CONSIDERATIONS ON A COMPREHENSIVE REGULATORY FRAMEWORK FOR ENERGY STORAGE IN MEXICO

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Summary: I. *Why talk about energy storage?* II. *The added value of energy storage.* III. *Existing and missing pieces in mexican legislation.* IV. *Conclusions.* V. *Bibliography.*

I. Why talk about energy storage?

By now, the consensus among the scientific community is that climate change is a real phenomenon caused by human activity, primarily the concentration of greenhouse gases (GHG).[1] In light of this problem, many countries have adopted various commitments to reduce their emissions and mitigate the effects of climate change, including both individual strategies and international agreements. Among the latter, one that stands out is the 2015 Paris Agreement, in which Mexico committed itself —unconditionally— to reduce 22% of the nation's GHG emissions by 2030.[2]

Since the energy sector accounts for almost two-thirds of global GHG emissions,[3] it has a responsibility to come up with innovative solutions in this sector to address the problem of global warming. The growing incorporation of renewable energies into the energy matrix has made it possible to gradually displace the use of contaminating fossil fuels in power generation and is one of the most popular strategies to mitigate GHG in the energy industry.

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1 Intergovernmental Panel on Climate Change, *Summary for Policy Makers,* in *Climate Change 2013: The Physical Science Basis*, Cambridge, Cambridge University Press, 2013, pp. 2 and 17.

2 Gobierno de la República, *Compromisos de mitigación y adaptación ante el cambio climático para el periodo 2020-2030*, México, Gobierno de la República, 2014, p. 9.

3 International Energy Agency, *Energy and Climate Change*, France, OECD, 2015, p. 18.

Mexico has enormous renewable potential due to its geographical location. There are high levels of sunlight across the entire country, as well as many areas with strong and constant winds, such as Tamaulipas or the Isthmus of Tehuantepec. However, the penetration of renewable energy resources is still low. In 2017, wind and solar energy technologies contributed less than 5% of the country's generation.[4] This situation, nonetheless, is rapidly changing due to three factors: i) the clean energy goals[5] that Mexico established in its Energy Transition Law and are part of its climate commitments: 25% by 2018, 30% by 2021 and 35% by 2024;[6] ii) the success of three electricity auctions held between 2015 and 2017, which will bring 20 wind projects and 40 solar power plants into operation to increase the percentage of power generation from Intermittent Renewable Energy Sources (IRES) to 11%,[7] i.e., whose production depends on natural forces that cannot be controlled by man, such as solar radiation and wind intensity, and iii) sustained growth in distributed generation that, if the current trend continues, could reach 6.7 GW in 2023, mainly from photovoltaic resources.[8]

Notwithstanding its potential to mitigate GHG emissions in electricity generation, the variability of the IRES can jeopardize the reliability and safety of the electricity system, as well as negatively affect energy prices if the proper strategies are not applied to address it.[9] Hence, a climate action policy that prioritizes the use of renewable energies, especially intermittent ones, should not overlook the creation of regulatory and market instruments that make it possible to use existing options for dealing with this issue.

In this context, electrical energy storage (EES) is a promising tool to incorporate higher proportions of IRES by giving system operators more

4 Secretaría de Energía, *Programa de Desarrollo del Sistema Eléctrico Nacional 2018-2032*, México, SENER, 2018, pp. 19 y 22.

5 Clean energy includes solar, wind, hydro, geothermal, nuclear and efficient cogeneration resources, among the other technologies described in Article 8 of the Energy Transition Law.

6 Secretaría de Gobernación, Ley de la Transición Energética, *Diario Oficial de la Federación*, artículo tercero transitorio, México, December 24, 2015, available at: *http://dof.gob.mx/nota_detalle.php?codigo=5421295&fecha=24/12/2015*.

7 Gobierno de la República, *En la tercera Subasta Eléctrica se obtuvo uno de los precios más bajos internacionalmente: PJC*, November 21, 2017, available at: *https://www.gob.mx/cenace/prensa/en-la-tercera-subasta-electrica-mexicana-se-obtuvo-uno-de-los-precios-mas-bajos-internacionalmente-pjc-141671*.

8 Energy Regulatory Commission estimates.

9 World Energy Council, *Variable Renewables Integration in Electricity Systems: How to Get It Right*, United Kingdom, WEC, 2016, pp. 31-38.

room to maneuver in order to balance generation and demand even when the energy is not generated at the very instant it is required. In general terms, EES encompasses various technologies (lithium batteries, pumped storage, compressed air, flywheels, and supercapacitors, among others) that enable to capture the energy produced at a given moment for later use.[10]

EES systems are not the only technological solution to contend with the variability of IRES and thus reap its benefits. Improved wind and solar resource forecasting, greater flexibility in generation, transmission and distribution grid expansion, increased visibility of distributed generation resources, and the implementation of demand response programs are other well-known options.[11]

EES detractors point to cost as the greatest disadvantage of this technology. For now, it is true that EES is still an expensive option for many players in various markets, so its development has focused primarily on advanced economies like those of California or Germany. However, their costs are becoming more and more affordable. In fact, between 2010 and 2017, the price per kWh of lithium batteries went from approximately $1000 USD to $200 USD; by 2030, it is expected to drop even further, down to $70 USD per kWh.[12] Additionally, there are already specific business models and applications for which EES makes economic sense.

This article is not intended to promote EES as a unique alternative to deal with the variability of IRES, but to highlight the benefits this technology could bring to the Mexican electricity system and its young market, as just one more option available, always leaving the final decision to the market players as to which one would make the most economic and technical sense for each specific case. In addition, it aims to provide an overview of the current state of the existing regulatory framework for EES in Mexico and a comparison with the most dynamic market in this regard, California.

Building a regulatory framework for EES is needed so that projects of this type can flourish in cases where they are the most viable option. In the 2017-2031 National Electrical System Development Program (PRODESEN), the installation of a 20 MW battery bank was first proposed in order to improve operational flexibility and enable the incorporation of IRES

10 Deloitte, *Energy Storage: Tracking the Technologies that Will Transform the Power Sector*, United States of America, Deloitte, 2015, p. 4.

11 *World Energy Council…*, *op. cit.*, pp. 44 and 45.

12 Bloomberg New Energy Finance, *New Energy Outlook 2018 Report*, United States, Bloomberg Finance L. P., 2018, available at: *https://bnef.turtl.co/story/neo2018?teaser=true.*

into the National Electric System (specifically in Baja California Sur).[13] In the last edition, the project had disappeared. Without a clear understanding of the remuneration mechanisms and operating rules for such systems, it will be impossible for any of them to materialize, even when they are a leading option in cost-benefit analysis processes, such as PRODESEN.

II. The added value of energy storage

Due to its physical and operational characteristics, energy storage can provide a wide range of services along the entire value chain of the electrical sector: enhancing energy security by reducing dependence on fossil fuels; improving generation efficiency and facilitating the incorporation of renewables; improving grid operation and allowing investments to expand transmission and distribution infrastructure to be deferred; reinforcing the grid by providing greater flexibility; and providing an effective alternative for end users to manage their electricity bills.

The following discusses the ways in which EES can generate value to both grids and users, as well as to the economy and society.

1. *Incorporation of renewable energies*

Perhaps the most promising side of EES is its potential to incorporate more and more clean technologies to the generation matrix since storage is particularly well equipped to handle both the short- and long-term variability of energy produced from IRES and the possible negative effects these may have on the quality of electrical service.

The ability to store energy at one point in time for later use is an essential feature of EES technologies. This service, known as arbitrage or time shifting, is very valuable for IRES whose generation depends on uncontrollable factors like the weather and therefore cannot be timed to coincide with demand. To give an example, solar generation takes place during the day when energy demand is not very high; but by adding a storage system to a photovoltaic power plant, it is then possible to store the energy produced during the day and later inject it into the grid when there is higher demand.

[13] Secretaría de Energía, *Programa de Desarrollo del Sistema Eléctrico Nacional 2017-2031*, México, SENER, 2017, pp. 113 and 114.

Moreover, sudden changes in weather conditions (*e. g.*, cloud accumulation or lighter winds) can cause sudden fluctuations in solar and wind energy generation levels that must be counterbalanced by other resources on the grid. EES systems can handle these "ramps" because they can be programmed to rapidly neutralize IRES variability and can do so much more efficiently than conventional combustion plants.

Another way EES contributes to the integration of renewables is by ensuring their generation levels are kept at a certain level ("firm" capacity), which allows them to deliver high-power products and services.

2. *Advantages of the system*

The most important advantages of storage are the flexibility it can give the overall system. Flexibility is the ability to maintain continuous electrical service despite sudden changes that may occur on either the supply or demand side. As IRES participation increases, flexibility is an issue that becomes more pressing since, on the one hand, these sources displace the conventional generators that provide flexibility and, on the other hand, increase the need for additional flexibility due to their intermittent nature, creating a "flexibility gap" that must be covered by other resources.[14]

Because of their ability to time-shift supply and demand and their unique technical characteristics, EES systems can provide a wide range of services that —alone or combined— offer valuable flexibility alternatives for the system. Some ways in which EES can contribute to electricity grid flexibility are analyzed below.

Time-shift. As mentioned above, the most basic function of EES is to store energy during periods of low demand when its price is relatively low to be used or sold later when the demand is high and so is the price. In addition to the possibility of generating profits through this type of price arbitrage, this function of EES decreases the need for dedicated power plants to meet peak demand (plants that tend to be more costly and polluting), which can lead to significant savings in the total cost of energy.

Capacity. EES makes it possible to "firm up" generation from IRES and, consequently, offer capacity. Traditionally, this type of product is provided by more inefficient fossil fuel-fired power plants, which is why this use of

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14 ECOFYS, *Flexibility Options in Electricity System*, Germany, European Copper Institute, 2014, available at: *https://www.ecofys.com/files/files/ecofys-eci-2014-flexibility-options-in-electricity-systems.pdf.*

EES could reduce the cost of operating and maintaining obsolete power plants, as well as that of installing new generation equipment. However, many markets still have placed hurdles for EES to effectively supply power as conventional plants are required to operate for open or long enough periods of time so that storage cannot participate.[15]

Ancillary services. A stable, reliable and efficient electrical grid requires various support services for electricity to flow smoothly from power generation plants to the loads. Some of these services are frequency regulation, operating reserves, rolling reserves, voltage regulation, emergency start-up and island operation, among others.

Different EES technologies can provide most ancillary services more efficiently than conventional fossil-fuel fired generating plants. This advantage is due to the fact that storage has shorter response times than most existing generators because its start-up time is very fast. Some EES technologies can respond in a fraction of a second while a fast-start combined cycle plant needs at least 10 minutes and conventional thermal power plants take about 20 minutes to start up.

A further advantage over conventional plants is that EES can serve as both a generation source and a load. Hence, it can provide ancillary services by either modifying its energy delivery (discharge mode) or changing its demand patterns (load mode) and as mentioned above, can do so very rapidly.

The use of EES systems for ancillary services can streamline and simplify system operators' planning and operation processes. In fact, in late 2016, the UK grid operator held an auction for enhanced frequency regulation services, which privileged bids from faster response generation resources like those of EES systems. The auction was successful in securing fairly competitively priced allocations ($9.9 USD per MWh).[16]

Transmission and distribution backup (T&D). EES systems can also add value to T&D networks in several ways. First, it reinforces power lines, substations, transformers and other equipment so that the same unit working with EES can handle higher amounts of energy. EES can also mitigate T&D equipment overloads, decreasing wear and tear and thus prolonging its lifespan.

Second, if installed downstream of a congested section of the grid, EES can ease congestion by storing energy during periods of low congestion

15 In Mexico, the Capacity Market Balance Manual establishes a minimum of six consecutive hours for EES plants to demonstrate firm power.

16 Manghani, R. and McCarthy, R., *Global Energy Storage: 2017 Year-in-Review and 2018-2022 Outlook*, GTM Research, April 2018, available at: *https://www.greentechmedia.com/research/report/global-energy-storage-2017-year-in-review-and-2018-2022-outlook#gs.ImD43tk*.

(overnight or weekends) to later be released during periods of peak demand. This application would allow users to avoid congestion charges.[17]

A third benefit comes from the fact that EES integrated into T&D systems can increase the use of grid assets and, therefore, improve their cost-benefit ratio. For instance, when more energy is transmitted for storage during off-peak periods, more energy (kWh) is transported over the same T&D capacity (kVA). In turn, greater asset use may lead to lower T&D rates that would benefit users.

To the extent that EES relieves grid congestion, mitigates equipment overload and extends equipment lifespan, storage makes it possible to defer or even avoid costly investments to modernize and expand the grid. This application of EES has already proven successful in Queensland, Australia, where batteries were used to support an outdated distribution network and maintain reliable electricity service.

3. *Advantages for end users*

Behind-the-meter EES systems also have considerable potential benefits: they empower consumers and allow them to take a more active role in their consumption decisions and, as a result, can generate savings in the cost of energy consumed. The main ways in which end users, whether homes or businesses, can benefit from implementing EES solutions are discussed below.

Backup power. Storage systems can help with power supply during outages caused by natural disasters or grid failures. This application can be particularly important for commercial and industrial users for whom a sudden power outage can result in significant monetary losses. Moreover, these types of users tend to invest in costly, polluting backup generation equipment, such as diesel plants. So, EES provides a useful electricity backup alternative with the potential to save money through other applications, such as those discussed below.

Quality of service. In cases where the energy delivered by the grid is poor quality, EES can prevent cost and losses caused by this type of deficiency, such as voltage variations and interference caused by lightning or other equipment connected to the grid. The use of EES systems can improve the quality of the energy received and protect sensitive equipment.

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[17] Energy Storage Association, *Grid Infrastructure Benefits*, Energy Storage Association, n.d., available at: *http://energystorage.org/energy-storage/energy-storage-benefits/benefit-categories/grid-infrastructure-benefits.*

Distributed generation. EES contributes to the penetration of IRES. This is also true for behind-the-meter EES systems as they allow consumers to keep the surplus energy generated throughout the day for later consumption, thus reducing their spending on electricity. Some studies argue that residential storage could increase the share of self-consumption of energy from 30% to 65-75%,[18] adding value to distributed solar energy resources and boosting their profitability. Furthermore, higher consumption of on-site generation contributes to grid stability since most existing distribution networks cannot handle high volumes of electricity backfeed.

One possible disadvantage of this application is that if more and more users become self-sufficient by installing EES systems, there may be significant load-shedding —and even grid defection— affecting the revenues of system operators and traditional generators and increasing the cost for users who remain connected.

Consumption management. There are at least two ways in which EES allows end-users to optimize their demand and reduce their spending on electricity. On one hand, for customers subject to demand charges (electricity tariffs based on consumers' peak demand during specific periods), EES allows them to automatically respond to a peak load on their facilities by replacing their demand for grid energy with stored energy and, consequently, lowering their electricity bill. On the other hand, for customers subject to hourly tariffs, this application of EES can also generate significant savings by substituting consumption from the grid at times when the tariff is higher.

Controllable demand. Another way consumers can lower electricity spending is by participating in demand control programs, which is much easier with EES systems since these make it possible to reduce energy consumption from the grid during peak hours without affecting consumers' processes.

4. *Energy security*

A country's energy security depends to a large extent on the degree of diversification of its energy sources which in most cases calls for reducing dependence on hydrocarbons. Energy storage can become a promising ally in this effort; one simple example is the growing penetration of electric vehicles.

18 European Parliament, *Energy Storage: Which Market Designs and Regulatory Incentives Are Needed?*, October 2015, available at: *http://www.europarl.europa.eu/RegData/etudes/STUD/2015/563469/IPOL_STU(2015)563469_EN.pdf.*

In Mexico, natural gas is the main fuel for generating energy. In fact, in 2017, combined cycle plants served 50% of the total demand.[19] However, national production of this hydrocarbon has been falling steadily since 2009 and now the country depends on imports, which today equal 55% of the total natural gas demand, with 87% of these coming from the United States.[20]

In this scenario and in light of the recent changes in the US political and trade agenda, concerns have arisen about Mexico's energy security. As mentioned before, by favoring the incorporation of renewables, EES can reduce Mexico's dependence on US gas and strengthen its energy security.

On the other hand, EES can also play a key role in responding to attacks on the power grid, which are not implausible in a context of increasing digitalization. In the event of a cyberattack causing a massive blackout, EES systems could provide backup power for essential activities, like medical or military facilities, or help restore the power supply after the attack has been neutralized (emergency start-up), thus improving system security.

5. *Other benefits*

Economic benefits. As a market, EES is set to continue its growth. In fact, some projections predict a 12-fold increase in the global storage market by 2030, reaching a capacity of 125 GW or 305 GWh and investments of USD $103 billion.[21] This optimism reflects the huge economic potential of EES in the market, particularly for the manufacturing industry, and especially in the chemical batteries sector. This industry is now largely confined to the United States and, to a lesser degree, Germany, but there are opportunities for countries like Mexico that already have competitive value chains for products with electronic components.

Other ways in which storage promotes economic growth include the development of new industrial networks; job creation during the production, installation and operation of EES systems; export of storage equipment and components; research and development —and potential innovation— to increase competitiveness in the industry; greater reliability of electricity supply; and externalities to other EES-related industries, such as transportation, software, telecommunications and finance.

19 Secretaría de Energía, *Programa de desarrollo…, op. cit.*, p. 22.

20 Secretaría de Energía, *Prospectiva de Gas Natural 2017-2031*, México, SENER, 2017, p. 16.

21 Bloomberg New Energy Finance, *Global Storage Market to Double Six Times by 2030*, November 2017, available at: *https://about.bnef.com/blog/global-storage-market-double-six-times-2030/*.

Environmental benefits. EES allows higher percentages of renewable energy to be incorporated, which will eventually lead to lower GHG emissions. Storage systems do not produce emissions during operation, so they do not have negative impact on air quality or climate change. Thanks to their versatility, storage systems can also help optimize the operation of traditional combustion generators and reduce their emissions by saving fuel.

Social benefits. More than one billion people in the world do not have access to electricity, according to data from the International Energy Agency.[22] In Mexico, half a million homes, predominantly indigenous and rural ones, are in this same situation.[23] Mini-grids that combine EES systems and renewable technologies are an alternative to serve this population and replace the diesel generators and kerosene lamps they usually use. These systems reduce greenhouse gas emissions and provide a quality supply, similar to that provided by an electrical grid.

III. Existing and missing pieces of Mexican legislation

Since the 2013 reform, Mexico has worked on the liberalization of its energy markets. Secondary laws, regulations and other regulatory instruments essential for market operations were published in only two years, and there are still several issues pending to be resolved.

One of the missing pieces is the regulation for the EES, even though some progress has been made in this regard. For example, the Energy Transition Law establishes that the National Energy Control Center (CENACE), the independent system operator, must prepare a Smart Grid Program every three years that considers, *inter alia*, the integration of advanced EES technologies.[24] The first of these programs was published in 2016, and already recognized storage as a preferred technology because of its potential to reduce grid voltage variation and energy costs, promote renewable

22 International Energy Agency, *Energy Access Outlook 2017. From Poverty to Prosperity*, France, OECD/IEA, 2017, p. 40.

23 Cámara de Diputados, "En México, hay 500 mil viviendas sin electricidad, principalmente en comunidades indígenas y rural", Boletín, No. 1343, April 14, 2016, available at: *http://www5.diputados.gob.mx/index.php/esl/Comunicacion/Boletines/2016/abril/15/1343-En-Mexico-hay-500-mil-viviendas-sin-electricidad-principalmente-en-comunidades-indigenas-y-rurales.*

24 Secretaría de Gobernación, Ley de la Transición Energética, *Diario Oficial de la Federación*, Article 39, Mexico, December 24, 2015, available at: *http://dof.gob.mx/nota_detalle.php?codigo=5421295&fecha=24/12/2015.*

energy integration and prevent blackouts.[25] Furthermore, the Ministry of Energy has already deemed EES projects a solution to grid needs in the 2017-2031 PRODESEN.[26] However, in order to develop the potential of EES in Mexico, specific regulations are needed to provide greater certainty to the activities these assets can perform and their remuneration mechanisms. Even the 2017-2018 Special Energy Transition Program concedes that the current regulatory framework restricts the use of EES systems in certain market segments.[27]

Potential investors have expressed their interest in participating in storage projects in Mexico to the Energy Regulatory Commission (CRE) but have not undertaken any due to the lack of clear rules. Filling this regulatory void, clarifying the role of storage in the different markets and the permissible remuneration schemes is indispensable to develop the potential of EES in Mexico and access its manifold benefits.

1. *Everything starts with a definition*

The current regulatory framework does not contain a specific legal definition for EES systems —for the time being they must be registered under the figure of Power Plant and be represented by a Generator— and is limited in terms of the activity that such assets may engage in. Base 3.3.21 of the "Electricity Market Bases",[28] establishes that:

a) These Generators may make offers for the sale of all the products the storage equipment is capable of producing, under the same terms of any other Power Plant Unit.
b) Likewise, in order to operate the storage equipment, these Generators may make all the purchase offers that correspond to the Load Centers, assuming to this effect all the responsibilities that correspond to the Load Serving Entities.
c) When a piece of storage equipment is part of the National Transmission Grid or General Distribution Grid, strict legal separation must

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[25] Centro Nacional de Control en Energía, *Programa de Redes Eléctricas Inteligentes,* Mexico, SENER, 2016, pp. 26-36.

[26] SENER, *Programa de Desarrollo…, op. cit.,* pp. 113 and 114.

[27] Secretaría de Energía, "Programa Especial de la Transición Energética 2017-2018", *Plan Nacional de desarrollo 2013-2018*, Mexico, SENER, 2017, pp. 27 and 28.

[28] Secretaría de Energía, Bases del Mercado Eléctrico, *Diario Oficial de la Federación*, Article 3.3.21, 2015.

> be maintained between the Generator that represents the equipment in the Wholesale Electricity Market and the Transporter or Distributor that uses the equipment to provide the Public Transmission and Distribution Service, under the terms established by the Ministry of Energy. Likewise, these Generators, Transporters and Distributors shall adhere to the tariff regulations established by the CRE.

These provisions partially recognize the multipurpose nature of energy storage but create obstacles by placing EES within existing categories that are not necessarily applicable, relevant or flexible enough to take advantage of its full potential. One example is that the way in which EES would be charged for transmission service is unclear since there are different tariffs for Generators and for Load Centers. Nor is it clear how the different services EES assets can provide will coexist, which generates uncertainty about the possibility of receiving different revenues and, therefore, about the economic viability of these projects.

Success stories like the California power market show the importance of having a specific and suitable definition for storage that also recognizes its multipurpose nature. In this case, the EES market exploded with the publication of Assembly Bill 2514 of 2010,[29] which specifically defines EES systems without limiting different technologies or restricting asset ownership alternatives. An EES system can be owned by a Load Serving Entity, a State-owned company, an end user, a third party or any combination of these. This framework offers flexibility to different business models and provides clarity on the remuneration schemes available to EES.

This legislation was a milestone for the EES industry since it also required the California Public Utilities Commission (CPUC) to analyze the potential benefits and economic viability of EES and identify the appropriate targets for increasing storage capacity through bidding processes. CPUC set a goal of contracting 1,325 MW of EES capacity by 2020; by late 2017, it had already tendered 488 MW.[30] This mechanism —unique in the world— created a dynamic market in which new business models were built, research and development was strengthened, and an innovative regulatory framework was created.

29 California Legislative Information, *AB-2514 Energy Storage Systems (2009-2010)*, 2010, United States of America, Legislative Counsel's Digest, available at: *https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200920100AB2514*.

30 The Climate Group, *How California is Driving the Energy Storage Market through State Legislation,* United States of America, The Climate Group, 2017, pp. 2-5, available at: *https://www.theclimategroup.org/sites/default/files/downloads/etp_californiacasestudy_apr2017.pdf*.

Subsequently, the California independent system operator (CAISO) adopted the figure of "non-generating resources" for resources that can operate as generation and load and can be dispatched at full capacity, such as batteries or flywheels to electric vehicles.[31]

Following the example of California, the US Federal Energy Regulatory Commission (FERC),[32] published Order 841 in early 2018. This order obliges all electric system operators in the country to establish a participation model for EES in the market, recognizing its technical and operational characteristics. Moreover, it specifies that this model must ensure that EES systems are eligible to provide all technically feasible capacity, energy and ancillary services. Order 841 also asks that an explicit definition be established for EES systems to clarify their eligibility to participate in different market segments.[33]

2. *Regulating for multipurpose assets*

In addition to a proper definition, it is necessary for the regulator to establish a set of rules and contractual models so that EES can efficiently provide different services. The absence of clear rules could affect the operation of the system: for instance, if two services are required at the same time, which one should the asset give priority to? Who decides which of the two is a priority —the system operator or the asset owner?— How would this operation be coordinated?

In California, after allowing the participation of EES in different markets and collecting multiple revenues, in early 2018 the CPUC published eleven rules to facilitate the simultaneous participation of EES in different activities. One of the main contributions of these rules is the classification of services in different areas, which makes it possible to prioritize these services and determine which can be offered simultaneously, which cannot, and which are a priority.[34]

31 California Independent System Operator, *Storage Technologies Provide Flexible Resources in the Market,* s. f., available at: *http://www.caiso.com/participate/Pages/Storage/Default.aspx*.

32 Federal Energy Regulatory Commission, *Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators (Order 841)*, February 2018, available at: *https://www.ferc.gov/whats-new/comm-meet/2018/021518/E-1.pdf.*

33 *Idem.*

34 *California Public Utilities Commission, Decision on Multiple-Use Applications,* January 2018, pp. 11 and 12, available at: *http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M206/K462/206462341.PDF.*

These rules also address a frequent concern related to collecting multiple revenues: preventing double compensation. To this end, the CPUC clarifies that compensation is only permitted for incremental, distinct and measurable services. The same service must only be counted and compensated once.[35]

It is still too early to judge whether California's eleven rules will deliver on their objective and overcome the difficulties of operating EES systems in parallel markets. Nonetheless, California's experience has the longest track record and achievements in the world, so it is important to take into account its contributions, particularly in terms of service differentiation and hierarchization.

3. *A market for ancillary services that includes storage*

It has already been mentioned that due to its characteristics, EES is capable of providing ancillary services more efficiently than traditional generators, especially because of its fast response speeds. Recognizing this factor in the compensation of ancillary services can be an incentive to deploy EES, as well as to contribute to greater system stability, a particularly important issue in the current context of a growing participation of IRES.

In Mexico, the gamut of ancillary services is divided in those that are included in the market and those that are not (Table 1). The former are traded in the short-term market (a day ahead and real time) and their price is defined by the interaction of supply and demand. The latter consist of regulated services with tariffs regulated by the CRE (currently being developed). One of the main impediments for EES in the current scheme is that the plan does not include compensation for the primary regulation service —a service that requires greater speed and that in other parts of the world has been an attractive niche for the deployment of EES systems— which is considered a mandatory service that must be provided by all electricity generation units.[36]

In order to make providing ancillary services in Mexico more appealing for technologies like EES that are more efficient for this task, it is necessary for the Market Bases to allow the compensation of primary regulation and develop tariff methodologies for the compensation of ancillary services

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35 *Idem.*

36 Secretaría de Energía, Bases del Mercado Eléctrico, *Diario Oficial de la Federación*, Article 1.2.9, 6.2.1, 6.2.5 and 6.2.6, September 8, 2015, available at: *http://www.dof.gob.mx/nota_detalle.php?codigo=5407715&fecha=08/09/2015.*

not included in the market. Clearly establishing the compensation to be received for providing ancillary services is essential for the financial viability of EES projects, especially if such payments can be combined with revenues from other items like energy, capacity, transmission and distribution.

TABLE 1. CLASSIFICATION OF FEE-BASED ANCILLARY SERVICES IN MEXICO

Included in the market	*Not included in the market*
1) Secondary regulation reserves 2) Rolling reserves (10 minutes) 3) Non-rolling reserves (10 minutes) 4) Operating reserves 5) Supplementary reserves (30 minutes)	1) Emergency start-up 2) Island operation 3) Dead bus connection 4) Voltage and reactive power control

SOURCE: prepared by the author with information from the "Electricity Market Bases".[37]

4. *Monetizing value in transmission and distribution*

The value of EES as a T&D service provider has already been recognized by regulators, system operators and grid operators. California has already implemented EES applications as a grid asset with a defined compensation model. However, the combination of these —regulated— revenues with other revenues from the market is uncharted territory, even in advanced markets like California's (CAISO is already working on a proposal to be published in November 2018).[38]

Mexico has the potential to be a pioneer in this area as it is in the initial phase of setting up its markets and regulatory framework. For EES regulation to be successful and incentivize the deployment of these technologies, it is necessary to allow the collection of multiple —regulated and market-based— revenues from the outset. This would make it possible to leverage the myriad benefits of EES and pass them on to the system and to end users.

To better understand the challenge involved, it is worth looking again at the case of California. The following sections examine models that allow

37 *Idem*.

38 California Independent System Operator, *Storage as a Transmission Asset: Enabling Storage Assets Providing Regulated Cost-Of-Service Based Transmission Service to Access Market Revenues.* Revised Straw Proposal, August 2018, p. 7, available at: *http://www.caiso.com/Documents/RevisedStrawProposal-Storageas-TransmissionAsset.pdf.*

revenue recovery through regulated tariffs and their potential bundling with market revenues (Table 2). The purely merchant model, *i. e.*, which only receives revenues from the market, will not be discussed as it is beyond the scope of this paper.

TABLE 2. A SUMMARY OF EES PARTICIPATION MODELS IN THE CALIFORNIA POWER MARKET

Model	*Merchant*	*Grid asset*	*Hybrid*
Description	Projects aimed at providing services in the energy, capacity and ancillary services markets.	Projects designed to meet a specific need in the transmission or distribution grid.	A project that mainly provides grid services, but also participates in the electricity market.
Project origen	Submitted by a public company or regulatory institution, or by a private company that assumes all the risk.	Submitted as part of the power grid planning process.	*Proposal*: Submitted as part of the power grid planning process.
Compensation	Bilateral contracts, market revenues or both of the above.	Regulated tariffs	*Proposal A*: Regulated tariffs cover the full cost of the project; market revenues are deducted from the tariff. *Proposal B*: Regulated tariffs partially cover the cost of the project; market revenues are additional.

SOURCE: prepared by the author with information from CAISO.[39]

A. *The key to regulated tariffs lies in the planning process*

In 2013, CAISO developed a methodology to systematically consider EES assets in its grid planning process, which is a requirement to access regulated tariffs. During this process, the EES system must prove that it is the best option to solve a grid need using a cost-benefit assessment. This methodology was partly driven by California's energy policy, which identifies EES as a priority resource (energy efficiency, controllable demand and re-

39 *Ibidem*, pp. 16, 17, 24-28.

newable energy also fall under this category).[40] Previously, the EES projects were considered on a case-by-case basis, making approval difficult. Under the new methodology, two storage projects were approved in the 2017-2018 planning process.[41]

In Mexico, the National General Transmission and Distribution Grid Expansion and Modernization Program (PAM) is the instrument used to identify the projects that will meet the grid needs. The methodology used in these documents is not as sophisticated as that of California, partly because until 2013 these activities were carried out by a vertically integrated company (CFE). In the 2018-2032 period, the PAM evaluates only two alternatives for each identified need and chooses the one with the lowest cost based on an assessment by the grid operator. At this point in time, the PAM does not consider any alternatives to traditional grid technologies.[42]

Given that PAM results are used to prepare the PRODESEN[43] —which lists the projects to be undertaken in the next 15 years— it is necessary to include an EES alternative in the PAM so that these assets can access regulated tariffs as part of the grid.

Although the 2017-2031 PRODESEN considered the implementation of a storage system as an alternative to manage congestion in the Baja California grid,[44] Mexico still does not have a systematic assessment of this type of project. The inclusion of a battery bank for Baja California in the 2017-2031 period was the exception and not the rule. Thus, it is important to develop a methodology that ensures that EES is included in the range of potential grid solutions, which can lead to more efficient solutions for the grid that result in lower costs for users.

Moreover, it is necessary to define whether the system operator, CENACE, can own storage assets. In USA, the FERC had already rejected a proposal to consider EES as a transmission asset because the developer,

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40 California Independent System Operator, *Consideration of Alternatives to Transmission or Conventional Generation to Address Local Needs in the Transmission Planning Process*, September 2013, available at: *http://www.caiso.com/Documents/Paper-Non-ConventionalAlternatives-2013-2014TransmissionPlanningProcess.pdf*.

41 CAISO *Storage as a Transmission…, op. cit.*, p. 7.

42 Centro Nacional de Control en Energía, *Programa de Ampliación y Modernización de la Red Nacional de Transmisión y Redes Generales de Distribución del Mercado Eléctrico Mayorista 2018-2032*, Mexico, SENER, 2018.

43 Secretaría de Energía, *Programa de Desarrollo del Sistema Eléctrico Nacional*, May 31, 2018, available at: *https://www.gob.mx/sener/acciones-y-programas/programa-de-desarrollo-del-sistema-electrico-nacional-33462*.

44 Secretaría de Energía, *Programa de Desarrollo del Sistema Eléctrico Nacional 2017-2031*, Mexico, SENER, 2017, p. 113.

Nevada Hydro Company, suggested that the system operator should have control over it. FERC and the operator itself feared that this would compromise its independence, so the project was rejected.[45] Mexico does not have a defined position on the issue, but if a third party is allowed to own an EES asset, specimen contracts and rules of operation should be drafted to clarify the relationship between operator and owner.

B. *Combining regulated and non-regulated revenues: The big challenge*

In January 2017, FERC defined its position on EES participation in various activities. FERC noted the benefits of EES participation in various activities, whether regulated or market-based, and highlighted the importance of developing regulations that prevent adverse market impact, avoid double charges and protect the independence of the system operator.[46]

CAISO is the first operator to devise a proposal to combine multiple revenues (under discussion). This proposal states that EES projects that wish to access regulated tariffs must go through the grid planning process, even if their objective is to combine these tariffs with other market revenues.[47]

The proposal also includes a methodology to identify the conditions under which an EES project receiving regulated revenues for T&D services can offer other services to the market. CAISO suggests using the degree of predictability of grid needs to solve the dilemma: EES systems operating in low predictability contexts will not be able to participate in the market, while those where there is a high predictability will be eligible. In both cases, CAISO reserves the right to analyze case by case, and adjust the period where services can be provided to the market according to the existing conditions in the system.[48]

For those EES assets that can offer products to the market, CAISO puts forward two compensation mechanisms that reconcile regulated (fixed) revenues with market (variable) revenues, thus avoiding the duplication of costs:[49]

45 CAISO, *Storage as a Transmission Asset…, op. cit.*, p. 30.

46 Federal Energy Regulatory Commission, *Utilization of Electric Storage Resources for Multiple Services when Receiving Cost-based Rate Recovery*, January 2017, available at: *https://www.ferc.gov/whats-new/comm-meet/2017/011917/E-2.pdf.*

47 CAISO, *Storage as a Transmission Asset…, op. cit.*, pp. 16-18.

48 *Ibidem*, pp. 21-23.

49 *Idem.*

Proposal 1: The project will recover the full cost of the investment plus a reasonable return through regulated tariffs. The revenues obtained from the market will be deducted from the regulated tariff.

Proposal 2: The Project will recover part of the investment through regulated tariffs, and the rest will be recovered through the market. The developer will assume the merchant risk. The full recovery of investment costs is not guaranteed.

Proposal 1 has the advantage of ensuring the full cost recovery and making it easier to compare the project against other options in the grid planning process. However, it offers little or no incentive for EES assets to participate in the market. The second mechanism solves this disadvantage but instead leaves developers exposed to greater risk.[50]

In both cases, CAISO recognizes the importance of developing new contractual models for projects receiving regulated and market revenues. Additionally, one priority is to provide the operator with visibility in real-time operations of EES assets, including a path to operate the system when needed.[51] Therefore, the contractual model must be very clear on the circumstances under which the operator can take control of the assets and when it can operate freely to offer its services to the market.

Avoiding the duplication of costs and ensuring efficient coordination between the operator and EES assets are also concerns in the emerging Mexican storage market. Decision-makers can surely benefit from studying the ground already covered by California and should seriously consider including EES systems in the PAM and the PRODESEN.

IV. Conclusions

The decarbonization of the energy industry is key to addressing climate change. An important part of this strategy is increasing generation from renewable sources, especially in countries with high potential like Mexico. However, the expansion of these sources causes some concern since the fastest growing ones (solar and wind) are also intermittent and their incorporation complicates grid operation.

Fortunately, EES costs are going down in giant steps, by leaps and bounds, turning it into a viable solution to handle the voltage and frequency variability caused by higher percentages of IRES in the grid. EES also

50 CAISO, *Storage as a Transmission Asset…, op. cit.*, pp. 24-28.

51 *Ibidem*, p. 17.

has proven valuable for other purposes: increasing Mexico's energy security, empowering end users and encouraging the adoption of distributed generation (renewable in most cases). Storage also provides valuable ancillary services, especially those that require rapid response speeds.

One of the least recognized but highly valuable services is the use of EES as a transmission or distribution asset. These systems can reinforce existing grid infrastructure, prevent stress and thermal overloads on lines and avoid congestion. This way, EES can defer —and even avoid— investments in new T&D infrastructure, thereby cutting costs for the operator and end-users.

The viability of EES projects depends to a large extent on receiving multiple revenues from the different activities and services that it is technically capable of providing. However, this has not been easy because of the current structure of electricity markets. California —the most advanced EES market in the world— has made significant progress although there are still issues to be resolved, especially in the simultaneous compensation for market and T&D services.

Following the example of California, Mexico has a long way to go for the EES market to grow:

Create a new definition of EES that acknowledges its multipurpose nature. This new definition should avoid confining EES to existing concepts like Generator or Power Plant since storage has unique characteristics that do not necessarily match those of other types of assets.

Build the methodology for considering the ancillary services not included in the market; consider the inclusion of products that recognize the response speed of the asset at faster levels (included and not included in the market) and recognize that primary frequency regulation has a financial compensation.

Liaise with CENACE and the Ministry of Energy so that EES is considered in the electricity grid planning process (PRODESEN), a necessary step for EES to receive regulated tariffs for providing T&D services.

Design a methodology to identify the best alternatives for providing T&D services that are technologically neutral, as well as the circumstances under which EES systems used as grid assets can provide services to the market without compromising the efficient operation of the grid (this includes a fair compensation mechanism that prevents double charges).

Classify and categorize the services EES can provide as a basis for drafting operating rules so that different services can be provided simultaneously without compromising system operations or market performance.

Review the existing market instruments and modify those that are necessary.

The implementation of these actions requires collaboration between the players involved, especially between the regulator (CRE), the independent system operator (CENACE) and the policy maker (SENER).

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