NM Renewable Energy Storage Task Force Report

November 18, 2013

Executive Summary:

This report captures the research and ideas raised by the Renewable Energy Storage Task Force whose members represent diverse interests from energy related organizations in New Mexico. The Energy, Minerals and Natural Resources Department has compiled the following list of options, generated by this Task Force, to encourage Renewable Energy Storage in New Mexico. This report is not a document of policy preferences, rather it is a reference point capturing the progress of this team of experts from which to launch additional efforts.

The ideas presented below are options, not recommendations, and the Task Force did not rank or reach consensus on these options; inclusion in this report does not reflect that all Task Force participants are in support of each option mentioned.

A. **Create an energy storage advisory council to guide state government on renewable energy storage development and deployment in New Mexico.**

B. **Coordinate with other Western states to collectively identify opportunities for regional renewable energy storage.**

C. **Evaluate existing incentives for business development and modify them as needed to encourage design and manufacture of energy storage software and controls.**

D. **Continue research and development activities in partnership with New Mexico's national laboratories, universities and utilities.**

E. **Support a large-scale energy storage demonstration project.**

F. **Consider examining time-of-use rate expansion and how it would impact New Mexico ratepayers.**

G. **Explore modifications to the New Mexico Production Tax Credit (PTC) to provide more certainty to the renewable energy industry and/or directly incentivize renewable energy storage.**

H. Continue to investigate funding or cost recovery options for renewable energy storage projects in New Mexico.

I. Introduction: Purpose of the Report

During New Mexico's 2013 Legislative Session, House Joint Memorial 10 and Senate Joint Memorial 43 were passed. These memorials task the Energy, Minerals and Natural Resources Department (EMNRD) with convening a working group and developing a report for the Legislature's Interim Science, Technology and Telecommunications Committee that:

- Inventories major existing federal and state renewable energy storage policies and regulations; and
- Develops legislative and regulatory recommendations and alternatives that can incentivize renewable energy storage technologies and infrastructure development to benefit New Mexico, with the recommendations drawing on successful planning practices.

Task Force Members and Process

EMNRD convened a Renewable Energy Storage Task Force (Task Force) to address the requirement of these memorials. EMNRD's Energy Conservation and Management Division (ECMD) elicited participation from a diverse group of entities in the Task Force to contribute as broad a perspective of storage as possible. These entities are listed below, and Appendix A lists the names of individuals who participated in the Task Force deliberations:

- **Electric utilities and cooperatives:** El Paso Electric, Xcel Energy, Public Service Company of NM, Tri-State Generation & Transmission and NM Rural Electric Cooperative Association
- **National Laboratories:** Sandia National Laboratories and Los Alamos National Laboratory
- **Universities:** University of New Mexico, New Mexico Tech and the North American Wind Research & Training Center at Mesalands Community College
- **NM Private Sector:** Advance Energy, Applied Technology Associates, EMCORE, Qynergy, Simons Systems and Tetra Tech.
- **NM Renewable Energy and Environmental Non-Profits:** Interwest Energy Alliance, New Mexico Green Chamber of Commerce and Western Resource Advocates
- **NM State Government:** Office of the Governor, Economic Development Department, State Lands Office, Renewable Energy Transmission Authority, Public Regulation Commission, Environment Department, Indian Affairs Department, and Energy, Minerals and Natural Resources Department

ECMD convened four meetings of the Task Force during 2013. An initial meeting was held on July 25th in Santa Fe at EMNRD's Office of the Secretary to commence deliberations. The group met again on August 22nd in Albuquerque at the University of New Mexico's City Lab to review the various energy storage technologies and build upon the initial discussion. A third meeting was held on Sept 19th in Albuquerque at PNM's Aztec facility to review federal and state approaches to energy storage. This meeting included a presentation by PNM on their Prosperity Energy Storage project and a site tour. The fourth meeting was held on October 29th in Santa Fe at EMNRD's Porter Hall to review and discuss the draft report. Each meeting provided opportunities for everyone, including teleconference participants, to ask questions and provide feedback and discussion points.

The Task Force reviewed, discussed and debated all the information and ideas presented during these meetings to develop this written report with an emphasis on New Mexico's needs, regulatory and business climate. Not all members of the Task Force were in agreement with all of the items in this report. The Task Force has agreed to this menu-of-options approach to capture available alternatives. ECMD hosts a webpage[1] housing general information about the Task Force as well as links to energy storage resources, reports and presentations that is the foundational basis of this report.

The initial drafts of the report were written by eight members of the Task Force who volunteered their time to expedite the development of this final version: Abbas Akhil (Sandia National Laboratories - retired), Dhruv Bhatnagar (Sandia National Laboratories), Mark Gaiser (Emcore), Wish Krishnamoorthy (Qynergy), Jeremy Lewis (EMNRD- ECMD), Albert Migliori (Los Alamos National Laboratory), Laura E. Sanchez (NM Green Chamber of Commerce) and Michael Workman (University of New Mexico).

Energy Storage Technology Neutrality and Values

This Task Force recognizes that energy storage is an important option[2] in modernizing our electrical system, and it further recognizes that energy storage will play an increasingly important role in enhancing the resiliency of the electric grid as the State moves to greater penetration of renewable energy generation. The Task Force understands the need to explore ways to swiftly capture emerging energy storage markets and its corresponding benefits for New Mexico's economy.

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[1] See http://www.emnrd.state.nm.us/ECMD/RenewableEnergy/RenewableEnergyStorage.html

[2] Other options and tools that will bring our electric system up-to-date, but outside the scope of this report, include demand response, energy efficiency, improved grid controls and operation, and thermal storage.

It was not the purpose of this Task Force to pick energy storage technology winners and losers. The energy storage industry contains both mature and emerging technologies[3] while different storage technologies have different applications, strengths, and costs. Also, technology choices can only be made once the available financial resources are quantified and policy options are spelled out. Vetting energy storage technologies is best done by technical experts at our national laboratories, universities, and utilities and by the marketplace. For these reasons, this Task Force maintains a neutral stance toward all storage technologies at this time.

In the meantime, the Task Force acknowledges that New Mexico has unparalleled science and engineering assets that are crucial to energy storage deployment within the State. These assets can be leveraged to rapidly deploy energy storage systems in New Mexico and propel it to the forefront of renewable energy development in the Nation. The Task Force understands the importance of providing incentives to preserve and grow our business community and workforce. By fostering development of energy storage markets and associated business development in New Mexico, we can improve our economy at large, harness our resources, and lead the U.S. in the modernization of our electric grid.

Energy Storage is Needed in New Mexico, the United States and Worldwide

All electric grids are non-elastic in the sense that the power generated has to be consumed by the grid's loads instantaneously. Any excess or shortage of power leads to instability and, if unchecked, the grid could have a complete blackout. This delicate balancing act is performed by grid operators who are constantly matching power supply with customer demand. This moment-to-moment balance between generation and loads becomes more difficult to manage when renewable energy generation is added to the grid. These renewable resources have an inherent variability in their output due to fluctuations in wind speed and the impact of clouds on sunlight. Traditionally, grid operators have only had to manage largely predictable power generated by coal, natural gas, or nuclear power plants; the variability of renewable resources introduces a new paradigm in the management of the electric grid.

Pairing energy storage with renewable energy generators creates a more reliable and controllable energy resource. This becomes a more important pursuit as renewable energy plays a greater role in our electric system. Furthermore, energy storage allows solar power to

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[3] See "Electricity Storage Basics" available at: http://www.emnrd.state.nm.us/ECMD/RenewableEnergy/RenewableEnergyStorage.html. These slides provide an overview of energy storage including a definition, review of technologies, benefits, and regulatory issues. Presented by Georgianne Huff, Sandia National Laboratories, to the New Mexico Renewable Energy Storage Task Force on August 22, 2013.

be delivered on the electric grid after the sun goes down and more wind power to be effectively accessed to meet peak loads. See Appendix C – Energy Storage 101 for more on this topic.

The energy storage market is growing and it would be beneficial to New Mexico's economy to capture a large slice of this growth. Globally, the energy storage market is anticipated to grow from the current $150 million to $10 billion in ten years.[4] As of November 6, 2013, the Global Energy Storage Projects Database lists 448 projects from 36 countries representing 129,500 GW of energy storage.[5] We can capitalize on New Mexico's national laboratories strength and world leadership in the research of energy storage by providing incentives for the development of energy storage. A focus on the specialized software and controls necessary for integrating energy storage into grid operations is a logical niche that can take root in New Mexico. Until transmission lines are built to unlock New Mexico's renewable energy export potential, becoming a leader in renewable energy storage deployment remains an obstacle because New Mexico simply does not have the energy scale of more populated states. Indeed, New Mexico has the potential to become a focal point for businesses engaged in energy storage development for deployment in New Mexico, regionally, and world-wide.

II. New Mexico's Unique Market – Drivers that Could Support or Hinder Renewable Energy Storage

The United States and the world are in the midst of a long-term shift in the generation sources used for electric production. The declining price of solar panels and wind turbines are now providing energy at prices approaching fossil fueled generation.[6] The adoption of these technologies is accelerating in most markets and, in most U.S. states, the Renewable Portfolio Standards (RPS) are being met ahead of the required date.[7]

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[4] Navigant Research, 2013, Energy Storage for Wind and Solar Integration, available at: http://www.navigantresearch.com/research/energy-storage-for-wind-and-solar-integration.

[5] See the U.S. Department of Energy's web resource at: http://www.energystorageexchange.org.

[6] U.S. Department of Energy, 2013, Revolution Now: The Future Arrives for Four Clean Energy Technologies, (17 September), available at: http://energy.gov/sites/prod/files/2013/09/f2/Revolution%20Now%20--%20The%20Future%20Arrives%20for%20Four%20Clean%20Energy%20Technologies.pdf; in addition, a recent power purchase agreement for the southern New Mexico Macho Springs solar plant shows wholesale power sold to El Paso Electric for 5.7 cents per kWh, see page 8 of: NM Public Regulation Commission, 2012, Case No. 12-00386-UT, available at: http://164.64.85.108/infodocs/2013/1/PRS20179845DOC.PDF.

[7] Leon, W., 2013, The State of State Renewable Portfolio Standards, Clean Energy States Alliance (June), available at: http://www.cleanenergystates.org/assets/2013-Files/RPS/State-of-State-RPSs-Report-Final-June-2013.pdf, p. 17-18; for additional discussion on this topic, see also: Binz, R., et al., 2012, Practicing Risk-Aware Electricity

Deploying energy storage and using this capacity to meet peak demand would enable New Mexico to maximize its expanding wind and solar electricity generation resources and position it to be a net electricity exporter. If sufficient energy storage is installed in New Mexico, then electricity from wind turbines and solar farms could become an even more valuable resource for the state, providing energy both for the citizens of New Mexico and for our neighboring states. The value of energy storage resides in the flexibility it offers by being highly dispatchable. As stated in a 2010 Sandia National Laboratories Report on Energy Storage for the Electricity Grid: "Electric energy storage is poised to become an important element for the electricity infrastructure of the future. The storage opportunity is multifaceted – involving numerous stakeholders and interests – and could involve potentially rich value propositions." [8]

A. Potential for Renewable Energy Development in New Mexico

The open land and abundant sunshine in New Mexico make it a prime candidate for wind and solar energy production. A 2012 study by the National Renewable Energy Laboratory (NREL) estimated the renewable energy production potential for New Mexico, as summarized in Table 1.[9]

Regulation: What Every State Regulator Needs to Know, CERES (April), available at: http://www.ceres.org/resources/reports/practicing-risk-aware-electricity-regulation/view.

[8] Eyer, J. and G. Corey, 2010, Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide: A Study for the DOE Energy Storage Systems Program, Sandia National Laboratories, available at: http://www.sandia.gov/ess/publications/SAND2010-0815.pdf.

[9] Lopez, A., et al., 2012, U.S. Renewable Energy Technical Potentials: A GIS- Based Analysis, National Renewable Laboratory Technical Report, NREL/TP-6A20-51946, available at: http://www.nrel.gov/docs/fy12osti/51946.pdf.

Table 1. Renewable Energy Production Potential in New Mexico.

Resource / Location	Estimated Annual Energy (GWh)	National Rank
Rural Utility Scale Photovoltaic	16,318,543	2
Rural Utility Concentrating Solar Power	16,812,349	2
Urban Utility Scale Photovoltaic	71,356	8
Wind Power	1,399,157	11
Rooftop Photovoltaic	6,513	36
Total	34,607,918	

The total renewable energy potential estimated in the NREL study dwarfs the total electricity consumption in New Mexico which was only 22,428 GWh in 2010.[10] The State could capitalize on this vast renewable potential by developing robust transmission infrastructure with supportive energy storage installations. An investment in this infrastructure would enable a greater portion of renewable energy supply on the grid serving New Mexico loads while opening the export potential to other load centers in the region such as California, Arizona and Nevada.

B. Electricity Grid in New Mexico

The fundamental impediment to turning New Mexico into a renewable energy exporting state is the lack of transmission. While energy storage supports renewable energy, it will not help to move it out of state unless the transmission bottleneck is resolved. This lack of transmission is the key problem that will stand as an impediment to other initiatives like renewable energy storage.

New Mexico is served by three major Investor Owned Utilities (IOU) – the Public Service Company of New Mexico, Southwestern Public Service (SPS/XCEL), and El Paso Electric. These three companies along with the cooperative Tri-State Generation & Transmission provide the majority of the electricity transmission (the grid) in the state. In eastern New Mexico a division between the Western and Eastern Interconnections exists, both of these two major power grids

[10] Appendix B of Lopez et al. (2012).

are present in New Mexico. The Federal Energy Regulatory Commission's (FERC) Open Access Transmission Tariff (OATT) system provides a working framework for the use of the transmission system in the state. The eastern third of New Mexico's grid is operated by Southwest Power Pool, a Regional Transmission Organization (RTO), while the remainder of New Mexico's grid is coordinated by the Western Electricity Coordinating Council and balanced by PNM. PNM collaborates with the agency WestConnect to accomplish transmission planning and reliability. Through WestConnect, PNM has joined together with utilities to the west and north to address regional and inter-regional transmission cost allocation and planning requirements. While an RTO or Independent System Operator (ISO) is not present to negotiate use of the majority of the New Mexico grid, WestConnect presently fills this gap.

C. National Laboratories in New Mexico

Sandia National Laboratories (Sandia) and Los Alamos National Laboratory (Los Alamos) are huge resources for high-tech research and energy storage expertise in New Mexico. Both Sandia and Los Alamos have Department of Energy (DOE) programs with a total combined investment of over $30 million in renewable energy and energy storage research. Our laboratories are technical and honest brokers with active programs, funds and resources here in New Mexico that can be further tapped in pursuit of New Mexico's goals for Renewable Energy Storage.

Sandia has been the lead lab for DOE to implement its Energy Storage Program since the mid-1970s. This program has been key in the development of several energy storage technologies since its inception. Sandia also has a broad range of expertise in every aspect of energy storage including storage technologies, storage analysis, and regulatory incentives and programs that incentivize energy storage at the Federal and State levels. This overarching capability makes them ideal for evaluating and providing recommendations for renewable energy storage solutions that are specific to New Mexico's needs. Additionally, federal funds can be leveraged through the Clean Energy States Alliance, a DOE program managed through Sandia, to pursue New Mexico goals with renewable energy storage.

Los Alamos has designated electrical energy storage as a primary research direction in its energy security strategy. Their long-term research goals (10 year) focus on making chemical fuels from electricity that can then be converted back to electricity or used for transportation. These applications fall outside the purview of this Task Force. However, short-term Los Alamos research interests are in modular pumped hydroelectric energy storage, something that can be an approximate replacement for a gas turbine peaking plant.

Having the laboratories in New Mexico also provides opportunities for spin-off ventures based upon the research conducted at the laboratories. Given proper stimulus, these spin-off firms can provide a vehicle to create new industries and multiple jobs here in the state. Additional information on New Mexico's National Laboratory resources is included in Appendix D.

D. Attracting New Industries to New Mexico

Luring new businesses to New Mexico from outside the state continues to be a challenge and an opportunity. Various factors for this challenge include an undeveloped labor pool along with cost and logistics of shipping material to a distant market. Because the market for energy storage is not developed, it is anticipated that access to capital to fund projects in New Mexico will be limited.

E. University System and High-Tech Business

New Mexico universities produce graduate students that are highly capable of providing a qualified workforce to sustain homegrown industries that can develop energy storage controls, storage system analysis and energy accounting software. There is a growing need by electric utilities to obtain such software or service expertise from independent vendors. These startups could develop into a major industry for New Mexico.

F. Experience in Energy Storage Deployment

PNM's Prosperity PV/Storage site, Los Alamos County's microgrid project, and the microgrid infrastructure at Mesa Del Sol, which has a strong energy storage component, can be synergistic test beds to attract other energy storage opportunities from industry and DOE.

G. Low Electricity Prices

While low electricity prices in the state have benefits to ratepayers and industry, low prices have limited the market for investment into new technologies. Methodically fostering a modern electric system that meets our needs will ensure utility bills remain low into the future. Low electricity prices create jobs because businesses have more capital that is not spent on utility bills and can hire more workers with it.

H. Rural, Remote Populations

Rural communities in New Mexico including Native American, Land Grant, and remote communities could provide sites to utilize energy storage. These sites could provide valuable operational data about energy storage for remote customers that are located miles from the main electrical grid. Native American communities, with a unique opportunity to leverage their standing as sovereign nations, could access Federal funds to support these projects and attract industry. Another opportunity is to study the 600 home photovoltaic systems with energy storage installed by Sacred Power on the Navajo Nation[11] to provide a valuable database on the performance of residential-sized, distributed energy storage systems.

I. Electricity Cooperatives

Electric Cooperatives buy power from either an IOU or wholesalers out of Colorado or Oklahoma. Customers of cooperatives pay some of the highest power prices in the state. Short term spikes in consumption may lead to increases in electrical energy costs imposed by the generation provider. Short-term or time-shifting energy storage could help reduce the demand charges resulting in lower energy costs; however, Tri-State currently reports flat demand charges in their service territories. The cooperative's participation in a New Mexico state program could be leveraged through the Rural Utility Service and other regional and national organizations.

III. Review of Legislative and Regulatory Incentives Used in Other States

Federal and state organizations have recognized many barriers to the deployment of energy storage. Looking at these efforts collectively, it becomes clear the United States recognizes the great importance in modernizing our electric grid. As a country, we are taking steps to update our regulations, electric system infrastructure, and operations to reflect our modern computing power, technology advancements, and electricity demands. Many of these initiatives are not only specifically focused on increasing the deployment of energy storage resources, but also focus on the increased deployment of other emerging technologies such as renewable generation and demand response programs. These initiatives provide a framework from which other initiatives can be formed.

The Task Force studied what others have done at the federal, state and local levels to develop a list of regulatory and legislative options for New Mexico to explore. A review of legislative and regulatory incentives spearheaded by FERC, Colorado, Texas, Arizona, and California is included in Appendix B.

[11] Sacred Power, n.d., USDA Rural Utility Services-PV Hybrids for Underserved Navajo Nation Residents, available at: http://www.sacredpowercorp.com/content/projects/usda.html.

IV. Possible Options to Promote Energy Storage Technology Development and Deployment in New Mexico

After reviewing the strategies used by other states, and considering New Mexico's unique market and its strengths and weaknesses, the Task Force generated ideas for state renewable energy storage and infrastructure development to benefit the New Mexico economy. We formulated these possible policy incentives with the goal of avoiding any additional tax burden or increased electric rates. The ideas presented below are options, not recommendations, and the Task Force did not rank or reach consensus on these options; inclusion in this report does not reflect that all Task Force participants are in support of each option mentioned.

A. Energy Storage Advisory Council – Create an energy storage advisory council to guide state government on renewable energy storage development and deployment in New Mexico.

The Task Force discussed establishing an advisory council on renewable energy storage composed of representatives from different stakeholders in energy storage and renewable energy, which would institutionalize the work begun by this Task Force. This Task Force has provided a snapshot of the current state of the electricity storage market and options to promote its growth in New Mexico, but renewable energy storage is an emerging and dynamic market. Continuing to stay abreast of changes and opportunities are important technical functions that require attention. This advisory council would advise state government on how to best encourage renewable energy storage development and deployment in New Mexico.

B. Regional Policy Coordination on Energy Storage – Coordinate with other Western states to collectively identify opportunities for regional renewable energy storage.

Some renewable energy developers pursuing projects in New Mexico are seeking to export renewable energy to Arizona, Nevada, and California. This type of regional renewable energy electricity market would require a different configuration of storage technologies and sites than a New Mexico–focused energy storage market. It may be useful for EMNRD or the above-mentioned advisory council to work with its counterparts around the West to collectively identify opportunities to encourage renewable energy storage. New Mexico could also approach the Western Governors' Association or another trusted regional entity to suggest they convene discussions on how to pursue storage as a way to create more robust regional markets for renewable energy and export opportunities for states like New Mexico.

C. Incentives for Designing and Manufacturing Energy Storage Software and Controls – Evaluate existing incentives for business development and modify them as needed to encourage design and manufacture of energy storage software and controls.

According to staff at Sandia National Laboratories, the supply chains for existing energy storage components are already established. Therefore, the potential to attract supply manufacturers to this state could be limited. However, incentivizing the design and manufacture of the storage software and controls necessary for energy storage is an area worth examining. Fostering industry in these areas would add new high tech skilled jobs for software engineers. Particularly, with our proximity to two major national laboratories, New Mexico could become a hub for the design and manufacture of software and controls for integrating renewable energy storage onto the grid nationwide. Existing Economic Development Department initiatives could be reviewed for applicability to renewable energy storage businesses. One option would be to tailor existing incentives and initiatives to support the successful establishment of the energy storage software and controls sector.

D. Research and Development – Continue research and development activities in partnership with New Mexico's national laboratories, universities and utilities.

The tremendous amount of research and development in energy storage that has taken place here in New Mexico should continue. New Mexico's leadership in this field from our national labs, universities and utilities can help the state continue to innovate and vet energy storage technologies to work toward renewable energy storage solutions. As noted in Appendix D, our national laboratories have world renowned research and development capabilities that can access multiple funding sources, and inclusion of our universities in energy storage R&D ensures the next generation of leaders in this field is continually grown. Electric utilities and cooperatives partnering with our laboratories and universities provide specific requirements for these technologies to fit into and improve New Mexico's electric grid resources and reliability.

E. Large-Scale Energy Storage Demonstration Project – Support a large-scale energy storage demonstration project.

New Mexico could build on its current energy storage demonstration projects and pursue a large-scale demonstration project (in the 10 to 20 MW range) that would provide valuable data and experience for grid operators to learn how energy storage stabilizes a grid that includes renewable energy. Selection of specific application(s) on the grid, technologies used, and the site would determine the demonstration project cost, but the Task Force estimates it would be approximately $10 to $20 million for a 10 MW energy storage system.

Such a project could be supported by the state, and utilize cost-share with public, private, electric cooperatives, and utility partners to maximize invested funds. Other states have designed systems to promote these types of projects. For example, Colorado supplies direct state funding for storage through its general initiative on new power system technologies that includes research staff for emerging issues and a special legislative fund set aside for new energy resources. This set aside, called *Section 123 Resources,* requires Colorado's public utility commission to provide complete consideration and possible rate-based financing to alternative technologies, even those that are not necessarily economically competitive. It could also be advantageous for New Mexico to establish a framework of incentives to create a scenario where a private company could implement a demonstration project on its own accord.

F. Time-of-Use Rates – Consider examining time-of-use rate expansion and how it would impact New Mexico ratepayers.

One possible incentive for energy storage would be to expand the use of the present time-of-use rate structure so that the real value of renewable energy storage systems is recognized financially.[12] This action is designed to reduce the effective subsidy of the customer who uses electricity without paying the real time-of-use costs, such as one who continues to pay low prices during peak times when electricity is more expensive to generate. Instead of singling out groups for time-of-use rates, as is done now, actual time-of-use metering could be implemented. Approval of such a rate structure would be the responsibility of the Public Regulation Commission, although the Legislature could make a change to the Public Utilities Act to ensure that this new rate structure is used specifically to incentivize renewable energy storage systems.

Time-of-use rates can benefit ratepayers who lower their electricity usage during times of peak demand, when electricity is most costly. In addition, reducing demand during peak times can reduce rates for all customers, as generators that provide capacity during this time drive up costs system-wide. When coupled with energy storage, time-of-use rates can also benefit customers that charge energy storage devices during off-peak hours and then use the electricity during peak times, taking advantage of lower-cost energy.

However, time-of-use rate structures also have the potential to increase electricity bills for customers whose energy usage is not flexible and that cannot switch their power use away from peak times. An additional cost of implementing time-of-use rates in New Mexico is upgrading customer meters to ones that read on-peak and off-peak consumption, which most current meters cannot do. A solid financial analysis of costs and benefits to different electricity users would be required before pursuing time-of-use pricing across utilities in New Mexico.

[12] Presently, for PNM the 12-hour on-peak period averages the daily periods of peak energy use with several hours of less than peak. Breaking the 12-hour block into three 4-hour blocks may generate better market signals. The 4-hour block from 4:00 pm to 8:00 pm would then represent the time of highest energy use, and potentially the highest reward for time-shifting storage.

G. New Mexico Renewable Energy Production Tax Credit Modification – Explore modifications to the New Mexico Production Tax Credit (PTC) to provide more certainty to the renewable energy industry and/or directly incentivize renewable energy storage.

The demand for energy storage often corresponds with the amount of renewable energy in a system. Additional renewable energy deployment in New Mexico could therefore bolster energy storage demand and markets. Currently, there is some regulatory uncertainty surrounding one of the key drivers of renewable energy development in the state—the New Mexico Renewable Energy Production Tax Credit (PTC)—creating a difficult investment climate for renewable energy operators to plan projects in the state.[13]

A key uncertainty surrounds when the 10-year PTC eligibility period commences. Two different interpretations include: 1) starting the 10-year period of eligibility from the time the project first produces electricity, regardless of whether it is eligible to receive the tax credit, or 2) starting the period of eligibility from the time the project is certified by EMNRD as a "qualified energy generator," which occurs when the project is at the top of the queue to receive the tax credit and can be after the project has been in operation for years. With the first option, the project could lose years of tax credit eligibility while operating but waiting for the fully-subscribed tax credits to free up. [14] Legislative clarification of the intent of the law would help remove this uncertainty.

To incentivize energy storage directly, there could be a separate PTC for renewable energy storage or a carve-out for renewable energy storage within the existing PTC. For the latter to be feasible, however, the cap on the PTC would have to be raised, as the PTC is currently fully subscribed and will be until the credit expires December 31, 2017. A limit on the number of credits any one project could receive is another means to free up some of the PTC credits for additional renewable energy or storage projects. Changes in the PTC that relate to energy storage would have to be designed with care so that renewable energy electrons are not "double counted," or receive a per kWh incentive first when they are generated, and again

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[13] The state PTC provides $0.01/kWh for electricity generated from wind, biomass, landfill gas, municipal solid waste, and anaerobic digestion and an average of $0.027/kWh for solar-light and solar-heat derived qualified energy resources. The PTC is limited to a maximum of 2 million MWh annually, plus an additional 500,000 MWh produced by qualified solar generators (Section 7-2A-19.G, NMSA 1978). The PTC is available both under the Income Tax Act (NMSA 1978, 7-2-18.18) and under the Corporate Income and Franchise Tax Act (NMSA 1978, 7-2A-29). This means the tax credit can be taken on income taxes, for individuals, or on corporate taxes.

[14] There are waiting lists of renewable energy projects amounting to 80,000 MWh for solar and 1,660,000 MWh for wind. It is estimated that a new PTC solar application submitted to EMNRD in 2013, which meets criteria for future consideration, would begin tax credit eligibility in 2021, or after the tax credit expires in December 2017. For wind applications, tax credit eligibility would begin in 2020.

when they are dispatched from a renewable energy storage source. A study of anticipated renewables and storage growth, due to drivers such as the RPS and other states' needs for renewable electricity, and an analysis on impacts to the state General Fund, should support any proposals to modify the PTC.

H. Funding of Renewable Energy Storage Initiatives – Continue to investigate funding or cost recovery options for renewable energy storage projects in New Mexico.

As the review of other states shows (Appendix B), there are a variety of ratepayer and taxpayer funded options for developing Renewable Energy Storage initiatives. The Task Force discussed a number of creative options for funding renewable energy storage programs, from IOUs using possible differentials between the reasonable cost threshold (RCT) and actual cost of renewables to fund additional storage projects,[15] to including a small storage surcharge on electricity bills. An approach to funding storage initiatives that incentivizes utility investment, through mechanisms such as accelerated depreciation or return on equity (ROE) adders, could garner additional interest in private sector energy storage investment.

V. Conclusion

The U.S. energy storage landscape is changing rapidly. While this Task Force was convened and working on this report, California's Public Utilities Commission approved a mandate that requires the state's three large IOUs to add 1.3 gigawatts (GW) of energy storage to the grid by 2020. This development has the potential to drive down costs of energy storage, and is the result of two years of policymaking and deliberation in California. This Task Force and its report represent the beginning of New Mexico's own evaluation of how energy storage can best benefit its citizens and electricity system.

While the Task Force did not reach consensus on the options presented in this report, the diversity and level of engagement of its participants demonstrate a broad coalition of support for continuing to explore ways to deploy energy storage in the state and region. Options presented here range from promoting energy storage software control industries in New Mexico to developing a large-scale storage demonstration project. These options represent ways to build on the foundation of existing energy storage demonstration projects and

[15] The RCT states that a public utility is not required to add renewable energy to its electric energy supply portfolio, pursuant to the renewable portfolio standard, above the RCT established by the PRC. Since 2013, the reasonable cost threshold is 3% of plan year total revenues.

expertise in the state to advance energy storage policies and projects that will be of greatest benefit to New Mexico citizens.

VI. Appendix

a. List of Task Force Members and Participants

b. Review of Federal and State Legislative and Regulatory Initiatives

c. Energy Storage 101

d. New Mexico National Laboratory Resources

e. Glossary of Terms

Appendix A.

Renewable Energy Storage Task Force Members

Name	Title	Organization
Keven Groenewold	Executive Vice President & General Manager	NM Rural Electric Cooperative Association
Ed Rougemont	Self Insurer's Fund Administrator	NM Rural Electric Cooperative Association
Jennifer Drake	Manager of Utilization Resource Strategy	Tri-State G & T
Jon Hawkins	Manager, Advanced Energy Technology and Strategy	PNM (Public Service Company of New Mexico)
Frank Novachek	Director, Corporate Planning	Xcel Energy
Roberto Favela	Manager, Corporate Development, Renewables and Emerging Technologies	El Paso Electric
Albert Migliori	Laboratory Fellow	Los Alamos National Laboratory
Rick Ulibarri	Government Affairs	Los Alamos National Laboratory
Dhruv Bhatnagar	Technology and Policy Analyst	Sandia National Laboratories
Georgianne Huff	Project Manager, Energy Storage Systems Program	Sandia National Laboratories
Abbas Akhil	(Retired)	Sandia National Laboratories
Jim Morgan	Director, Institutional Technology & North American Wind Research & Training Center	Mesalands Community College
Van Romero	Vice President for Research and Economic Development	New Mexico Tech
Michael Workman	Graduate Student (Ph.D.) Nanoscience and Microsystems	University of New Mexico
Laura E. Sanchez	CEO	Green Chamber of Commerce
Sarah Propst	Executive Director	Interwest Energy Alliance
Steve Michel	Chief Council, Energy Program	Western Resource Advocates
Arlo Corwin	Owner	Advance Energy
Dennis Smith	Inertial Systems Engineer	Applied Technology Associates
Gerald Simons	Owner	Simons Systems
Mark Gaiser	Senior Applications Engineer	Emcore Solar Power
Tom Stoops	Director, Energy Services	Tetra Tech
Wish Krishnamoorthy	Vice President of Technology	Qynergy
Carlos Beserra	Special Projects Manager	Economic Development Department
Heather McDaniel	Policy Analyst	Office of the Governor
Tom Leatherwood	Director, Commercial Resources Division	State Land Office
Jeremy Lewis	State Energy Program Manager	Energy, Minerals and Natural Resources Dept.
Jeremy Turner	Director	NM Renewable Energy Transmission Authority
Angela Gonzales-Rodarte	Assistant Director	NM Renewable Energy Transmission Authority
Ken Hughes	Program Manager	Energy, Minerals and Natural Resources Dept.
Dwight Lamberson	Utilities Division	NM Public Regulation Commission
Morgan Nelson	Policy Analyst	Environment Department
David Martin	Secretary	Energy, Minerals and Natural Resources Dept.
Arthur Allison	Secretary	Indian Affairs Department

Appendix B.

Review of Federal and State Legislative and Regulatory Initiatives

Federal Initiatives

FERC Order 755: Pay for Performance

On October 20, 2011, FERC issued Order No. 755. The order addresses compensation for frequency regulation in wholesale power markets, with the purpose of ensuring "just and reasonable, and not unduly discriminatory or preferential" frequency regulation rates. The order applies only to secondary frequency response, or regulation, which is a fast-acting service provided by generators and other grid assets to address system energy imbalances. FERC cited evidence showing that regulation markets do not compensate resources providing better regulation service, but based compensation only on capacity bid. As a result, FERC found that existing market rules for compensation were "unjust, unreasonable and unduly discriminatory" to faster acting regulation resources, such as energy storage.[16]

Order 755 requires a two-part payment for frequency regulation service: a capacity payment and a performance payment. The capacity payment must be based on a uniform market-clearing price, while the performance payment must reflect the accuracy of the performance of a device providing frequency response service and must be market based. The final rule requires that all markets with centrally procured frequency regulation resources provide compensation for cross product and inter-temporal opportunity costs. All affected market operators have submitted compliance filings for Order 755, and PJM, MISO, CAISO and NYISO have received FERC approval and recently have begun operations with the new market methodology. Since these markets have only been in place for a limited amount of time, pricing data and an understanding of the impact of the order is limited.

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[16] FERC, 2011, Order No. 755 Final Rule: Frequency Regulation Compensation in the Organized Wholesale Power Markets (20 October).

FERC Order 784: Third Party Provision of Ancillary Services and Financial Reporting for New Electric Storage Technologies

FERC issued Order No. 784 on July 18, 2013, which goes into effect after November 12, 2013. With Order 784, FERC is modifying its regulations with the intent of promoting competition and transparency in ancillary service markets.[17]

Prior to Order 784, the Commission's *Avista* policy effectively restricted public utility transmission providers from procuring ancillary services from third parties to fulfill their *pro-forma* open access transmission tariff (OATT) requirements due to market power concerns. Order 784 reforms this policy, enabling third parties to sell ancillary services.[18] It allows the sale of imbalance service at market-based rates to public utility transmission providers as long as the balancing areas in which these utilities are located have implemented intra-hour scheduling. It also allows the sale of operating reserves in balancing areas that have intra-hour scheduling and allow the delivery of operating reserve across balancing areas. Sales of reactive supply, voltage control, and regulation and frequency response will either be allowed at rates not higher than the purchasing utility's OATT rate for that service or at market rates through competitive procurement meeting requirements of the order. Next, the order requires each public utility transmission provider to add a consideration of speed and accuracy in its calculation of regulation and frequency response service requirements. This allows for utility customers who choose to self-supply the service to have their reserve requirements reflect the capability of the resources they use to self-supply. Additionally, the order requires the utility to post certain area control error (ACE) data on the open access same-time information system (OASIS) to increase transparency in its regulation and frequency response service considerations.

With Order 784, FERC intends to promote transparency, address discrimination and promote competition in ancillary service markets. Public utility transmission providers will be able to procure ancillary services from third parties, potentially reducing the costs of this procurement relative to internal procurement. The utilities and their customers will have to consider speed and accuracy in the determination of regulation and frequency response requirements, opening

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[17] FERC, 2013, Final Rule Order No. 784: Third-Party Provision of Ancillary Services; Accounting and Financial Reporting for New Electric Storage Technologies (18 July).

[18] FERC defines ancillary services as: "those services necessary to support the transmission of electric power from seller to purchaser given the obligations of control areas and transmitting utilities within those control areas to maintain reliable operations of the interconnected transmission system;" FERC, 1995, Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities, Docket RM95-8-000, Washington, DC (29 March).

this market to new, faster performing resources such as energy storage and removing the market access barrier. The final impact will depend on the implementation of these reforms.

FERC Order 784: Financial Reporting for New Electric Storage Technologies

Order 784 also requires utilities to better account for and report transactions related to the use of energy storage resources by revising accounting and reporting procedures under the Commission's Uniform System of Accounts (USofA).[19]

It creates new electric plant accounts specific to energy storage assets in the existing functional classifications of production, transmission and distribution. Asset costs will be allocated across these accounts depending on the function performed by the storage system. Additionally, the order creates a new account for the power purchased during startup and operating of a storage system, creates a new expense account for operation and maintenance expenses, and amends existing schedules under USofA forms to better clarify the accounting and reporting process for energy storage assets.

Specifying new accounts and procedures for energy storage resources should address the complexity involved in their accounting and remove a barrier to their increased deployment. The final impact will depend on the implementation of Order 784 as these reforms go into effect.

FERC Order 719: Wholesale Competition & FERC Order 745: Demand Response Compensation

FERC Order 719, in addition to other requirements, requires that RTOs and ISOs must accept bids from demand response resources for energy and ancillary services. Another requirement is that there be a five-minute calculation of minimum prices for energy and ancillary services, improving the payment mechanism by capturing short-term market variability, something energy storage and demand response are able to reply to more effectively than most thermal generation sources.[20] In Order 745, FERC requires that market operators compensate demand response resources participating in an RTO or ISO energy market at the market price of energy, the LMP (locational marginal price). This requires that the demand response resource be

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[19] FERC, 2013, Final Rule Order No. 784: Third-Party Provision of Ancillary Services; Accounting and Financial Reporting for New Electric Storage Technologies (18 July).
[20] FERC, 2008, Final Rule Order No. 719: Wholesale Competition in Regions with Organized Electricity Markets (17 October).

capable of balancing supply and demand and be cost-effective, as determined by an identified net-benefits test.[21]

While these orders are intended to address issues related to demand response, they are valuable for distributed energy storage resources that act as demand response. These resources include residential or commercial water heaters, ice cooling systems, and customer-sited battery resources. Orders 719 and 745 enable these resources full participation in the wholesale energy and ancillary service markets.

State Initiatives

Colorado

Colorado has a few energy storage projects, including a single pumped hydro system, the Cabin Creek Pumped Hydro Plant with a 359 MW capacity, owned by Xcel Energy. Xcel largely uses this plant time shift, black start, peak capacity and regulation. It is used as part of the resources utilized for ramp management for Xcel's installed wind. Public Service Company of Colorado (PSCo), which is owned by Xcel, built the SolarTAC facility outside of Denver, another storage project with an installed 1MW/1MWh Xtreme Power battery system for photovoltaic support. The funding for this project included deferred rate base approval from the PUC.[22] Xcel also operates a hydrogen storage project in Minnesota and has completed the evaluation of a 1MW/7MWh sodium sulfur battery for wind support.[23]

The Colorado Public Utility Commission has supported energy storage by sponsoring a study to study its potential in Colorado and approving funding for R&D of energy storage through the state's *Innovative Clean Technology Program*. This program helped fund the SolarTAC battery facility.

Colorado does contain a number of potential sites for pumped hydroelectric and compressed air energy storage.[24] These storage projects and studies highlight that the potential exists for further deployment of energy storage technologies in the state. This would require either PSCo or other utilities to evaluate and propose energy storage resources to provide grid services, or

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[21] FERC, 2011, Final Rule Order No. 745: Demand Response Compensation in Organized Wholesale Energy Markets (15 March).

[22] Deferred rate base approval by the PUC indicates that PSCo can claim the resource as part of its rate base of system assets and earn recovery on the resource through retail rates. Rate base recovery provides for recovery of capital and operating costs including a PUC determined rate of return; SolarTAC Information Sheet.

[23] Xcel Smartgrid Projects information sheet.

[24] Colorado School of Mines report (Neumiller 2006) & UCo ESRG; Aitken & DuVivier, 2011.

storage developers to propose projects that are economically competitive in open bidding requests. In 2009, two storage developers bid into PSCo's open bid process for 1,200 MW of generation and capacity, but the PUC did not find them to be competitive with other proposed resources.[25]

Colorado has a general initiative on new power system technologies that includes research staff for emerging issues and a special legislative monetary set aside for new energy resources. This set aside, called *Section 123 Resources,* requires the PUC to provide a complete consideration and possible rate-based financing to alternative technologies without a need to be economically competitive. It enables consideration of these technologies separately from traditional resources. That said, there must still be a compelling reason for their use, primarily that they show a potential future of being economically competitive with other resources.[26] The set aside does not specify specific technologies and the exact amount for each year will be set in the current integrated resource planning process, but it is estimated that it may be in the 120 MW range for this planning process.[27] A solar power tower system has been granted local approvals in Alamosa County and appears to be intending to use the *Section 123* provision.[28]

For the approval of resources outside the *Section 123* set aside, a utility will have to submit a resource plan that includes its entire requested portfolio and supporting analysis to which the commission approves specified resources. The commission then approves specifics of new rate base resources or new services procured through PPA in the second phase of resource planning proceedings, which occurs every four years. It is important to note that the state does not believe that there are any formal barriers that prevent the consideration of the use of energy storage resources. That said, within this resource bidding and approval process, a number of issues seems to exist that may pose a challenge to the further deployment of energy storage resources. PSCo's most recent Electric Resource Plan (ERP), filed with the PUC in 2011, asserts that conventional supply resources should continue to be adequate for mitigating the variability of wind and solar over the next several years. The utility "continues to study the potential value opportunities for energy storage on its electric grid and to monitor developments in energy storage technologies and their costs so that, when appropriate to do so, customers will benefit from energy storage resource additions."[29]

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[25] Utility interview.
[26] From Colorado PUC Decision No. C07-0829 [3], pages 10-11. *See* reference for the specific criteria outlined by the commission for use of Sec 123 resources.
[27] PUC interview.
[28] PUC interview.
[29] RPP Interview in front of CO PUC.

PSCo has evaluated the use of compressed air energy storage (CAES) and found value for its use. However, this value is not sufficient to provide an economic case considering the development of a CAES system. Battery resources have gone through a similar evaluation. These evaluations include a look at these resources being used to provide simultaneous multiple benefits including arbitrage, peak capacity and ancillary services. There is also the possibility for an upgrade on the existing 359 MW Cabin Creek pumped hydro system, further increasing its capabilities to provide services, and reducing the need for any other storage resources.[30] In the present PSCo system, a number of quick start units are not started and the utility has not seen a business case to support the deployment of any new frame-based (larger scale, more efficient) natural gas units.

Texas

Texas is different from other states in that it has a competitive retail market for electricity and its grid operator and manager of wholesale power sales, ERCOT (which serves 85% of the load in Texas) is fully contained in the state and not subject to FERC jurisdiction or regulations.[31] The integration of renewable technologies in ERCOT has grown exponentially in recent years and the market has over 10,000 MW of wind alone.[32] Much of this wind is in West Texas, where transmission constraints have limited the transfer of this energy to populous regions of the state, brought nighttime prices to negative values, and limited the deployment of further wind. The state has classified the region as a special economic zone with $6 billion in funding available for transmission improvements to address the issue. Depending on the variability of the system once transmission is put in place, there is a potential need for ancillary services to smooth the integration of this large amount of wind. Energy storage resources might be a means towards providing fast regulation reserve and other ancillary services, helping ERCOT to meet growing demand and potential capacity shortfalls. Several CAES projects, for example, have been proposed for this purpose.[33]

In 2008, the Public Utility Commission of Texas (PUCT) granted approval to American Electric Power (AEP) to install a Sodium Sulfur (NaS) Battery to defer transmission upgrade costs, and classified the battery as a transmission asset because the battery provides transmission service benefits. Though this case provides a noteworthy example of the role of energy storage and the services it can provide, when issuing its decision, the PUCT stated the case would not be

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[30] Utility interview.
[31] ERCOT, About Us, 2012.
[32] Regulator and utility interviews.
[33] Utility and developer interviews.

considered precedent for other energy storage cases. The PUCT still requires a T&D utility to present an energy storage system for rate-base approval, and currently does not allow an approved device to also participate in the wholesale market.[34]

The Notrees Battery Storage system at the Notrees Texas Wind Farm is a 36 MW/24 MWH battery integrated with the Duke Energy facility. The battery is used to provide primarily regulation up and down services, and analysis will determine the best way to navigate current ERCOT market conditions. The Notrees battery stores energy during non-peak generation hours and provides fast responding energy storage to provide ancillary services. Other battery projects include the Electric Transmission Texas, LLC, 4.8 MW sodium sulfur battery (NaS), which functions as a transmission asset and provides reactive power support.[35] The Bethel Energy Storage center in Tennessee Colony, Texas, plans to install a 317 MW compressed air energy storage facility. The system is expected to offer generation services as approximately 10% to 20% of full generation capacity and will provide ancillary services when ERCOT needs it.

Texas Docket 39917 & State Bill 943

In June of 2011, the Texas legislature signed into law Senate Bill 943, which identifies how energy storage would be regulated in the ERCOT operating market. The bill defines energy storage as "a generation asset that must register as such when used to sell energy or ancillary services in the wholesale market." The bill requires that storage systems receive the same interconnection rights and transmission access as traditional generation sources and storage systems must follow Texas law in regards to selling energy or ancillary services in the wholesale market.[36]

To address SB 943, ERCOT opened Project 39567, which discusses CAES, specifically classifying CAES as a generation asset, allowing it to participate in energy and ancillary service markets.[37] Even with this implementation, operators of energy storage would be required to register as both generation and load assets, an issue that introduces complexity and delays for storage operators.[38] A key issue is to resolve how to treat a storage facility when it is acquiring energy. In the pending Nodal Protocol Revision 340, ERCOT has proposed that an energy storage device

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[34] Presidio NaS final order by the PUCT.
[35] http://interchange.puc.state.tx.us/WebApp/Interchange/Documents/35994_1_592495.PDF
[36] Public Utility Commission of Texas, 2011, PUCT Project 39657 - 39657 - Rulemaking to Implement SB 943, Relating to Electric Energy Storage Equipment or Facilities, available at: http://www.puc.texas.gov/industry/projects/rules/39657/39657.aspx.
[37] PUCT, 2011, Rulemaking to Implement SB 943, Relating to Electric Energy Storage Equipment or Facilities: Order Adopting Amendments to §25.5 and §25.109 as Approved at the November 10, 2011 Open Meeting.
[38] Utility and developer interviews.

can only charge (withdraw energy) and provide regulation service if ERCOT has issued a regulation down control signal. Alternatively, when ERCOT issues a regulation up control signal as the device is charging, the resource operator, or QSE (qualified scheduling entity), must add the amount being charged to its control signal. This effectively would allow an energy storage resource to provide regulation service during charging. Per this protocol revision, an energy storage resource, referred to as a duration limited resource, is not allowed to provide synchronous (spinning) or non-synchronous reserves. The protocol is still under consideration by ERCOT.[39]

In Texas Docket 39917, and the associated ERCOT Nodal Protocol Revision Request 461 (approved December 2012), the Commission determined that energy storage, during both charge and discharge modes, would be considered a wholesale transaction and settled at the node, rather than zonally like load and face retail rates and associated retail transmission and ancillary services charges.[40] Until ERCOT approved this protocol revision, energy storage resources faced a difficult environment in which electricity would have to be purchased at zonal retail rates and sold at lower wholesale nodal rates, creating market distortions in the location and operation of resources.

ERCOT's Emerging Technologies Working Group (ETWG) has identified potential revisions to ERCOT rules to help increase the participation of emerging technologies, such as energy storage, into the market. This work has included exploration of creating a new asset class for energy storage. ERCOT permits pilot projects for energy storage and at times exempts projects from certain ERCOT rules and regulations. Pilot project proposals are presented to the ERCOT governing board who consults with market participants and PUCT staff on their deployment.[41] These pilot projects have enabled ERCOT and facility owners to gain experience working with storage facilities and provide data that could be used in the future to revise ERCOT rules and regulations that limit the entry of energy storage resources.

Arizona

The state of Arizona has made inroads into the deployment of energy storage. A molten salt, concentrating solar thermal project has recently come online in the state with a generating

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[39] ERCOT, 2011, NPRR340: Introduction and Definition of Duration Limited Resources.
[40] PUCT, 2012, Rulemaking on Energy Storage Issues: Order Adopting Amendments to §25.192 and §25.501 as Approved at the March 7, 2012 Open Meeting.

[41]PUCT, 2012, Rulemaking on Energy Storage Issues: Order Adopting Amendments to §25.192 and §25.501 as Approved at the March 7, 2012 Open Meeting. .

capacity of 230 MW and a 6-hour storage duration. The Solana project by developer Abengoa is a private project funded through a 30-year power purchase agreement (PPA) with the major Arizona utility, Arizona Public Service (APS).[42] It qualified for federal renewables investment support and helps the utility meet its state RPS requirements. That said, the state does not have specific incentives or requirements of energy storage. Nonetheless, this project is indicative of the real market that exists for renewable energy storage in the Southwest.

California

California has a number of installed storage resources. Table 3 below identifies those greater than 2 MW in capacity.

Table 3. Listing of large (>2 MW) installed storage resources in California.

System	Type	Capacity (MW)
Castaic Pumped-Storage Plant	Pumped Hydro	1247
Edward Hyatt (Oroville) Power Plant	Pumped Hydro	819
San Luis (William R. Gianelli) Pumped Storage Hydroelectric Powerplant	Pumped Hydro	424
Big Creek (John S. Eastwood) Pumped Storage	Pumped Hydro	199.8
O'Neill Powerplant	Pumped Hydro	25.2
Southern California Edison Tehachapi Wind Energy Storage Project	Lithium Ion Battery	8
Los Angeles Community College District	Ice Thermal	4.6
PG&E Yerba Buena Battery Energy Storage Pilot Project	Sodium Sulfur Battery	4
SCPPA Thermal Energy Storage Program	Ice Thermal	2.4
PG&E Vaca Battery Energy Storage Pilot Project	Sodium Sulfur Battery	2
Disney California Adventure	Chilled Water Thermal	2
Alameda County RDSI CERTS Microgrid Demonstration Santa Rita Jail Smart Grid	Lithium Ferrous Phosphate	2

The State of California has an energy storage initiative underway through its Public Utility Commission (CPUC) rulemaking process. Assembly Bill (AB) 2514 requires the PUC to "determine whether energy storage procurement targets should be established for regulated load serving entities." As part of this proceeding, the commission is interested in "considering whether steps need to be taken to reduce barriers to the deployment of storage." This includes

[42] See: http://www.elp.com/articles/2013/10/abengoa-s-solana-project-tests-solar-energy-storage-system.html.

evaluating the need for procurement policies, developing a cost-effectiveness framework and designating energy storage as a “preferred resource” for new resource procurements.[43]

As of October 2013, the Commission established a 1,325 MW procurement target for energy storage resources (excluding pumped storage hydro) for its IOUs by 2020 with installation to be complete by 2024. This target is separated into targets for generation, transmission and distribution level investment. As it is implemented, this storage target may make a significant impact in addressing barriers to the deployment of energy storage in California and other states by forcing deployment and requiring utilities and other electricity system entities to deal with barriers as they arise. It may also create the manufacturing scale necessary to bring system costs down.

As part of this effort, PUC staff, with the help of stakeholders, identified use cases for energy storage, perceived barriers to energy storage adoption, and possible policy actions to address these barriers. Staff is also working to develop a global cost-effectiveness methodology that can be used as the procurement processes move forward. And staff identified barriers to adoption in California and groups them into nine broad categories.

1. Lack of definitive operational needs for energy storage
2. Lack of a cohesive regulatory framework
3. Evolving markets and market product definitions
4. Resource adequacy accounting not accounting for energy storage
5. Lack of cost-effectiveness evaluation methods
6. Lack of a cost recovery policy
7. Lack of cost transparency and price signals
8. Lack of commercial operating experience
9. Lack of a well-defined interconnection process

Energy storage issues are also under consideration in other proceedings in front of the Commission. These proceedings include the long-term procurement proceeding to address capacity and operating requirements in the face of renewables integration, the resource adequacy proceeding to meet state resource adequacy requirements, the renewable portfolio

[43] Malashenko, E., A. O’Donnell, & A. Gupta, 2013, CPUC Energy Storage Proceeding R.10-12-007: Energy Storage Phase 2 Interim Staff Report.

standard proceeding, the Rule 21 proceeding, and the Electric Program Investment Charge (EPIC) proceedings underway for each of the state's load serving entities.[44]

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[44] Further information on these proceedings is available in Malashenko, E., A. O'Donnell, & A. Gupta, 2013, CPUC Energy Storage Proceeding R.10-12-007: Energy Storage Phase 2 Interim Staff Report,.

Malashenko, E., O'Donnell, A., & Gupta, A. (2013). CPUC Energy Storage Proceeding R.10-12-007: Energy Storage Phase 2 Interim Staff Report. Sacramento, CA: California Public Utilities Commission.

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Appendix C. Energy Storage 101[45]

Electricity energy storage plants provide the ability to move electricity though time by charging up when there is excess power and discharging when the power is needed most. They can be categorized into energy services (MWh) or power services (MW) with an array of applications that include providing power for infrequent peaking generation or as emergency power plant back-ups.[46] A more complete description of the uses and benefits of energy storage plants are described in Table 3. The energy storage industry contains both mature and emerging technologies.[47] Energy storage is useful for utilities as well as customers; however this report emphasizes utility scale projects.

The impact of an energy storage plant on the electric grid is driven by how long it takes to charge an energy storage system, how long the energy is stored, and how long it takes to discharge the system. Other drivers include system programming, software and controls that while now are customized for most installations, plausibly may advance swiftly as experience mounts the energy storage sector. A 2011 cost study report, as part of Sandia National Laboratories' Energy Storage Systems Program, categorizes operational characteristics of available technologies into four categories (Table 4).

[45] Adapted from a working document prepared for Western Resource Advocates by Jeremy Lewis, May 2012.
[46] Kaufman, S., et al., 2011, Storage in Regulated Markets: Getting the Rules Right, *Electricity Journal* 24.6 (July): 63-71.
[47] See http://www.emnrd.state.nm.us/ECMD/RenewableEnergy/RenewableEnergyStorage.html.

Table 3. Uses and Benefits of Energy Storage Plants

Energy Applications *Large amounts of energy discharged at a constant power for up to 10 hours – cycled once or twice per day*	Load following	Large scale energy storage plants can be used for following load on the sub-hour to hour time scale. This would partly replace the need for certain generation facilities to be run at partial capacity to provide load following services.
	Transmission congestion relief	Energy storage plants can be placed downstream from congested transmission areas and used to store energy when transmission is not congested and then discharged during times of congestion. This may also allow utilities to delay costly grid updates.
	Demand side management	Instead of providing interruptible loads, industrial electricity customers can install energy storage that is charged during non-peak times and discharged during peak times in response to a signal from the utility.
	Renewable time-shifting and capacity firming	Certain renewable energy resources, such as wind, often generate the most electricity during non-peak demand times. Energy storage plants can store this energy and reduce the need to cycle base-load generation during these times.
	Energy arbitrage (through time-shifting)	If time-of-use pricing is in place, customers can reduce their energy costs by purchasing and storing energy at low-cost times and using the stored energy instead of buying high-cost, peak electricity.
Power Applications *Large amounts of power discharged for only seconds or minutes –cycled frequently*	Frequency Regulation	Energy storage plants can be used to better respond to rapid fluctuations in demand and help maintain constant frequency output.
	Renewable capacity firming (short time)	Energy storage plants can respond quickly to ramping events (such as cloud cover or a sudden wind gust). This allows renewable facilities to be treated as more predictable generation sources and prevents the need for other facilities to respond to ramping events.

Table 4. Characteristics and Examples of Utility-Scale Energy Storage Technologies[48]

Category/Characteristics	Hours of Storage	Cycles of Use (annually)	Application
Long-duration storage, frequent discharge	4 to 8	250	Load-leveling, source-following, arbitrage
• Compressed Air Energy Storage (CAES) • Pumped hydro • Lead-acid batteries (advanced or with carbon-enhanced electrodes) • Sodium/sulfur (NAs) batteries • Flow batteries • Electricity-to-liquid chemical fuels • Lithium-ion batteries			
Long-duration storage, infrequent discharge	4 to 8	20	Capacity credit
• Lead-acid batteries (advanced or with carbon-enhanced electrodes) • Sodium/sulfur (NAs) batteries • Flow batteries • Electricity-to-liquid chemical fuels • Lithium-ion batteries			
Short-duration storage, frequent discharge	.25 to 1	Up to 10,000	Frequency or area regulation
• Lead-acid batteries (advanced or with carbon-enhanced electrodes) • Flow batteries • Lithium-ion batteries • Flywheels • Supercapacitors			
Short-duration storage, infrequent discharge	.25 to 1	20	Power quality
• Lead-acid batteries (advanced or with carbon-enhanced electrodes) • Flow batteries • Lithium-ion batteries • Flywheels • Supercapacitors			

[48] Schoenung, S., 2011, *Energy Storage Systems Cost Update: A Study for the DOE Energy Storage Systems Program,* Sandia National Laboratories (April).

Appendix D. New Mexico National Laboratory Resources

The Sandia National Laboratories Energy Storage Test Pad (ESTP) provides trusted third-party testing and validation from the cell level to 1-MW AC electrical energy storage systems. The ESTP can test for both power and energy applications and offers a variety of services including energy time-shift, capacity, load-following, area regulation, voltage support, Transmission and Distribution deferral, demand charge management, and power quality and reliability. Along with SNL's Energy Storage Analysis Laboratory (ESAL), which tests from cell to module systems, these facilities provide users a venue for testing and validation of energy storage systems. In addition to providing testing and validation, system performance analysis, and development of new testing procedures, the ESTP and ESAL provide pre-certification, pre-installation, and verification of electrical energy storage systems. These capabilities, supported by SNL's electrochemistry and material sciences experience provide a great depth in fundamental testing at the cell and module level.

Right next to the ESTP is the Distributed Energy Technologies Laboratory (DETL). The DETL has a large portfolio of distributed and renewable generation technologies, including the 160-kW PV array, microturbine, diesel engine, an additional 750 kWh of battery storage, and several types of loads. These resources are interconnected on a 480-V bus to test various microgrid configurations. The ESTP, which can interconnect to the DETL to use the full capabilities of the DETL microgrid, provides the ability to test the storage systems under an even wider range of operating conditions.

Los Alamos already has systems available for renewable energy storage research including a 1.4 GW generator, not hooked to the grid, which is a unique utility-scale power source for exercising grid scale storage. Los Alamos also has a 1MW solar array.

The deployable, fieldable, and extensive instrumentation used for Los Alamos climate research are capabilities second-to-none and applicable to predicting weather and usage patterns that can improve utilization of renewable energy generation and storage.

Appendix E. Glossary of Terms

Ancillary services: Services that assist the grid operator in maintaining system balance, including load regulation, spinning reserve, non-spinning reserve, replacement reserve, and voltage support.

Arbitrage: Purchasing inexpensive electricity when its demand and cost are low and then selling the electricity when demand and price are high.

Balancing area: Area managed by a responsible entity (the balancing authority) that ensures the total of all generation must equal the total of all loads.

Baseload capacity: The generating equipment normally operated to serve loads on an around-the-clock basis.

Concentrating solar power: A solar energy conversion system characterized by the optical concentration of solar rays through an arrangement of mirrors to generate a high temperature working fluid.

Demand response: When electric power customers temporarily reduce their demand for power at certain times in exchange for a reduction in their electricity bills. Some demand response programs allow electric power system operators to directly reduce load, while in others customers retain control.

Demand-side management: A utility action that reduces or curtails end-use equipment or processes. It is often used to reduce customer load during peak demand and/or in times of supply constraint. Demand-side management includes programs that are focused, deep, and immediate such as the brief curtailment of energy-intensive processes used by a utility's most demanding industrial customers, and programs that are broad, shallow, and less immediate such as the promotion of energy-efficient equipment in residential and commercial sectors.

Dispatchable generation: Sources of electricity that can be turned on or off or adjusted for power output by grid operators.

Distributed energy (or distributed generation): A generator that is located close to the load that it is intended to serve.

Electric grid: See “grid”

Electric cooperative utility: An electric utility legally established to be owned by and operated for the benefit of those using its service. The utility company will generate, transmit, and/or distribute supplies of electricity to a specified area not being serviced by another utility. Most electric cooperatives have been initially financed by the Rural Utilities Service (prior Rural Electrification Administration), U.S. Department of Agriculture.

Energy storage: Substance or technology that is capable of absorbing energy, storing it for a period of time, and thereafter dispatching the energy.

Federal Energy Regulatory Commission (FERC): The Federal agency with jurisdiction over interstate electricity sales, wholesale electric rates, hydroelectric licensing, natural gas pricing, oil pipeline rates, and gas pipeline certification. FERC is an independent regulatory agency within the Department of Energy.

Gas turbine peaking plant: Natural gas plant normally reserved for operation during the hours of highest daily, weekly, or seasonal loads.

Gigawatt (GW): One billion watts or 1,000 megawatts.

Gigawatt-hour (GWh): One billion watt-hours or 1,000 megawatt-hours.

Grid: The infrastructure used by utility companies to distribute power to their customers. The grid is generally made up of transmission lines (that cover longer distances at higher voltages) and distribution lines (the local lines that deliver electricity to homes and businesses at lower voltages).

Grid operator: The entity responsible for the reliability of its localized transmission system and that operates or directs the operations of the transmission facilities.

Independent System Operator (ISO): An independent, federally regulated entity established to maintain system balance, reliability, and electricity market operation. There is no ISO covering the majority of New Mexico, though an RTO (the Southwest Power Pool) covers some of the eastern portion of the state.

Investor Owned Utility (IOU): A privately-owned electric utility whose stock is publicly traded. It is rate regulated and authorized to achieve an allowed rate of return. In New Mexico, there are three IOUs: Public Service Company of New Mexico (PNM), Southwestern Public Service (SPS, a division of Xcel), and El Paso Electric (EPE).

Kilowatt (kW): One thousand watts.

Kilowatt-hour (kWh): A measure of electricity defined as a unit of work or energy, measured as 1 kilowatt (1,000 watts) of power expended for 1 hour.

Load: An end-use device or customer that receives power from the electric system.

Load following: Regulation of the power output of electric generators to match the aggregate load within a prescribed area, accounting for energy imports and exports.

Load forecasting: Load forecasts are predictions of future electricity demand. For normal operations, daily and weekly forecasts of the hour-by-hour demand are used to help develop generation schedules to ensure that sufficient quantities and types of generation are available when needed.

Megawatt (MW): One million watts of electricity.

Megawatt-hour (MWh): One thousand kilowatt-hours or 1 million watt-hours.

Nameplate capacity: The maximum rated output of a generator or other electric power production equipment under specific conditions designated by the manufacturer. Installed generator nameplate capacity is commonly expressed in megawatts (MW) and is usually indicated on a nameplate physically attached to the generator.

Off-peak: Period of relatively low system demand. These periods often occur in daily, weekly, and seasonal patterns.

On-peak: Periods of relatively high system demand. These periods often occur in daily, weekly, and seasonal patterns.

Peak demand: The maximum load during a specified period of time. New Mexico's highest peak loads are on hot summer afternoons.

Peaking capacity: Capacity of generating equipment normally reserved for operation during the hours of highest daily, weekly, or seasonal loads. These plants are often combustion turbines with low capital cost and high or very high fuel costs.

Photovoltaic (PV): An electronic device consisting of layers of semiconductor materials that convert sunlight into electricity. A collection of solar cells creates a solar panel.

Power: The rate of producing, transferring, or using energy, most commonly associated with electricity. Power is measured in watts and often expressed in kilowatts (kW) or megawatts (MW).

Production tax credit (PTC): A per-kilowatt-hour tax credit for electricity generated by qualified facilities. In the U.S. there is a production tax credit for wind, geothermal, and biomass energy of $0.023/kWh. New Mexico has a state production tax credit of $0.01/kWh for wind and biomass and a production tax credit that averages $0.027/kWh for solar.

Pumped storage hydroelectric: A plant that usually generates electric energy during peak load periods by using water previously pumped into an elevated storage reservoir during off-peak periods when excess generating capacity is available to do so. When additional generating capacity is needed, the water can be released from the reservoir through a conduit to turbine generators located in a power plant at a lower level.

Rate (electric): The price set for a specified amount and type of electricity by class of service in an electric rate schedule or sales contract.

Rate structure: The terms and conditions governing electric rate application. In New Mexico, the Public Regulation Commission is responsible for determining rates for investor-owned utilities and rural electric cooperatives.

Reasonable cost threshold (RCT): The upper cost limit at which a public utility is not required to add renewable energy to its electric energy supply portfolio to meet the renewable portfolio standard. Beginning in 2013 in New Mexico, the reasonable cost threshold is 3% of a utility's plan year total revenues.

Regional Transmission Organization (RTO): Groups responsible for maintaining system balance, reliability, and electricity market operation on a regional basis. RTOs typically perform the same functions as ISOs, but cover a larger geographic area. Southwestern Power Pool, an RTO, covers part of eastern New Mexico.

Renewable portfolio standard (RPS): Standards specifying that electric utilities deliver a certain amount of electricity from renewable energy sources by a certain date. New Mexico's RPS dictates that IOUs must supply 15% of their electricity from renewable energy by 2015 and 20% by 2020. For rural electric cooperatives, renewable energy must comprise no less than 5% of retail sales to New Mexico customers by 2015 and 10% by 2020.

Rural electric cooperative: see "electric cooperative utility"

Southwest Power Pool (SPP): An RTO that lies within the Eastern Interconnection and serves Kansas and Oklahoma, eastern New Mexico, and portions of Texas, Arkansas, Louisiana, Missouri, Mississippi, and Nebraska.

Spinning reserve: Reserve generating capacity running at a zero load and synchronized to the electric system so that it can come online quickly if and when demand rises.

Stranded wind: Wind energy that does not have transmission capacity to transport it to an electricity market.

Time-of-use: A rate schedule in which the utility customer is charged different amounts for power based on the time of day and season. Typically peak rates are during summer afternoons.

Transmission (electric): An interconnected group of lines and associated equipment for the movement or transfer of electric energy.

Transmission operator: see "Grid operator"

Utility-scale: Large electric generators that feed power into the grid and supply a utility with energy. Though there is no set wattage definition, utility-scale generators are generally considered to be at the multiple megawatt scale.

Watt (w): The unit of electrical power that is the product of current and voltage.

Watt-hour: The electrical energy unit equal to one watt of power supplied or consumed steadily for one hour.

WestConnect: Group of utility companies that provide electricity transmission in the western United States that work collaboratively to assess stakeholder and market needs and develop cost-effective enhancements to the Western wholesale electricity market.

Western Electricity Coordinating Council (WECC): The Regional Entity responsible for coordinating and promoting electricity system reliability in the Western Interconnection.

Western Interconnection: A power grid that stretches from Western Canada south to Baja California in Mexico, reaching eastward over the Rockies to the Great Plains. All of the electric utilities in the Western Interconnection are electrically tied together during normal system conditions and operate at a synchronized frequency.

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