it was found that the LAC country with the highest penetration of distributed solar PV is the Dominican Republic with 18% from the total non-hydro renewable generation

installed capacity, equivalent to 110 MW. The LAC region shows a wide gap mainly because of the delay in the regulation by the government. In comparison, the benchmark country with the highest penetration of distributed solar PV is Australia with 49%, equivalent to 8 GW.

Figure 40 Distributed solar PV capacity

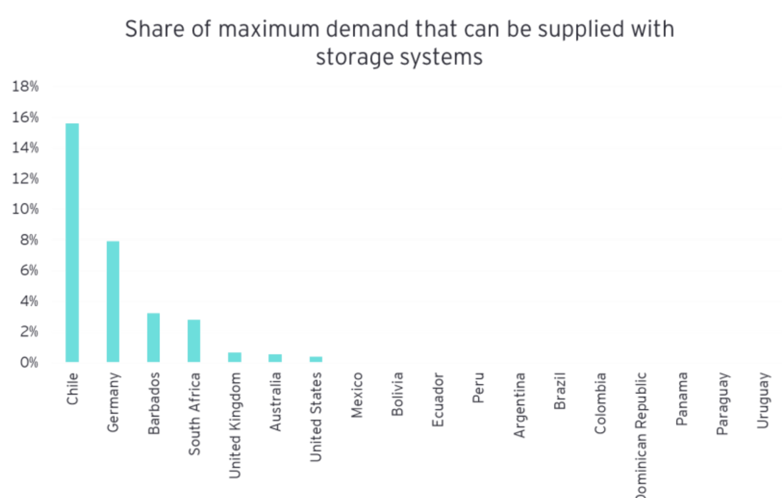


Source: EY Power and utilities innovation lab

Utility scale storage

The country that leads the innovation in the field of utility Scale Energy Storage System (ESS) is Chile, which can serve 15.6% of its peak load through utility Scale ESS, the aggregated capacity of all the ESS in Chile is 1627 MW of which 1570 MW correspond to Molten Salt technology ESS. There is a wide gap in the implementation of ESS at a utility scale in the LAC region where there is little to none installed capacity of ESS projects (developed, under construction or announced). Germany leads the other benchmark countries with a ESS penetration of 7.9%.

Figure 41 Utility scale storage

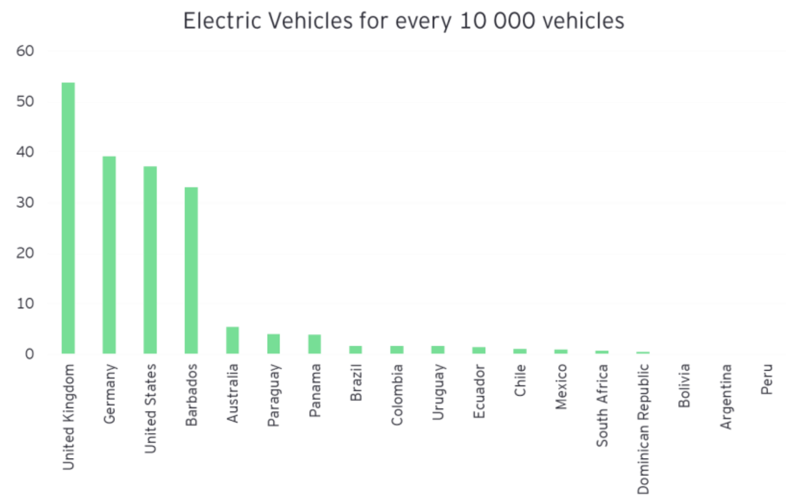


Source: EY Power and utilities innovation lab

EV Fleet / 10,000 vehicles

The most developed country in the adoption of Electric Vehicles (EV) in the LAC region is Barbados, which has 33 EV for every 10,000 vehicles, the total amount of EVs in Barbados corresponds to 430. The least developed country is Argentina and Peru that do not report EVs. In comparison, the benchmark country with the biggest insertion is the United Kingdom with an amount of 54 EVs.

Figure 42 EV fleet

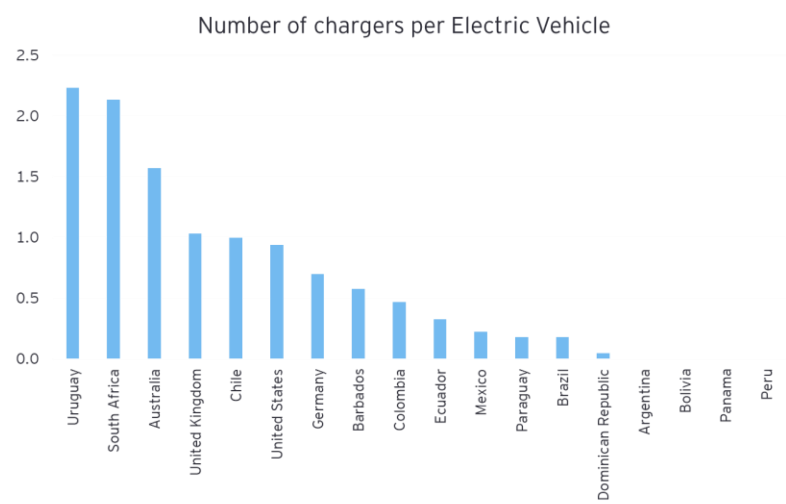


Source: EY Power and utilities innovation lab

EV charging stations

Comparing the number of EVs with EV charging infrastructure, the country that has relatively the largest infrastructure is Uruguay with 2.2 EV chargers for every EV. There are countries with no infrastructure in the LAC region, because of the lack of regulation or incentives. In the benchmark countries, the leader is South Africa with 2.1 EV chargers for every EV.

Figure 43 EV charging stations



Source: EY Power and utilities innovation lab

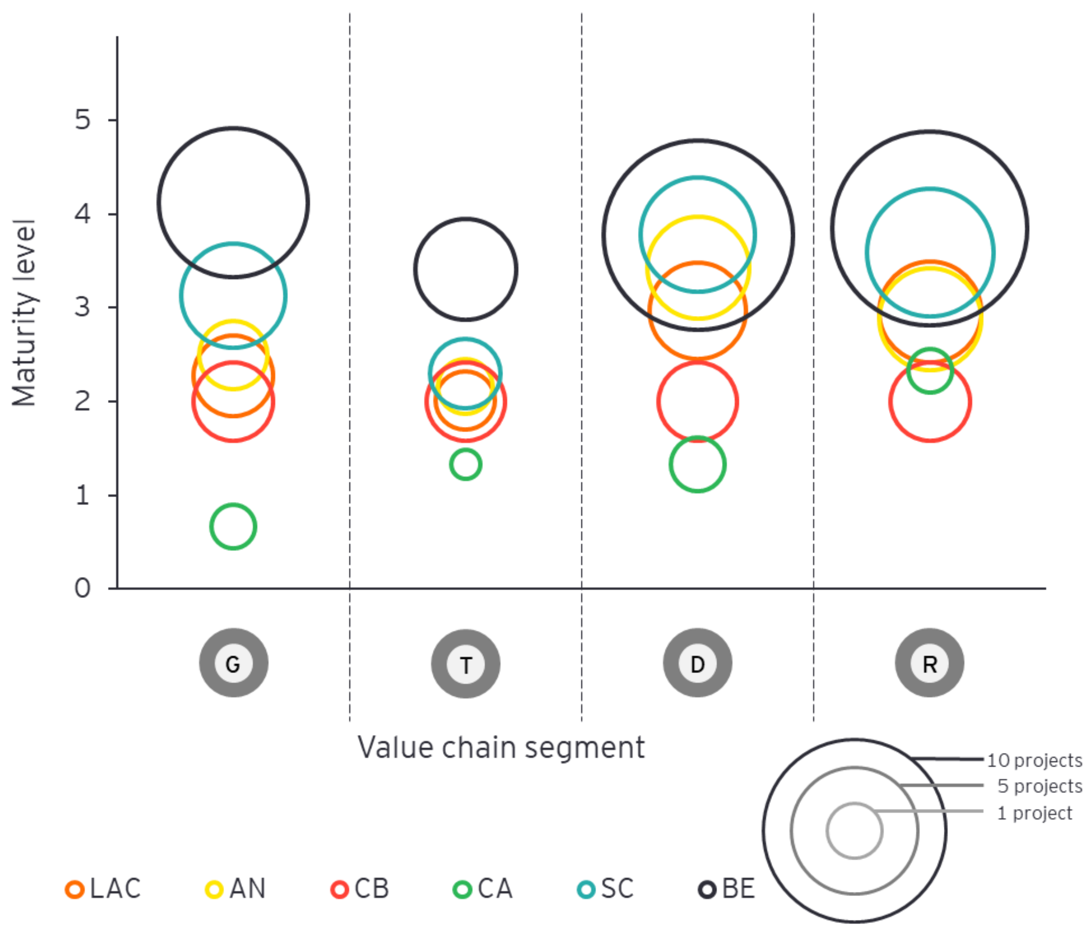
4.2. Enabling technologies

The identified enabling technologies projects show a concentration of projects in the Distribution and Retail segments while the segment with fewer projects is Transmission. The Benchmark (BE) countries show the highest level of maturity in its projects, leading the innovation of enabling technologies over the regions of LAC. The Southern Cone (SC) is the most advanced region, followed by the Andean (AN) and the Caribbean (CB) region, the Central America (CA) region is the one lagging.

The highest level of project maturity is found in the Retail segment while the lowest is found in the Transmission segment. For all the four segments of the value chain the SC region lead the other regions and is the one with the biggest potential to share its knowledge with the others; and so is the case for the Benchmark countries, that having the highest level of maturity in its projects can guide all the LAC region into a more advanced and innovative market.

A summary for the enabling projects identified for the LAC region and the benchmark countries is shown below. It shows the average maturity and number of projects for each subregion of LAC and for the benchmark countries by each value chain segment of the energy sector.

Figure 44 Enabling technologies summary

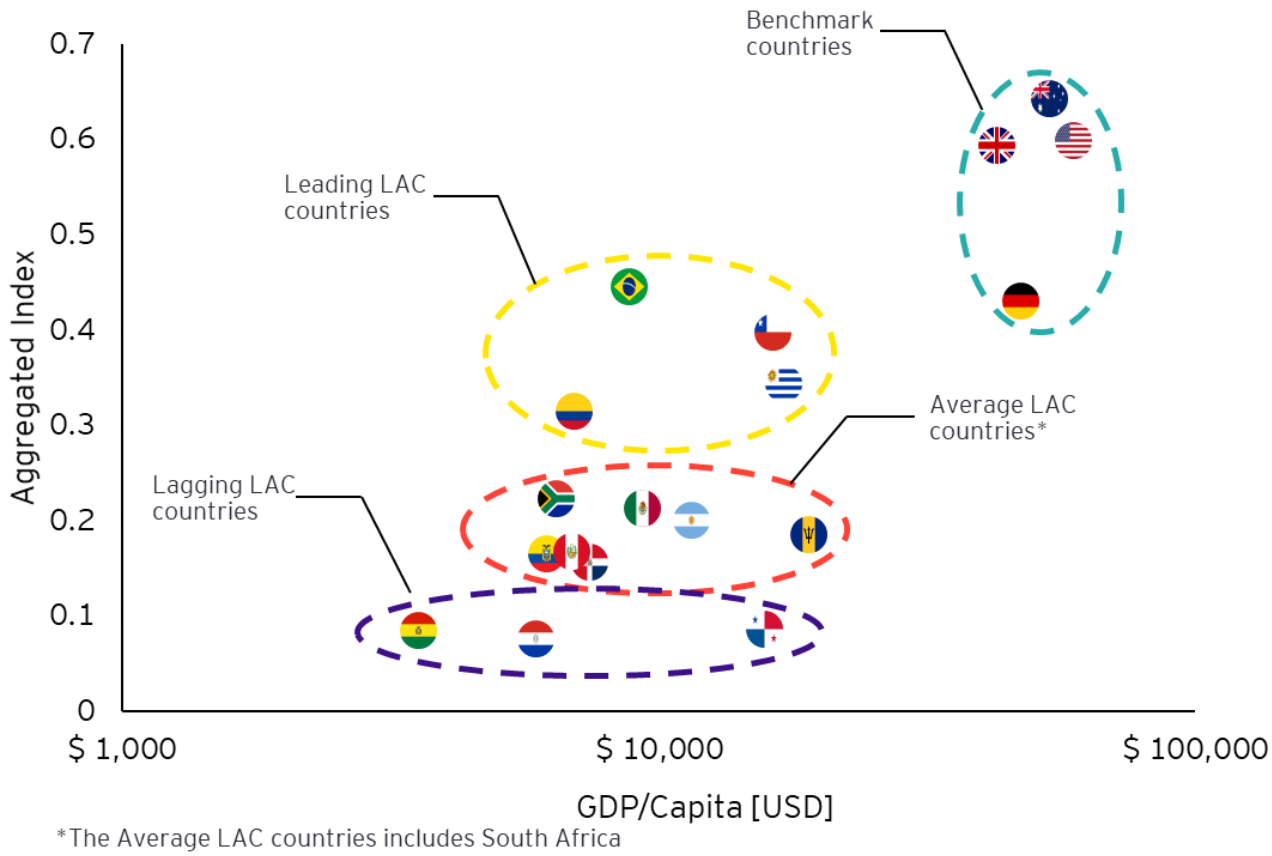


Source: EY Power and utilities innovation lab

4.3. Country insights

For the country insights, the analysis is made by dividing the countries into four clusters: (i) benchmark countries, (ii) leading LAC countries, (iii) average LAC countries, and (iv) lagging LAC countries. These clusters were made to identify the current situation of each LAC countries, towards their innovative degree, by giving an insight and an understanding of how advanced or lagged a country is towards other countries of LAC region and abroad. With these clusters, each country will be analyzed, looking at its main findings, main conclusions and the opportunities each one has towards their involvement in the industry. Annex I presents the results of each country in greater detail.

Figure 45 Aggregated Index and country clusters



Source: EY Power and utilities innovation lab

Argentina:

Argentina is in the cluster of average LAC countries, demonstrating a trend towards the improvement of their innovative index but still being behind the application of many of the recent technologies in the industry. The country has a good adoption of technologies such as cybersecurity and RPA. Towards physical technologies, the country does not demonstrate an important adoption, lagging on the innovation of the decentralized grid. At the end of 2018 the country had an installed capacity of approximately 10 GW from hydropower sources, while reaching 1.6 GW of non-hydro renewable generation, having a high performance in clean energy throughout the territory, there is an opportunity of deployment of no-conventional renewable energy as well as storage due to the lithium supply.

Barbados:

Barbados is in the cluster of average LAC countries demonstrating a trend towards the improvement of their innovative index but still being behind the application of many of the recent technologies in the industry. The country demonstrates an interests in the adoption of physical technologies such as the smart meters, being the top performer in the LAC region, also in EV deployment, having the highest number of EVs per 10,000 vehicles. The country demonstrates a low adoption of enabling technologies, leaving a wide gap against the benchmark countries.

This country has a good opportunity with the use of renewable and alternative energy due to the number of resources they have. With the use of these new alternatives, there is an opportunity for the growth of the distribution grid as well as a new application with the renewable sources.

Bolivia:

Bolivia is in the cluster of lagging LAC countries, this can be explained due to the lack of adoption in the technologies that support the retail, transmission and generation segments. On the other hand, the distribution sector demonstrates an interest in the adoption of new technologies utilizing technologies like drones. Due to the participation in the lithium triangle just like Argentina and Chile, Bolivia has a good lithium supply giving the opportunity to build storage infrastructure and increase innovative perception.

Brazil:

Brazil is in the cluster of leading LAC countries, this high innovative index is due to the developed generation segment adopting projects of advanced analytics and drones, as well as the use of renewable energy and distributed generation with mainly solar PV sources. In the enabling technologies sector, Brazil is trying to have use of drones, but their projects still have a low maturity level, demonstrating a slow development in this area. Towards its opportunities, the country has a planned expansion of renewable energy having a capacity of 45% for renewable sources, also the growth of distribute generation capacity will give the opportunity for the entrance of smart meters in the domestic service, creating an energy efficiency program.

Chile:

Chile is in the cluster of leading LAC countries, this high innovative index is due to the usage of technologies in the generation stage, adopting projects of machine learning, advanced analytics and blockchain, and renewable generation from solar energy. Also, the fact of having a storage capacity that covers 15.6%[6] of the peak demand represents an interest of the government to have a prepared and advanced industry towards any problem. Big Data projects are still not mature enough because most projects are on the pilot stage and there are not recorded projects that are being used at a commercial level.

[6] 1627 MW of total storage, of which 1570 MW correspond to molten salt technology.

Chile has the commitment to de-carbonize the electricity matrix by 2050 and reach carbon neutrality by 2050. Both commitments will strongly push innovation in the Chilean energy sector. A plan for renewable energy usage is a clear opportunity for the country that will help with energy modernization, social approval, energy development, low emissions, and sustainable transportation. Also, the distributed generation is having quick growth due to the application of laws that incentivize the usage of these generations for different types of consumers, supporting themselves also with the capacity of storage at a utility-scale.

Colombia:

Colombia is in the cluster of leading LAC countries, being the lowest one of this cluster but still with an index better than the average LAC countries. This indicator is due to the usage of enabling technologies, demonstrating a mature use of technologies such as drones, advanced analytics, cybersecurity, and Big Data. The distribution segment is also part of the innovative advancement of the country thanks to the integration of electric mobility mainly with the supply of EV chargers. On the other hand, one factor that reduces the country indicator is the lack of adoption of storage projects leaving Colombia as one of the LAC countries with the lowest utility-scale storage adoption.

The use of non-conventional energy is still growing thanks to the climatic and geographical conditions. This advantage offers the chance to develop solar, wind, biomass, geothermal, and tidal energy projects, helping in the diversification of the generation matrix. For example, in 2019 a Solar project of 9.4 MW went into operation in the country, also in the same year, two bidding processes were carried out resulting in the adjudication of over 2,000 MW.

Also, the enlargement of the EV fleet could result in a decrease in the use of fossil fuels and therefore decrease the emission of greenhouse gases.

Dominican Republic:

Dominican Republic is in the cluster of average LAC countries, this can be explained with the lack of enabling technologies projects, with a maturity level of pilot projects in the sectors of cloud services, IoT and advanced analytics technologies that are only found in the retail segment of the value chain. This country has a good adoption of physical technologies such as smart meter penetration, non-hydro renewable generation, utility-scale storage (second behind Chile), and EV charging infrastructure in comparison to the number of EVs in the country. Dominican Republic government is interested in supporting projects for energy generation based on non-petroleum-based fuels, such as wind, sun, water and other renewables sources, the last is carried out by promoting private participation in this type of generation.

Ecuador:

Ecuador is in the cluster of average LAC countries, an improvement trend towards the adoption of emerging technologies is clear, but the implementation of some technologies is still lagging. This country has a good adoption of enabling technologies such as big data and cyber security, but lags in the adoption of physical technologies expecting some efforts in the deployment of EV fleet and charging infrastructure. In the past decade, Ecuador has reduced the use of fossil fuels and increased

generation through renewables energies and furthermore to use smart - technologies to reduce electricity losses.

Mexico:

Mexico is in the cluster of average LAC countries, demonstrating a trend towards the improvement of their innovative index but still lagging in the application of many of the recent technologies in the industry. The country has a good adoption of cloud-based technologies and is leading its LAC peers in terms of AMI deployment (being the second - highest after Uruguay) and in distributed solar PV deployment. In the Development Program of the National Electric System AMI has been a relevant topic. In the 2018-2022 period, the installation of 121 thousand AMI meters with an approximate investment of 340 billion pesos is considered. The country through the Environmental and Natural Resources Ministry (SEMARNAT) is developing the Electromobility and is working towards the deployment of electric charging stations through the Program for the Promotion of Electromobility developed by Comision Federal de Electricidad (CFE), government agencies, the Mexico City Government, industry associations and private companies.

Panama:

Panama is in the cluster of lagging LAC countries, this can be explained due to the lack of adoption in the enabling technologies that support the retail, transmission and generation segments. On the other hand, the distribution sector demonstrates an interest in the adoption of drones. Panama has a high adoption of AMI, distributed solar PV and EVs, but needs to improve the utility-scale storage system, as well as the EV charging infrastructure. The U.S. Department of the Treasury sign a Memorandum of Understanding (MOU) with the Republic of Panama with the objective to accelerate Panama's adoption of innovative power technologies, including renewables and related micro, mini-grid and battery storage systems, that will help achieve energy source integration and catalyze investment in rural areas and at critical infrastructure facilities, thereby increasing Panama's energy resiliency.

Paraguay:

Paraguay is in the cluster of lagging LAC countries, this is explained due to the lack of adoption in the enabling technologies where only a project involving advanced analytics was found. Paraguay has a high adoption of EVs and the charging infrastructure for them but needs to improve the utility-scale storage system and the deployment of utility and distributed scale non-hydro renewables generators. This country is developing at an industrial level the so-called Intelligence Energy Storage System that proposes to carry out the technology of sodium batteries. Also, the country is developing on the updating of the map of water, solar and wind energy that will help the development of non-hydro renewable projects in the utility and distributed scale. There is a project to open the first solar green route for electric vehicles that will have four solar charging stations.

Peru:

Peru is in the cluster of average LAC countries, demonstrating a trend towards the improvement of its innovative index but still being behind the application of many of the enabling technologies in the industry. The country has a good adoption of enabling technologies such as cloud service, advanced analytics, and blockchain but lags in the deployment of AMI, distributed solar PV, utility-scale storage and EV technologies. Peru should promote electric and hybrid vehicles and install electricity supply infrastructure. The Peruvian Automotive Association (AAP), which created a committee to accompany their deployment of EVs and the charging infrastructure needed. Also, the International Solar Alliance is helping Peru become a reference country in attracting investments in solar energy to achieve greater use of renewable energy.

Uruguay:

Uruguay is in the cluster of leading LAC countries, this high innovative index is due to the usage of technologies in the distribution and retail segments of the value chain, adopting projects of advanced analytics, Big Data and RPA. Also, it has the highest penetration of AMI and non-hydro renewable generation in comparison with its LAC peers, it also has the most advanced deployment of EV charging infrastructure in comparison to the number of EVs in the country. Uruguay lags in terms of distributed solar PV generation and utility-scale storage deployment, also in terms of the other enabling technologies, with a low maturity level or no projects identified for those technologies.

Nonconventional energy application has implemented innovative adaptions such as distributed energy generation, microgrids, and storage. The implementation of distributed generation laws is expected to help the growth of usage of distributed generation, incentivizing the entrance of figures such as the prosumers and creating microgrids in different zones of the country, especially in the non-interconnected zones. Behind the meter, storage is another innovative technology that is expected to be introduced into the electricity market due to the growth of clean energy.

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Distributed Solar Capacity PV:

- Distributed Energy

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AMI Deployment:

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Mexico

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