# Energy storage in Mexico: fertile ground for technological development and investment

Enrique Quiroga-González[1,2*], Ana Karina Cuentas-Gallegos[1,3**]

[1] Mexican Energy Storage Network

[2] Institute of Physics, Benemérita Universidad Autónoma de Puebla, Puebla, Mexico

[3] Center of Nanosciences and Nanotechnology, Universidad Nacional Autónoma de México, Ensenada, B.C., Mexico

* equiroga@ieee.org, ** akcg@ens.cnyn.unam.mx

## The energy storage in the international context

Energy storage is a key topic nowadays due to the growing energy needs worldwide. The boom in the number of scientific publications in this area is mainly driven by the development in mobile electronic devices, electric vehicles (electromobility) and the growing adoption of renewable energies, which require efficient storage systems.

Lithium batteries have established themselves as the standard choice in mobile devices and electric vehicles due to their high energy density per unit volume and weight. However, in order to guarantee a constant supply of renewable energies, such as solar and wind power, it is necessary to have storage systems that allow their use when conditions are not optimal for generation.

Globally, according to the U.S. Department of Energy, by 2020 there will be approximately 10 GW of installed capacity in storage systems, excluding pumped hydroelectric plants (totaling 191.5 GW). Within this matrix, batteries have found an important niche due to their reliability and low maintenance, and their use is expected to expand further as their cost decreases.

In addition to batteries, other storage technologies such as supercapacitors (which provide high instantaneous power), flow batteries (which provide high net capacities at low cost), thermal and mechanical storage, are being explored for specific applications in the global energy matrix. These energy storage systems can operate in both isolated and

interconnected grids, offering a wide range of services such as time shifting, peak shaving, and power factor correction.

**Actions in academic and research institutions in Mexico**

In Mexico, the development of energy storage technologies has been driven mainly by the academic sector. Since 2014, numerous research groups have emerged in this field. Initially, only six groups, such as those from IER-UNAM, CICY, UANL, IPN, UAM-I, INEEL and BUAP, stood out in in-depth energy storage research. However, the number of groups has increased significantly, reaching around 20 by 2023, spread across institutions such as CNYN-UNAM, CINVESTAV-Saltillo, CIMAV, CIO, CIDETEQ, UdG and CIQA, among others.

BUAP has played a crucial role in promoting research in this area, organizing the first international congress dedicated to energy storage in Mexico, the Energy Storage Discussions (ESD: http://www.ifuap.buap.mx/energysd2014/), which has been held biennially since 2014. In the 2023 edition (ESD- 2023: http://www.ifuap.buap.mx/energysd2023/), research of international impact was presented, and the next ESD, to be held at CNYN-UNAM in November 2025, in Ensenada, is expected to continue fostering collaborations between academia and industry.

In addition to scientific advances, several Mexican research institutions have worked to bridge the gap between academia and government. One notable example is the National Institute of Ecology and Climate Change (INECC), which with the support of the Federal Electricity Commission (CFE) and the International Energy Agency (IEA), and the technical collaboration of Mexican energy storage experts from the Mexican Energy Storage Network, published in 2020 a series of technical papers on various energy storage technologies. These papers explore how these technologies can be integrated into Mexico's electricity grid to reduce emissions caused by fossil fuel-based energy overproduction. The feedback meetings that gave rise to these papers began in 2018, with the goal of persuading government entities about the importance of investing in energy storage, in compliance with the Paris agreements for climate change mitigation.

By its part, the National Institute of Electricity and Clean Energy (INEEL), with the support of the Ministry of Energy (SENER) and the National Council for Humanities, Science and Technology (CONAHCyT), organized a workshop in 2019 to evaluate the use of energy storage systems in Mexico. The report generated from this workshop addressed key issues, such as the inclusion of storage systems in the Electricity Market Rules, as well as their integration in the planning of the National Transmission Grid and General Distribution Networks. It also highlighted the importance of establishing regulations for the testing, certification and interconnection of storage systems, as well as the promotion of research and technological development in this area, and the dissemination of the technical and economic viability of energy storage systems to facilitate their acceptance in Mexico.

Several research groups in Mexico have managed to establish national and international collaborations, generating developments that have led to patent applications and have had a social impact. Among the advances are new high-speed and high-capacity batteries, using abundant and low-cost materials, as well as alternative or complementary devices such as supercapacitors. These actions demonstrate a concerted effort by the academic and research community in Mexico to promote the development of energy storage technologies, with a view to consolidating the country as a relevant player on the international energy scene.

**The Mexican Energy Storage Network: Promoter of development in Mexico**

The creation of the Mexican Energy Storage Network in 2017 has been a key driver for the growth of the scientific community in this field. The network emerged from the interaction between various research groups in the international congress Energy Storage Discussions in 2014 and 2016. This congress has been fundamental in the consolidation of the Network, by promoting collaboration and knowledge exchange between Mexican researchers and international experts in energy storage.

In its early years, the Network received financial support from CONAHCyT, which allowed the development of a number of initial collaborative projects. However, the Network

currently operates without external financial resources, and is sustained by the effort and commitment of its members. Despite this limitation, it is expected that in the coming years it will be able to attract investment from both the private sector and the government, which will allow the Network to expand its activities and continue promoting the development of energy storage technologies in Mexico.

One of the tangible products of the Network is the organization of free monthly seminars given by international experts on energy-related topics. These seminars have been a valuable platform for the dissemination of knowledge and are available online through its page (https://www.facebook.com/ReddeAlmacenamientodeEnergiaCONACYT/). In addition, specialized workshops have been organized, such as one on impedance spectroscopy, a powerful technique used for the analysis of electrochemical energy storage devices.

The Network's activities have had a significant impact, not only in the development of new scientific and technological vocations in Mexico, but also in the promotion of a broader dialogue with key actors in society. This has allowed the scientific community dedicated to energy storage in the country to mature, giving it greater competence at the international level.

Among the members of the network, there are Mexican research groups working on the entire energy storage value chain, from lithium purification and synthesis of active materials to device modeling and testing. Some of these groups have more than 10 years of experience in the field, which positions them as important references in the development of innovative and sustainable technologies.

In summary, the Mexican Energy Storage Network has been a crucial catalyst for the advancement of the storage sector in the country, facilitating collaboration among researchers and promoting high-impact research in this strategic area for Mexico's energy future.

**Energy storage: a chance for Mexico**

In order for Mexico to move towards a more reliable electric grid with a greater participation of renewable energies, it is essential to make the electric system more flexible to support the inherent variability of these sources. Energy storage in batteries is key to grid management. Currently, only 12.1% of Mexico's energy comes from renewable sources, such as solar and wind. However, a major limiting factor is that electricity transmission and distribution lines in the country are very old, which requires adequate modernization and regulation for the energy transition to be successful. The incoming president, Dr. Claudia Sheinbaum, has announced a national energy plan that envisions encouraging investment in renewable energy, expanding electromobility, and modernizing electricity infrastructure to integrate up to 54% renewable energy.

As for solar energy, Mexico currently generates around 10,905 MW. Of this capacity, 7,544 MW correspond to large-scale commercial operation plants, while 3,361 MW come from distributed solar generation. As the country moves forward in its transition to clean energy, it is estimated that 2.3 GW of energy storage will be required over the next 10 years to avoid distortions in the electric grid and counteract the variability of solar and wind energy.

The Indicative Program for the Installation and Retirement of Power Plants (PIIRCE), which is part of the National Electric System Development Program (PRODESEN), projects that around 4,505 MW of energy storage systems could be installed throughout the country by 2022-2036. However, one of the current challenges is the lack of specific regulation for energy storage in the private sector, especially for grid services. Although there are some companies that offer services such as time shifting for individuals who wish to reduce their electricity costs, there is still ample opportunity to expand the use of energy storage in Mexico.

In the field of electromobility, sales of electric or hybrid vehicles in Mexico have reached a total of 73,680 units in 2023, representing 6% of the national automotive market. This figure reflects accelerated growth, with a 44% increase compared to sales in 2022. This trend is expected to continue, driven by incentives such as tax forgiveness, and the expansion of the electric charging infrastructure, which currently has 2,000 charging

stations. This growth will also drive demand for batteries, which are the main component of electric vehicles after the engine and account for approximately half of their total cost.

**Possible short-term actions to foster the development of the energy storage market in Mexico**

The energy storage landscape in Mexico is still in its early stages of development, but has immense potential that could explode as soon as significant progress is made in regulation and grid modernization. As these challenges are overcome, the adoption and growth of energy storage technologies is expected to boom rapidly across the country.

On the research side, it is crucial to focus on the development of new storage technologies. Internationally, innovations that could transform the energy sector are already being explored, and Mexico must position itself at the forefront of these advances. This includes the development of new, more efficient batteries, supercapacitors, and hybrid technologies, which can offer solutions tailored to the country's energy needs.

From the government's point of view, the promotion of clear and effective legislation is fundamental to establish the rules of the game and attract private investment. The creation of a regulatory framework that provides certainty to investors will allow energy storage to take off as a viable market. Currently, the Energy Regulatory Commission (CRE) is in the process of consultation to regulate storage systems, with the expectation of approving it in the coming months. This regulation will improve the efficiency of the electricity grid and accelerate the transition from an energy system that is highly dependent on fossil fuels (86.4% of emissions) to a more sustainable and diversified one.

As for industry, the key will be to strengthen collaboration between academia, industry, government and society. Industry must lead the way by further fostering linkages between these sectors to develop viable and scalable solutions. The lack of adequate financial schemes has been a major brake on the growth of the storage market, but once the relevant regulations are in place, it is expected that investment will flow more easily, truly reflecting the real costs of energy.

In addition, regulation must address crucial aspects such as quality standards. Concerns have been raised about the fire risks associated with storage systems, underscoring the need for clear safety and quality standards to protect users and ensure the reliability of these systems.

It is important not to forget the recyclability and reusability of batteries. With the growth of the energy storage industry, there is also a need to properly manage batteries at the end of their useful life. Implementing policies and technologies that enable the recycling of these devices will be essential to minimize the environmental impact and ensure a sustainable life cycle.

In short, the development of energy storage systems will be key to the modernization of Mexico's electricity grid. These systems will accelerate the transition to a cleaner and more efficient grid, helping to expand the infrastructure of the national electricity system, increase the penetration of renewable energies and mitigate grid reliability problems. Once the regulation and modernization of the grid is advanced, energy storage will be ideally positioned to experience explosive growth in Mexico.

**Intersolar contributes to the diffusion of energy storage in Mexico**

In its fifth edition, the Intersolar Mexico Exhibition and Conference, from September 3 to 5, 2024 in Mexico City, presents companies in the electrical energy storage sector in the **ees Area** and the **ees Pavilion**. Additionally, the Conference program includes conferences and panel discussions on the development and use of energy storage systems. "Storage: solid foundations for a resilient electrical grid" will be a topic of discussion in the inaugural panel of the Conference. Subsequently, California and Chile will be taken as a reference to have a smooth transition towards a generation-storage model, through the implementation of fair regulations. The motivation for these initiatives derives from good planning: these two countries know the importance of having energy storage support when installing new photovoltaic plants, to increase reliability and be able to have self-sustainable systems.

During the second day of the Intersolar Mexico Conference, the most relevant aspects of ees Europe, which celebrates its tenth anniversary in 2024, will be presented. In this session there will be a summary of how this topic began as a small exhibition together with Intersolar Europe until it became at the largest and most international exhibition of batteries and energy storage systems in Europe. Subsequently, the first steps that Mexico is taking to have large-scale energy storage will be presented. Discussions will develop about photovoltaic plants supported by storage in northwest Mexico. To close that day, alternative energy storage concepts will be presented, to see that lithium-ion batteries are not the only way to store energy. It will be seen that there are different possibilities for each application.

Parallel to the Conference, at the **Intersolar Stage**, there will be different talks on energy storage given by exhibiting companies and sector specialists. Among them, there will be daily talks by members of the Mexican Energy Storage Network, in which energy storage topics that cover new materials, new devices and systems will be discussed. Everyone is cordially invited to join the discussion.