ELECTRIC POWER RESEARCH INSTITUTE

Energy Storage Integration Council (ESIC) Energy Storage Modeling Bibliography

References for Energy Storage in Electric Power Planning, Operations, and Markets

2017 TECHNICAL UPDATE

Energy Storage Integration Council (ESIC) Energy Storage Modeling Bibliography

References for Energy Storage in Electric Power Planning, Operations, and Markets

EPRI Project Manager
E. Minear

ELECTRIC POWER RESEARCH INSTITUTE

3420 Hillview Avenue
Palo Alto, CA 94304-1338
USA

PO Box 10412
Palo Alto, CA 94303-0813
USA

800.313.3774
650.855.2121

askepri@epri.com

www.epri.com

3002009356
Technical Update, December 2017

THE FOLLOWING ORGANIZATION, UNDER CONTRACT TO EPRI, PREPARED THIS REPORT:

Helman Analytics

This is an EPRI Technical Update report. A Technical Update report is intended as an informal report of continuing research, a meeting, or a topical study. It is not a final EPRI technical report.

NOTE

For further information about EPRI, call the EPRI Customer Assistance Center at 800.313.3774 or e-mail askepri@epri.com.

Acknowledgments

The following organization, under contract to the Electric Power Research Institute (EPRI), prepared this report:

Helman Analytics

Principal Investigator
U. Helman

This report describes research sponsored by EPRI.

Several people participated in the development of this bibliography, which was conceived in support of ESIC Working Group 1. Some members of that working group provided input on earlier versions. At EPRI, Ben Kaun reviewed, and Christian Martinez Ventura and Simon Gleeson helped format and organize the document.

On behalf of the IEEE Task Force on Storage Modeling Tools, Ramteen Sioshansi organized a survey of storage papers by task force members. EPRI would like to acknowledge the submissions from Audun Botterud, Kenneth Bruninx, Wesley Cole, Paul Denholm, Yury Dvorkin, Dennice Gayme, Ioannis Konstantelos, Hrvoje Pandžić, Masood Parvania, Aidan Touhy, Bolun Xu, Hamidreza Zareipour, and Ziang (John) Zhang. In addition, other task force members provided input on earlier versions.

This publication is a corporate document that should be cited in the literature in the following manner:

Energy Storage Integration Council (ESIC) Energy Storage Modeling Bibliography: References for Energy Storage in Electric Power Planning, Operations, and Markets.
EPRI, Palo Alto, CA: 2017.
3002009356.

Abstract

This report is a bibliography focused on recent published papers and studies on energy storage modeling in electric power planning, operations, and markets. Section 10 of the bibliography is the set of full references, including web links where available. Sections 2–9 of the bibliography organize shortened references into several categories, including by domain (transmission-connected, distribution-connected, and customer-sited), utility or independent system operator (ISO) function, technology type, geographical location of the study, and mathematical model types. For convenience, every shortened reference is linked internally to the full reference. The bibliography is intended to be updated as the literature continues to evolve and expand. In its current version, the bibliography is focused on stationary storage and primarily of transmission-connected and distribution-connected resources.

Keywords
Energy storage
Planning
Storage modeling
Storage modeling tools
System operations
Wholesale markets

Acronyms

ASME	American Society of Mechanical Engineers
BESS	battery energy storage system
BMS	battery management system
CAES	compressed air energy storage
CAISO	California ISO
CPUC	California Public Utilities Commission
CSP	concentrating solar power
DESS	distributed energy storage system
DOE	Department of Energy
DOER	Department of Energy Resources
DOI	digital object identifier
EAC	Electricity Advisory Committee
EEEIC	Environment and Electrical Engineering International Conference
EIC	Eastern Interconnection
ELCC	effective load carrying capability
EPIC	Electric Program Investment Charge
EPRI	Electric Power Research Institute
ERCOT	Electricity Reliability Council of Texas
ESIC	Energy Storage Integration Council
IEEE	Institute of Electrical and Electronics Engineers
ISO	Independent System Operator
ISO-NE	ISO New England
LLNL	Lawrence Livermore National Laboratory
LOLE	loss of load expectation
MISO	Midcontinent Independent System Operator
NRECA	National Rural Electric Cooperative Association
NREL	National Renewable Energy Laboratory

NYISO	New York ISO
PG&E	Pacific Gas and Electric Company
PHES	pumped hydroelectric energy storage
PJM	Pennsylvania-Jersey-Maryland RTO
PSIP	power supply improvement plan
PV	Photovoltaic
RTO	regional transmission organization
SCE	Southern California Edison
TEP	Tucson Electric Power Company
TES	thermal energy storage
WECC	Western Electricity Coordinating Council

Table of Contents

List of Tables

Section 1: Introduction

This bibliography was developed in support of activities by different organizations and initiatives related to operational, planning and economic analysis of energy storage technologies.[1] Included in the bibliography are research papers and other documents that are focused on the modeling of different storage technologies, either as stand-alone resources or within a larger electric power system. With a few exceptions, the bibliography does not include papers which model utility or regional power systems and include storage resources, but do not evaluate their operation directly. The bibliography is intended to be updated and refined periodically.

The bibliography is organized as follows. The full list of papers, in alphabetical order and including a full citation and web links where available, is found in the last section of the paper (Section 10). Following this introduction, the next eight sections categorize the papers into several topics. In these sections the citations are shortened to reduce space, but can be clicked on to get to the full citation in Section 10. In some subsections, there are tables providing summary information about details in the papers, including models or tools used. The topic sections are as follows:

- Section 2: literature reviews and other surveys,
- Section 3: categorization by point of interconnection (transmission-connected, distribution-connected, customer-sited),
- Section 4: categorization by electric power organizational function (planning/reliability, operations, wholesale markets),
- Section 5: studies which conduct storage modeling for purposes of policy or regulatory development or evaluation (storage mandate, renewable policy goals, low carbon futures),
- Section 6: categorization by storage technology type,
- Section 7: U.S. studies by geographical region and/or organization (utility/ISO/state/national),
- Section 8: non-U.S. studies by geographical region and/or organization, and
- Section 9: modeling structure and software tools.

---

[1] Notably, this includes the Energy Storage Integration Council (ESIC) (www.epri.com/esic), other EPRI activities, including development of the StorageVET™ model (www.storagevet.com), and the IEEE task force on storage modeling tools.

The bibliography focuses on newer types of electrical storage devices which charge from an electric power system, such as batteries and flywheels and compressed air energy storage (CAES), but includes selected references to pumped storage and concentrating solar power with thermal energy storage (CSP-TES). Given its long history, pumped storage has a very long set of references, which have not been compiled extensively. However, the bibliography includes a number of recent papers which utilized advanced modeling tools to analyze pumped storage or which model it alongside other storage technologies. Similarly, papers modeling CSP-TES, which charges from the solar field but provides grid services, may have value to other types of integrated solar with storage.

The bibliography does not include references to other types of energy storage, including non-stationary storage (such as electric vehicles), storage systems for hydrogen or natural gas, and hydro dam storage.

Moreover, while many of the references cited include assumptions about current and future energy storage technology costs, the bibliography did not include a systematic review of such cost forecasts.

In addition to papers in academic journals and some research studies, a few state regulatory orders which are influential in storage valuation have been included, as well as some recent utility integrated resource plans which included significant storage. However, this bibliography does not include a complete list of such documents related to storage.

While many of the papers included here have been reviewed in the course of compiling this survey, others have not. Inclusion in this bibliography does not suggest that either models or results have been validated.

Finally, as noted above, this bibliography is intended to be updated periodically. Readers can suggest additional entries or make corrections to existing entries via communications with ESIC Working Group 1 or other EPRI staff.

Section 2: Literature Reviews and Other Surveys

The following are selected literature reviews and other types of surveys of economic and operational modeling of storage. Some of these papers may survey the policy and market context for storage modeling but not include mathematical models or results. Note that many of the other papers cited in subsequent sections may also have brief literature surveys, but are not intended primarily to be surveys.

Click on short reference to get to full reference and links.

Akhil, A.A., et. al., "DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA," 2015.

Augustine, C. et. al., "Renewable Electricity Futures Study. Volume 2: Renewable Electricity Generation and Storage Technologies." 2012.

Castillo, A., and D. F. Gayme, "Grid-scale energy storage applications in renewable energy integration: A survey," 2014.

Center for Energy and Environment (Minnesota), "The Context for Energy Storage to Facilitate Renewable Electricity in Minnesota," 2016. [*surveys studies of Minnesota and MISO*]

Cole, W., et al., "Optimization and Advanced Control of Thermal Energy Storage Systems." 2012.

Denholm, P., et al., "Energy Storage for Power Grids and Electric Transportation: A Technology Assessment," 2012.

Department of Energy (DOE), Electricity Advisory Committee (EAC), "2016 Storage Plan Assessment: Recommendations for the U.S. Department of Energy," 2016. *[includes recommendations for storage modeling improvements*]

Department of Energy (DOE), Electricity Advisory Committee (EAC), "2014 Storage Plan Assessment." September 2014. *[includes recommendations for storage modeling improvements*]

Ecofys, "Energy Storage Opportunities and Challenges: A West Coast Perspective White Paper." 2014.

Electric Power Research Institute (EPRI), "Energy Storage Valuation in California: Policy, Planning and Market Information Relevant to the StorageVET™ Model." 2016. [*surveys market rules and data for storage modeling*]

European Commission, Directorate-General for Energy, "The future role and challenges of Energy Storage," DG ENER Working Paper, 2013.

Eyer, J., and G. Corey, "Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide," 2010.

Hoffman, M.G., et al., "Analysis Tools for Sizing and Placement of Energy Storage for Grid Applications - A Literature Review," 2010.

Sioshansi, R., et. al., "A Comparative Analysis of the Value of Pure and Hybrid Electricity Storage," 2011.

Xu, B., et al., "A Comparison of Policies on the Participation of Storage in U.S. Frequency Regulation Markets," 2016.

Zakeri, B., and S. Syri. "Electrical energy storage systems: A comparative life cycle cost analysis," 2015.

Zucker, A., et. al., "Assessing Storage Value in Electricity Markets: A literature review," 2013.

Section 3: Categorization by Point of Interconnection

Storage technologies are often analyzed on the basis of where they are connected: to the high-voltage transmission network (also called "the grid"), the distribution network or at a customer-site, typically but not always behind-the-meter. The point of connection will have an impact on the types of eligible services, whether wholesale market services, other grid services, retail rate impacts, islanding or microgrids, or services related to avoided investment in transmission and distribution upgrades.

Transmission-Connected Storage

This subsection includes papers modeling or analyzing storage primarily providing services to the high-voltage transmission system. This is a fairly general category which includes many of the papers cited in this bibliography. Generally, transmission-connected storage can provide wholesale market services, other grid operational and reliability services, and contribute to deferral of transmission investment.

Click on short reference to get to full reference and links.

Akhil, A.A. et. al., "DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA," 2015.

Augustine, C. et. al., "Renewable Electricity Futures Study. Volume 2: Renewable Electricity Generation and Storage Technologies," 2012.

Benini, M., et al., "Battery energy storage systems for the provision of primary and secondary frequency regulation in Italy," 2016.

Benitez, L. E. et. al., "The economics of wind power with energy storage," 2008.

Bhatnagar, D. and Loose, V., "Evaluating Utility Procured Electric Energy Storage Resources: A Perspective for State Electric Utility Regulators," 2012.

Bistline, J., "Economic and Technical Challenges of Flexible Operations under Large-Scale Variable Renewable Deployment," 2017.

Black & Veatch Corporation., "Iowa Stored Energy Plant Economic Feasibility Analysis, Final Report.," 2005.

Bose, S., et al., "Optimal Placement of Energy Storage in the Grid," 2012.

Brown, P. D. et. al., “Optimization of Pumped Storage Capacity in an Isolated Power System With Large Renewable Penetration,” 2008.

Bruninx, K., and E. Delarue, “Improved energy storage system and unit commitment scheduling,” 2017.

Bruninx, K., et al., “Coupling Pumped Hydro Energy Storages with Unit Commitment,” 2016.

Byrne, R.H. and C.A. Silva-Monroy, “Estimating the Maximum Potential Revenue for Grid Connected Electricity Storage: Arbitrage and Regulation,” 2012.

California ISO (CAISO), “Moorpark Sub-Area Local Capacity Alternative Study,” 2017.

California ISO (CAISO), “Benefits Analysis of Large Energy Storage,” 2017.

California Public Utilities Commission (CPUC), " Decision 13-10-040, Decision adopting energy storage procurement framework and design program," 2013.

Carrión, M., et al., “Primary Frequency Response in Capacity Expansion with Energy Storage,” IEEE Transactions on Power Systems, 2017.

Castillo, A. and D.F. Gayme, “Evaluating the Effects of Real Power Losses in Optimal Power Flow Based Storage Integration,” 2017.

Castillo, A., et al., “Lossy DC OPF for Optimizing Congested Grids with Renewable Energy and Storage,” 2014.

Chen. Y., et. al., “Incorporating short-term stored energy resource into Midwest ISO energy and ancillary service market,” 2011.

Cho, K.T. et. al., “Optimization and Analysis of High-Power Hydrogen/Bromine-Flow Batteries for Grid-Scale Energy Storage,” 2013.
Connolly, D. et. al., “Practical Operation Strategies for Pumped Hydroelectric Energy Storage (PHES) Utilizing Electricity Price Arbitrage.” 2011.

Cole, W., et al., “SunShot 2030 for Photovoltaics (PV): Envisioning a Low-Cost PV Future.” 2017.

Cole, W., et al., “2017 Standard Scenarios Report: A U.S. Electricity Sector Outlook.” 2017.

Cole, W., et al., “Utility-Scale Lithium-Ion Storage Cost Projections for Use in Capacity Expansion Models,” 2016.

Culver , W.J., “High-Value Energy Storage for the Grid: A Multi-Dimensional Look,” 2010.

Click on short reference to get to full reference and links.

de Sisternes, F., et al., "The contribution of energy storage to climate change mitigation in the electricity sector," 2016.

Denholm, P., and T. Mai,"Timescales of Energy Storage Needed for Reducing Renewable Energy Curtailment" 2017.

Denholm, P., et al., "Evaluating the Technical and Economic Performance of PV Plus Storage Power Plants" 2017.

Denholm, P., and R. Margolis "Energy Storage Requirements for Achieving 50% Solar Photovoltaic Energy Penetration in California" 2016.

Denholm, P., et al., "The Relative Economic Merits of Storage and Combustion Turbines for Meeting Peak Capacity Requirements under Increased Penetration of Solar Photovoltaics" 2015.

Denholm, P., et. al., "Value of CSP with Thermal Energy Storage in the Western United States." 2014.

Denholm, P. et. al., "Analysis of Concentrating Solar Power with Thermal Energy Storage in a California 33% Renewable Scenario," 2013.

Denholm, P. et. al., "Value of Energy Storage for Grid Applications," 2013.

Denholm, P., et. al., "Impact of Wind and Solar on the Value of Energy Storage," 2013.

Denholm, P., and M. Hummon,. "Simulating the Value of Concentrating Solar Power with Thermal Energy Storage in a Production Cost Model." 2012.

Denholm, P. et. al., "Energy Storage for Power Grids and Electric Transportation: A Technology Assessment," 2012.

Denholm, P., "Energy Storage to Reduce Renewable Energy Curtailment," 2012.

Denholm, P., and S. Ong, "Thermal Energy Storage as an Enabling Technology for Renewable Energy". 2012.

Denholm, P., et. al., "Decarbonizing the Electric Sector: Combining Renewable and Nuclear Energy using Thermal Storage," 2012.

Denholm, P., and M. Mehos, "Enabling Greater Penetration of Solar Power via the Use of Thermal Energy Storage" 2011.

Denholm, P., and M. Hand, "Grid Flexibility and Storage Required to Achieve Very High Penetration of Variable Renewable Electricity," 2011.

Denholm, P., "Enabling Technologies for High Penetration of Wind and Solar Energy," 2011.

Denholm, P. et. al., “Role of Energy Storage with Renewable Electricity Generation,” 2010.

Denholm, P., and R. Sioshansi, “The value of compressed air energy storage with wind in transmission-constrained electric power systems,” 2009.

Denholm, P., and R.M. Margolis, “Evaluating the Limits of Solar Photovoltaics (PV) in Electric Power Systems Utilizing Energy Storage and Other Enabling Technologies.” 2007.

Department of Energy (DOE), “Hydropower Vision: A New Chapter for America’s 1st Renewable Electricity Source.” 2016. [*Includes pumped storage*]

Ding, H. et. al., “Stochastic Optimization of the Daily Operation of Wind Farm and Pumped-Hydro- Storage Plant.” 2012.

DNV-GL, "Energy Storage Cost-effectiveness Methodology and Results," 2013.

Drury, E., et al., “Value of Compressed Air Energy Storage in Energy and Reserve Markets,” 2011.

Dvorkin, Y., et al., “Ensuring Profitability of Energy Storage,” 2017.

Dvorkin, Y., et al., “Co-planning of Investments in Transmission and Merchant Energy Storage,” 2017.

Dvorkin, Y., “Can Merchant Demand Response Affect Investments in Merchant Energy Storage?” 2017.

Eichman, J. et. al., “Operational Benefits of Meeting California’s Energy Storage Targets,” 2015.

Ela, E. et. al., “Role of Pumped Storage Hydro Resources in Electricity Markets and System Operation,” 2013.

Electric Power Research Institute (EPRI), “Energy Storage Valuation in California: Policy, Planning and Market Information Relevant to the StorageVET™ Model,” 2016.

Electric Power Research Institute (EPRI), “Cost-Effectiveness of Energy Storage in California: Application of the Energy Storage Valuation Tool to Inform the California Public Utility Commission Proceeding,” 2013.

Electric Power Research Institute (EPRI), “Quantifying the Value of Hydropower in the Electric Grid: Final Report, 2013.

Exarchakos, L. et. al., Modelling electricity storage systems management under the influence of demand-side management programmes,” 2009.

Click on short reference to get to full reference and links.

Eyer, J. and Corey, G., “Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide,” 2010.

Fattori, F., et al., “High Solar Photovoltaic Penetration in the Absence of Substantial Wind Capacity: Storage Requirements and Effects on Capacity Adequacy,” 2017.

Feldman, D., et al., “Exploring the Potential Competitiveness of Utility-Scale Photovoltaics plus Batteries with Concentrating Solar Power, 2015-2030,” 2016.

Fernandez-Blanco, R., et al., “Optimal Energy Storage Siting and Sizing: A WECC Case Study,” 2017.

Fertig, E., and Apt, J. “Economics of compressed air energy storage to integrate wind power: A case study in ERCOT,” 2011.

Figueiredo, F.C. et. al., “The Economics of Energy Storage in 14 Deregulated Power Markets.” 2006.

Garcia-Gonzalez, J. et. al., “Stochastic Joint Optimization of Wind Generation and Pumped-Storage Units in an Electricity Market,” 2008.

Gayme, D. F., and U. Topcu, “Optimal Power Flow with Large-Scale Energy Storage Integration,” 2013.

Gayme, D. F., and U. Topcu, “Optimal Power Flow with Distributed Energy Storage Dynamics,” 2011.

Gevorgian, V. and Corbus, D. “Ramping Performance Analysis of the Kahuku Wind-Energy Battery Storage System,” 2013.

Graves, F. et. al., “Opportunities for electricity storage in deregulating markets,” 1999.

Hale, E., et al., “Capturing the Impact of Storage and Other Flexible Technologies on Electric System Planning,” 2016.

Hawaiian Electric Companies, PSIP Update Report: December 2016, 2016.

Hennessy, T. and Kuntz, M., "The multiple benefits of integrating electricity storage with wind energy," 2005

Hessami, M. A., and Bowly, D. R., “Economic feasibility and optimisation of an energy storage system for Portland Wind Farm (Victoria, Australia),” 2011.

Hoffman, M.G., et al., “Analysis Tools for Sizing and Placement of Energy Storage for Grid Applications - A Literature Review,” 2010.

Jorgenson, J. et. al., “Estimating the Value of Utility-Scale Solar Technologies in California Under a 40% Renewable Portfolio Standard,” 2014.

Kanakasabapathy, P. and Shanti Swarup, K. “Bidding Strategy for Pumped-Storage Plant in Pool-Based Electricity Market,” 2010.

Kazemi, M., et al., “Operation Scheduling of Battery Storage Systems in Joint Energy and Ancillary Services Markets,” 2017.

Kazemi M., and H. Zareipour, “Long-term Scheduling of Battery Storage Systems in Energy and Regulation Markets Considering Battery’s Lifespan,” 2017.

Keles, D. et. al., “Compressed-air energy storage power plant investments under uncertain electricity prices: an evaluation of compressed-air energy storage plants in liberalized energy markets,” 2012.

Kintner-Meyer, M., et al., “National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase II: WECC, ERCOT, EIC, Volume 1: Technical Analysis,” 2013.

Kintner-Meyer, M.C.W., et al., “National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase 1, WECC,” 2012.

Kirby, B. et. al., “Modeling and Analysis of Advanced Pumped Storage Hydro Plants,” (forthcoming).

Kirby, B., “Energy Storage Management for VG Integration,” 2013.

Kirby, B., “Co-Optimizing Energy and Ancillary Services from Energy Limited Hydro and Pumped Storage Plants,” 2012.

Kirsch, L.D., “Compensating Electrical Storage Resources,” 2011.

Konstantelos, I., and G. Strbac, “Valuation of Flexible Investment Options under Uncertainty,” 2015.

Konstantelos, I., et al., “Contribution of Energy Storage and Demand Response to Security of Distribution Networks,” 2017.

Koritarov, V., et al., “Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the United States,” 2014.

Koritarov, V. et. al., "Modeling and Simulation of Advanced Pumped - Storage Hydropower Technologies and their Contributions to the Power System," 2013.

Korpaas, M., et. al., “Operation and sizing of energy storage for wind power plants in a market system,” 2003.

Krad, I. et. al. “Quantifying the Operational Benefits of Conventional and Advanced Pumped Storage Hydro on Reliability and Efficiency,” 2014.

Click on short reference to get to full reference and links.

Krishnamurthy D., et al., “Energy Storage Arbitrage Under Day-Ahead and Real-Time Price Uncertainty,” 2017.

Kumaraswamy, K. and J. Cotrone., “Evaluating the Regulation Market Maturity for Energy Storage Devices,” 2013.

Lawder, M. T. et. al., “Battery Energy Storage System (BESS) and Battery Management System (BMS) for Grid-Scale Applications,” 2014.

Li, N., et al., “Flexible Operation of Batteries in Power System Scheduling with Renewable Energy,” 2016.

Liu, Y., et al., “Multistage Stochastic Investment Planning with Multiscale Representation of Uncertainties and Decisions,” forthcoming.

Loisel, R., “Power system flexibility with electricity storage technologies: A technical–economic assessment of a large-scale storage facility,” 2012.

Loisel, R. et. al., “Valuation framework for large scale electricity storage in a case with wind curtailment,” 2010.

Luburić, Z., et al., “Assessment of N-1 criteria using energy storage,” 2017.

Lund, H., “Optimal operation strategies of compressed air energy storage (CAES) on electricity spot markets with fluctuating prices,” 2009.

Madaeni, S. H., et al., “Estimating the Capacity Value of Concentrating Solar Power Plants with Thermal Energy Storage: A Case Study of the Southwestern United States,” 2013.

Madaeni, S. H., et al., “How Thermal Energy Storage Enhances the Economic Viability of Concentrating Solar Power,” 2012.

Marano, V. et. al., “Application of dynamic programming to the optimal management of a hybrid power plant with wind turbines, photovoltaic panels and compressed air energy storage,” 2012.

Mauch, B. et. al., “Can a wind farm with CAES survive in the day-ahead market?,” 2012.

Mills, A., and R. Wiser, "Strategies for Mitigating the Reduction in Economic Value of Variable Generation with Increasing Penetration Levels,” 2014.

Mokrian, P., and S. Moff. “A stochastic programming framework for the valuation of electricity storage,” 2006.

Muche, T., “A real option-based simulation model to evaluate investments in pump storage plants,” 2009.

Nasrolahpour, E., et al., “A bilevel model for participation of a storage system in energy and reserve markets,” 2017.

Nasrolahpour, E., et al., “Impacts of ramping inflexibility of conventional generators on strategic operation of energy storage facilities,” 2016.

Nasrolahpour, E., et al., “Bidding strategy for an energy storage facility,” 2016.

Nasrolahpour, E., et al., “Strategic sizing of energy storage facilities in electricity markets,” 2016.

Oh, H. S. “Optimal Planning to Include Storage Devices in Power Systems,” 2011.

Oikonomou, K., et al., “Energy Storage in the Western Interconnection: Current Adoption, Trends and Modeling Challenges,” 2017.

Pandzic, H., et al., “Near-Optimal Method for Siting and Sizing of Distributed Storage in a Transmission Network,” 2015.

Parvania, M. et. al., “Comparative Hourly Scheduling of Centralized and Distributed Storage in Day-Ahead Markets,” 2014

Peterson, S.B. et. al., “The Economics of Using PHEV Battery Packs for Grid Storage.” 2010.

Qiu, T., et al., “Stochastic Multi-Stage Co-Planning of Transmission Expansion and Energy Storage,” 2017.

Rajat, D. “Operating Hydroelectric Plants and Pumped Storage Units in a Competitive Environment.” 2000.

Rastler, D. “MISO Energy Storage Study Phase 1 Report.” 2011.

Rittershausen, J., and McDonagh, M., “Moving Energy Storage from Concept to Reality: Southern California Edison’s Approach to Evaluating Energy Storage,” 2010.

Rugoloa, J. and M. J. Aziz., “Electricity storage for intermittent renewable sources,” 2012.

Sakti A., et al., “Enhanced representations of lithium-ion batteries in power systems models and their effect on the valuation of energy arbitrage applications,” 2017.

Salgi, G. and H. Lund., “System behaviour of compressed-air energy-storage in Denmark with a high penetration of renewable energy sources,” 2008.

Schill, W.P. and Kemfert, “Modeling strategic electricity storage: The Case of Pumped Hydro Storage in Germany,” 2011.

Click on short reference to get to full reference and links.

Shafiee, S., et al., “Developing Bidding and Offering Curves of a Price-maker Energy Storage Facility Based on Robust Optimization,” in press.

Shafiee, S., et al., “Risk-Constrained Bidding and Offering Strategy for a Merchant Compressed Air Energy Storage Plant,” 2017.

Shafiee, S., et al., “Economic Assessment of a Price-Maker Energy Storage Facility in the Alberta Electricity Market,” 2016.

Shafiee, S., et al., “Considering Thermodynamic Characteristics of a CAES Facility in Self-scheduling in Energy and Reserve Markets,” 2017.

Shahmohammadi, A., et al., “Market Equilibria and Interactions Between Strategic Generation, Wind, and Storage.” 2017.

Shayesteh, E., et al., “System Reduction Techniques for Storage Allocation in larger Power Systems,” 2018.

Sioshansi, R. et. al., “Dynamic Programming Approach to Estimate the Capacity Value of Energy Storage.,” 2014.

Sioshansi, R., "Increasing the Value of Wind with Energy Storage," 2011.

Sioshansi, R., et. al., "A Comparative Analysis of the Value of Pure and Hybrid Electricity Storage," 2011.

Sioshansi, R., et. al., “Dynamic Programming Approach to Estimate the Capacity Value of Energy Storage. IEEE Transactions on Power Systems,” 2014.

Sioshansi, R., and P. Denholm, “Benefits of Colocating Concentrating Solar Power and Wind,” 2013.

Sioshansi, R., and P. Denholm, “The Value of Concentrating Solar Power and Thermal Energy Storage,” 2010.

Sioshansi, R., “Emissions Impacts of Wind and Energy Storage in a Market Environment,” 2011.

Sioshansi, R., et. al., "A Comparative Analysis of the Value of Pure and Hybrid Electricity Storage," 2011.

Sioshansi, R. "Welfare Impacts of Electricity Storage and the Implications of Ownership Structure," 2010.

Sioshansi, R. et. al., “Estimating the Value of Electricity Storage in PJM: Arbitrage and Some Welfare Effects.” 2009.

Sjödin, A. E., et al., “Risk-mitigated Optimal Power Flow for Wind Powered Grids,” 2012.

Strbac, G., et al., “Opportunities for Energy Storage: Assessing Whole-System Economic Benefits of Energy Storage in Future Electricity Systems,” 2017.

Swider, D. J., “Compressed Air Energy Storage in an Electricity System With Significant Wind Power Generation,” 2007.

Sun, Q. et. al., “Fundamental Value of Information and Strategy in Stochastic Management of Distributed Energy Storage,” 2012.

Tuohy, A., and M. O’Malley, “Impact of Pumped Storage on Power Systems with Increasing Wind Penetration,” 2009.

Tuohy, A., and M. O’Malley, “Pumped storage in systems with very high wind penetration,” 2011.

Walawalkar, R. et. al., “Economics of Electric Energy Storage for Energy Arbitrage and Regulation in New York.” 2007.

Wang, Y., et al., “Look-Ahead Bidding Strategy for Energy Storage,” 2017.

Wang Y., et al., “Stochastic coordinated operation of wind-battery energy storage system considering battery degradation,” 2016.

Wankmüller F., et al., “Impact of Battery Degradation on Energy Arbitrage Revenue of Grid-level Energy Storage,” 2017.

Ward, M., " Resource Commitment and Dispatch in the PJM Wholesale Electricity Market," 2011.

Wilson, D. and L. Hughes., “Barriers to the Development of Electrical Energy Storage: A North American Perspective,” 2014.

Wogrin, S. and D.F. Gayme, “Optimizing Storage Siting, Sizing and Technology Portfolios in Transmission-Constrained Networks,” 2015.

Xu, B., et al., “Scalable Planning for Energy Storage in Energy and Reserve Markets,” 2017.

Xu, B., et al., “A Comparison of Policies on the Participation of Storage in U.S. Frequency Regulation Markets,” 2016.

Zamani-Dehkordi, P., et al., “Price impact assessment for large-scale merchant energy storage facilities,” 2017.

Zhang, N. et. al., “Planning Pumped Storage Capacity for Wind Power Integration,” 2013.

Distribution-Connected Storage

This subsection includes papers modeling or analyzing storage primarily providing services to the distribution system, as well as possibly to the transmission system. Generally, distribution-connected storage can, if eligible, provide wholesale market services, other grid operational and reliability services, distribution services, and contribute to deferral of distribution investment as well as distribution operations.

Click on short reference to get to full reference and links.

Augustine, C. et. al., "Renewable Electricity Futures Study. Volume 2: Renewable Electricity Generation and Storage Technologies." 2012.

Celli G., et al., "Optimal Integration of Energy Storage in Distribution Networks," 2009.

Chang, J. et al., "The Value of Distributed Electricity Storage in Texas: Proposed Policy for Enabling Grid-Integrated Storage Investments," 2015.

Chitsaz, H., et al., "Electricity price forecasting for operational scheduling of behind-the-meter storage systems," 2017.

DNV-GL., "Energy Storage Cost-effectiveness Methodology and Results," 2013.

Electric Power Research Institute (EPRI), "Energy Storage Valuation in California: Policy, Planning and Market Information Relevant to the StorageVET™ Model," 2016.

Electric Power Research Institute (EPRI), "Cost-Effectiveness of Energy Storage in California," 2013.

Eyer J., "Electric Utility Transmission and Distribution Upgrade Deferral Benefits from Modular Electricity Storage," 2010.

Eurelectric, "Decentralised Storage: Impact on future distribution grids," 2012.

Falugi, P., et al., "Application of Novel Nested Decomposition Techniques to Long-term Planning Problems," 2016.

Fatouros, P., et al., "Stochastic Dual Dynamic Programming for Operation of DER Aggregators under Multidimensional Uncertainty," in press.

Gauthier D. et. al., "Energy Storage Systems In Distribution Grids: New Assets To Upgrade Distribution Networks Abilities," 2009.

Giannelos, S., et al., "A new class of planning models for option valuation of storage technologies under decision-dependent innovation uncertainty," 2017.

Keane, A. et. al., "State-of-the-Art Techniques and Challenges Ahead for Distributed Generation Planning and Optimization," 2012.

Konstantelos, I., et al., “Contribution of Energy Storage and Demand Response to Security of Distribution Networks,” 2017.

Maitra, A. et. al., “Evaluation of Energy Storage In Distribution System,” 2014

National Alliance for Advanced Technology Batteries (NAATBatt) –DNV GL, “Distributed Energy Storage Roadmap: Final Report,” 2014.

Nourai A., “Installation of the First Distributed Energy Storage System (DESS) at American Electric Power (AEP),” 2007.

Palone, F., et al., “Commissioning and testing of the first Lithium-Titanate BESS for the Italian transmission grid,” 2015.

Strbac, G., et al., “Opportunities for Energy Storage: Assessing Whole-System Economic Benefits of Energy Storage in Future Electricity Systems,” 2017.

Wolfe, S., and A. Mensah., “Overcoming Challenges to High Penetration of Solar PV: Using Optimized Energy Storage and Distribution Grid Controls,” 2012.

Wu, D., et al.. “Assessment of Energy Storage Alternatives in the Puget Sound Energy System, Volume 2: Energy Storage Evaluation Tool,” 2013.

Xi, X., and R. Sioshansi, "A Dynamic Programming Model of Energy Storage and Transformer Deployments to Relieve Distribution Constraints," 2016.

Xi, X., et. al., "A Stochastic Dynamic Programming Model for Co-optimization of Distributed Energy Storage," 2014.

Customer-Side Storage

This subsection includes papers modeling or analyzing storage primarily providing services to retail customers through behind-the-meter or on-site in-front-of-the-meter installations. Generally, customer-sited resources offer avoided retail rates, when those are differentiated by time-of-day or demand level, in addition to back-up power, and integration of customer-sited PV depending on financial incentives and rate structures (e.g., net energy metering).

Alam, M.J.E., et al., “Mitigation of Rooftop Solar PV Impacts and Evening Peak Support by Managing Available Capacity of Distributed Energy Storage Systems,” 2013.

Chitsaz, H., et al., “Electricity price forecasting for operational scheduling of behind-the-meter storage systems,” 2017.

Electric Power Research Institute (EPRI), “Energy Storage Valuation in California: Policy, Planning and Market Information Relevant to the StorageVET™ Model,” 2016.

Click on short reference to get to full reference and links.

Fatouros, P., et al., “Stochastic Dual Dynamic Programming for Operation of DER Aggregators under Multidimensional Uncertainty,” in press.

Leadbetter, J., and L. Swan. “Battery Storage System for Residential Electricity Peak Demand Shaving,” 2012.

Neubauer, J, and M. Simpson, “Deployment of Behind-The-Meter Energy Storage for Demand Charge Reduction.” 2015.

Pacific Gas and Electric Company (PG&E), "EPIC Final Report - EPIC Project 1.01, Energy Storage End Uses: Energy Storage for Market Operations,” 2016.

Tuohy, A., et al., “Storage and demand-side options for integrating wind power,” 2014.

Wu, D., et al., “Analytical Sizing Methods for behind-the-meter Battery Storage.” 2017.

Xi, X., and R. Sioshansi, "A Dynamic Programming Model of Energy Storage and Transformer Deployments to Relieve Distribution Constraints," 2016.

Xi, X., et. al., "A Stochastic Dynamic Programming Model for Co-optimization of Distributed Energy Storage," 2014.

Xu, Y., et al., “Optimal scheduling and operation of load aggregator with electric energy storage in power markets,” 2010.

Islands or Microgrids[2]

Chitsaz, H., et al., “Electricity price forecasting for operational scheduling of behind-the-meter storage systems,” 2017.

Delille, G., et. al., “Dynamic Frequency Control Support by energy storage to reduce the impact of Wind and Solar generation on isolated power systems,” 2012.

Dragicevic, T., et al., “Capacity Optimization of Renewable Energy Sources and Battery Storage in an Autonomous Telecommunication Facility,” 2014.

Fatouros, P., et al., “Stochastic Dual Dynamic Programming for Operation of DER Aggregators under Multidimensional Uncertainty,” in press.

Kaldellis, J., et al., “Optimum sizing of photovoltaic-energy storage systems for autonomous small islands,” 2009.

[2] Note that this bibliography is not intended to review the extensive remote location or microgrid literature; however, a few references are offered here which may overlap with other bibliography topics.

Kapsali, M., et al., “Wind powered pumped-hydro storage systems for remote islands: A complete sensitivity analysis based on economic perspectives,” 2012.

Pacific Gas and Electric Company (PG&E), "EPIC Final Report - EPIC Project 1.01, Energy Storage End Uses: Energy Storage for Market Operations," 2016.

Sioshansi, R., “Emissions Impacts of Wind and Energy Storage in a Market Environment,” 2011.

Sioshansi, R., "Increasing the Value of Wind with Energy Storage," 2011.

Xi, X., and R. Sioshansi, "A Dynamic Programming Model of Energy Storage and Transformer Deployments to Relieve Distribution Constraints," 2016.

Xi, X., et. al., "A Stochastic Dynamic Programming Model for Co-optimization of Distributed Energy Storage," 2014.

Section 4: Categorization by Utility/System Operator Function

This section organizes studies by the type of functional role which they may plan in the areas of (1) resource and transmission planning and long-term reliability, (2) system operations (particularly renewable integration), and (3) operations and valuation within wholesale markets.

Click on short reference to get to full reference and links.

Planning and Reliability

Arizona Public Service (APS), 2017 Integrated Resource Plan, 2017.

Bistline, J., "Economic and Technical Challenges of Flexible Operations under Large-Scale Variable Renewable Deployment," 2017.

Bose, S., et al., "Optimal Placement of Energy Storage in the Grid," 2012.

California ISO (CAISO), "Moorpark Sub-Area Local Capacity Alternative Study," 2017.

California ISO (CAISO), "Benefits Analysis of Large Energy Storage," 2017.

Castillo, A., and D.F. Gayme, "Evaluating the Effects of Real Power Losses in Optimal Power Flow Based Storage Integration," 2017.

Carrión, M., et al., "Primary Frequency Response in Capacity Expansion with Energy Storage," IEEE Transactions on Power Systems, 2017.

Cole, W., et al., "SunShot 2030 for Photovoltaics (PV): Envisioning a Low-Cost PV Future." 2017. [*includes section on integrated storage*]

Cole, W., et al., "2017 Standard Scenarios Report: A U.S. Electricity Sector Outlook." 2017.

Cole, W., et al., "Utility-Scale Lithium-Ion Storage Cost Projections for Use in Capacity Expansion Models," 2016.

de Sisternes, F., et al., "The contribution of energy storage to climate change mitigation in the electricity sector," 2016.

Denholm, P., and T. Mai, "Timescales of Energy Storage Needed for Reducing Renewable Energy Curtailment," 2017.

Denholm, P., et al., "The Relative Economic Merits of Storage and Combustion Turbines for Meeting Peak Capacity Requirements under Increased Penetration of Solar Photovoltaics" 2015.

Dragicevic, T., et al., "Capacity Optimization of Renewable Energy Sources and Battery Storage in an Autonomous Telecommunication Facility," 2014.

Dvorkin, Y., et al., "Ensuring Profitability of Energy Storage," 2017.

Dvorkin, Y., et al., "Co-planning of Investments in Transmission and Merchant Energy Storage," 2017.

Dvorkin, Y., "Can Merchant Demand Response Affect Investments in Merchant Energy Storage?" 2017.

Falugi, P., et al., "Application of Novel Nested Decomposition Techniques to Long-term Planning Problems," 2016.

Fernandez-Blanco, R., et al., "Optimal Energy Storage Siting and Sizing: A WECC Case Study," 2017.

Giannelos, S., et al., "A new class of planning models for option valuation of storage technologies under decision-dependent innovation uncertainty," 2017.

Hale, E., et al., "Capturing the Impact of Storage and Other Flexible Technologies on Electric System Planning," 2016.

Hawaiian Electric Companies, "PSIP Update Report: December 2016," Vol. 1-4, 2016.

Oh, H. S., "Optimal Planning to Include Storage Devices in Power Systems. IEEE Transactions on Power Systems," 2011.

Kintner-Meyer, M., et al., "National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase II: WECC, ERCOT, EIC, Volume 1: Technical Analysis," 2013.

Kintner-Meyer, M.C.W., et al., "National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase 1, WECC," 2012.

Konstantelos, I., and G. Strbac, "Valuation of Flexible Investment Options under Uncertainty," 2015.

Click on short reference to get to full reference and links.

Konstantelos, I., et al., “Contribution of Energy Storage and Demand Response to Security of Distribution Networks,” 2017.

Koritarov, V., et al., “Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the United States,” 2014.

Keane, A. et. al., “State-of-the-Art Techniques and Challenges Ahead for Distributed Generation Planning and Optimization,” 2012.

Liu, Y., et al., “Multistage Stochastic Investment Planning with Multiscale Representation of Uncertainties and Decisions,” forthcoming.

Luburić, Z., et al., “Assessment of N-1 criteria using energy storage,” 2017.

Madaeni, S. H., et al., “Estimating the Capacity Value of Concentrating Solar Power Plants with Thermal Energy Storage: A Case Study of the Southwestern United States,” 2013.

Mills, A. and R. Wiser., "Strategies for Mitigating the Reduction in Economic Value of Variable Generation with Increasing Penetration Levels," 2014.

Nasrolahpour, E., et al., “A bilevel model for participation of a storage system in energy and reserve markets,” 2017.

Nasrolahpour, E., et al., “Impacts of ramping inflexibility of conventional generators on strategic operation of energy storage facilities,” 2016.

Nasrolahpour, E., et al., “Bidding strategy for an energy storage facility,” 2016.

Nasrolahpour, E., et al., “Strategic sizing of energy storage facilities in electricity markets,” 2016.

Pandzic, H., et al., “Near-Optimal Method for Siting and Sizing of Distributed Storage in a Transmission Network,” 2015.

Qiu, T., et al., “Stochastic Multi-Stage Co-Planning of Transmission Expansion and Energy Storage,” 2017.

Sioshansi, R., et. al., “Dynamic Programming Approach to Estimate the Capacity Value of Energy Storage,” 2014.

Sjödin, A. E., et al., “Risk-mitigated Optimal Power Flow for Wind Powered Grids,” 2012.

Strbac, G., et al., “Opportunities for Energy Storage: Assessing Whole-System Economic Benefits of Energy Storage in Future Electricity Systems,” 2017.

Wogrin, S. and D.F. Gayme, “Optimizing Storage Siting, Sizing and Technology Portfolios in Transmission-Constrained Networks,” 2015.

Wu, D., et al.. “Assessment of Energy Storage Alternatives in the Puget Sound Energy System, Volume 2: Energy Storage Evaluation Tool,” 2013.

Xu, B., et al., “Scalable Planning for Energy Storage in Energy and Reserve Markets,” 2017.

Xu, B., et al., “A Comparison of Policies on the Participation of Storage in U.S. Frequency Regulation Markets,” 2016.

Zhang, N. et. al., “Planning Pumped Storage Capacity for Wind Power Integration,” 2013.

System Operations (particularly Renewable Integration)

Beaudin, M. et. al., “Energy storage for mitigating the variability of renewable electricity sources : An updated review,” 2010.

Benini, M., et al., “Battery energy storage systems for the provision of primary and secondary frequency regulation in Italy,” 2016.

Benitez, L. E. et. al., “The economics of wind power with energy storage,” 2008.

Bistline, J., “Economic and Technical Challenges of Flexible Operations under Large-Scale Variable Renewable Deployment,” 2017.

Bruninx, K., and E. Delarue, “Improved energy storage system and unit commitment scheduling,” 2017.

Bruninx, K., et al., “Coupling Pumped Hydro Energy Storages with Unit Commitment,” 2016.

California ISO (CAISO), “Benefits Analysis of Large Energy Storage,” 2017.

Connolly, D. et. al., “The technical and economic implications of integrating fluctuating renewable energy using energy storage,” 2012.

Denholm, P., and T. Mai,“Timescales of Energy Storage Needed for Reducing Renewable Energy Curtailment” 2017.

Denholm, P., and R. Margolis “Energy Storage Requirements for Achieving 50% Solar Photovoltaic Energy Penetration in California” 2016.

Denholm, P., et al., “The Relative Economic Merits of Storage and Combustion Turbines for Meeting Peak Capacity Requirements under Increased Penetration of Solar Photovoltaics” 2015.

Denholm, P., et. al., “Impact of Wind and Solar on the Value of Energy Storage,” 2013.

Denholm, P., et. al., “The Value of Energy Storage for Grid Applications,” 2013.

Click on short reference to get to full reference and links.

Denholm, P. and M. Mehos, "Enabling Greater Penetration of Solar Power via the Use of Thermal Energy Storage" 2011.

Denholm, P., and R. Sioshansi, "The value of compressed air energy storage with wind in transmission-constrained electric power systems," 2009.

Ding, H. et. al., "Stochastic Optimization of the Daily Operation of Wind Farm and Pumped-Hydro- Storage Plant." 2012.

Ela, E. et. al., "Role of Pumped Storage Hydro Resources in Electricity Markets and System Operation," 2013.

Fatouros, P., et al., "Stochastic Dual Dynamic Programming for Operation of DER Aggregators under Multidimensional Uncertainty," in press.

Gevorgian, V. and Corbus, D., "Ramping Performance Analysis of the Kahuku Wind-Energy Battery Storage System," 2013.

Howell, S. D. et. al., "A partial differential equation system for modelling stochastic storage in physical systems with applications to wind power generation," 2009.

Jorgenson, J. et. al., "Estimating the Value of Utility-Scale Solar Technologies in California Under a 40% Renewable Portfolio Standard," 2014.

Kazemi, M., et al., "Operation Scheduling of Battery Storage Systems in Joint Energy and Ancillary Services Markets," 2017.

Kazemi, M., and H. Zareipour, "Long-term Scheduling of Battery Storage Systems in Energy and Regulation Markets Considering Battery's Lifespan," 2017.

Kintner-Meyer, M., et al., "National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase II: WECC, ERCOT, EIC, Volume 1: Technical Analysis," 2013.

Kintner-Meyer, M.C.W., et al., "National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase 1, WECC," 2012.

Koritarov, V., et al., "Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the United States," 2014.

Korpaas, M. et. al., "Operation and sizing of energy storage for wind power plants in a market system," 2003.

Li N., et al., "Flexible Operation of Batteries in Power System Scheduling with Renewable Energy," 2016.

Loisel, R., "Power system flexibility with electricity storage technologies: A technical–economic assessment of a large-scale storage facility," 2012.

Loisel, R. et. al., “Valuation framework for large scale electricity storage in a case with wind curtailment,” 2010.

Luburić, Z., et al., “Assessment of N-1 criteria using energy storage,” 2017.

Madaeni, S. H., et al., “Estimating the Capacity Value of Concentrating Solar Power Plants with Thermal Energy Storage: A Case Study of the Southwestern United States,” 2013.

Madaeni, S. H., et al., “How Thermal Energy Storage Enhances the Economic Viability of Concentrating Solar Power,” 2012.

Makarov, Y.V., et al., “Sizing Energy Storage to Accommodate High Penetration of Variable Energy Resources,” 2012.

Marano, V. et. al., “Application of dynamic programming to the optimal management of a hybrid power plant with wind turbines, photovoltaic panels and compressed air energy storage,” 2012.

Nasrolahpour, E., et al., “A bilevel model for participation of a storage system in energy and reserve markets,” 2017.

Nasrolahpour, E., et al., “Impacts of ramping inflexibility of conventional generators on strategic operation of energy storage facilities,” 2016.

Nasrolahpour, E., et al., “Bidding strategy for an energy storage facility,” 2016.

Nasrolahpour, E., et al., “Strategic sizing of energy storage facilities in electricity markets,” 2016.

Palone, F., et al., “Commissioning and testing of the first Lithium-Titanate BESS for the Italian transmission grid,” 2015.

Sioshansi, R., and P. Denholm, “Benefits of Colocating Concentrating Solar Power and Wind,” 2013.

Sioshansi, R., and P. Denholm, “The Value of Concentrating Solar Power and Thermal Energy Storage,” 2010.

Strbac, G., et al., “Opportunities for Energy Storage: Assessing Whole-System Economic Benefits of Energy Storage in Future Electricity Systems,” 2017.

Wang, Y., et al., “Look-Ahead Bidding Strategy for Energy Storage,” 2017.

Xu, B., et al., “A Comparison of Policies on the Participation of Storage in U.S. Frequency Regulation Markets,” 2016.

Wholesale Markets

This section reviews studies which examine operations and valuation within the wholesale markets. Wholesale markets include day-ahead and real-time markets for energy and ancillary services as well as forward markets for capacity.

Click on short reference to get to full reference and links.

California ISO (CAISO), "Benefits Analysis of Large Energy Storage," 2017.

California Public Utilities Commission (CPUC), California Energy Commission (CEC) and California ISO (CAISO), "Energy Storage Roadmap," 2014.

Chang, J. et al., "The Value of Distributed Electricity Storage in Texas: Proposed Policy for Enabling Grid-Integrated Storage Investments," 2015.

Chen. Y. et. al., "Incorporating short-term stored energy resource into Midwest ISO energy and ancillary service market," 2011.

Denholm, P., et al., "Evaluating the Technical and Economic Performance of PV Plus Storage Power Plants" 2017.

Denholm, P., et al., "The Relative Economic Merits of Storage and Combustion Turbines for Meeting Peak Capacity Requirements under Increased Penetration of Solar Photovoltaics" 2015.

Denholm, P., and R. Sioshansi, "The value of compressed air energy storage with wind in transmission-constrained electric power systems," 2009.

Drury, E., et al., "Value of Compressed Air Energy Storage in Energy and Reserve Markets," 2011.

Dvorkin, Y., et al., "Ensuring Profitability of Energy Storage," 2017.

Dvorkin, Y., et al., "Co-planning of Investments in Transmission and Merchant Energy Storage," 2017.

Dvorkin, Y., "Can Merchant Demand Response Affect Investments in Merchant Energy Storage?" 2017.

Ela, E. et. al., "Role of Pumped Storage Hydro Resources in Electricity Markets and System Operation," 2013.

Electric Power Research Institute (EPRI), "Energy Storage Valuation in California: Policy, Planning and Market Information Relevant to the StorageVET™ Model," 2016.

Electric Power Research Institute (EPRI), "Quantifying the Value of Hydropower in the Electric Grid: Final Repor, 2013.

Fertig, E. and Apt, J., "Economics of compressed air energy storage to integrate wind power," 2011.

Garcia-Gonzalez, J. et. al., “Stochastic Joint Optimization of Wind Generation and Pumped-Storage Units in an Electricity Market,” 2008.

Graves, F. et. al., “Opportunities for electricity storage in deregulating markets,” 1999.

He, G., et al., “Optimal Bidding Strategy of Battery Storage in Power Markets Considering Performance-Based Regulation and Battery Cycle Life,” 2016.

Hussein, A. A. et. al., “Distributed battery micro-storage systems design and operation in a deregulated electricity market,” 2012.

Kanakasabapathy, P. and Shanti Swarup, K., “Bidding Strategy for Pumped-Storage Plant in Pool-Based Electricity Market.” 2010.

Kazemi, M., et al., “Operation Scheduling of Battery Storage Systems in Joint Energy and Ancillary Services Markets,” 2017.

Kazemi M., and H. Zareipour, “Long-term Scheduling of Battery Storage Systems in Energy and Regulation Markets Considering Battery’s Lifespan,” 2017.

Kintner-Meyer, M., et al., “National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase II: WECC, ERCOT, EIC, Volume 1: Technical Analysis,” 2013.

Kintner-Meyer, M.C.W., et al., “National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase 1, WECC,” 2012.

Koritarov, V., et al., “Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the United States,” 2014.

Krishnamurthy D., et al., “Energy Storage Arbitrage Under Day-Ahead and Real-Time Price Uncertainty,” 2017.

Kumaraswamy, K., and J. Cotrone, “Evaluating the Regulation Market Maturity for Energy Storage Devices,” 2013.

Madaeni, S. H., et al., “Estimating the Capacity Value of Concentrating Solar Power Plants with Thermal Energy Storage: A Case Study of the Southwestern United States,” 2013.

Madaeni, S. H., et al., “How Thermal Energy Storage Enhances the Economic Viability of Concentrating Solar Power,” 2012.

Massachusetts Department of Energy Resources (DOER), "State of Charge: Massachusetts Energy Storage Initiative Study," 2016.

Mauch, B. et. al., “Can a wind farm with CAES survive in the day-ahead market?,” 2012.

Click on short reference to get to full reference and links.

Nasrolahpour, E., et al., “A bilevel model for participation of a storage system in energy and reserve markets,” 2017.

Nasrolahpour, E., et al., “Impacts of ramping inflexibility of conventional generators on strategic operation of energy storage facilities,” 2016.

Nasrolahpour, E., et al., “Bidding strategy for an energy storage facility,” 2016.

Nasrolahpour, E., et al., “Strategic sizing of energy storage facilities in electricity markets,” 2016.

Pacific Gas and Electric Company (PG&E), "EPIC Final Report - EPIC Project 1.01, Energy Storage End Uses: Energy Storage for Market Operations," 2016.

Parvania, M. et. al., “Comparative Hourly Scheduling of Centralized and Distributed Storage in Day-Ahead Markets,” 2014.

Rajat, D., “Operating Hydroelectric Plants and Pumped Storage Units in a Competitive Environment.” 2000.

Sakti A., et al., “Enhanced representations of lithium-ion batteries in power systems models and their effect on the valuation of energy arbitrage applications,” 2017.

Salles, M. B. C., et al., “Potential Arbitrage Revenue of Energy Storage Systems in PJM during 2014,” 2015.

Shafiee, S., et al., “Developing Bidding and Offering Curves of a Price-maker Energy Storage Facility Based on Robust Optimization,” in press.

Shafiee, S., et al., “Risk-Constrained Bidding and Offering Strategy for a Merchant Compressed Air Energy Storage Plant,” 2017.

Shafiee, S., et al., “Economic Assessment of a Price-Maker Energy Storage Facility in the Alberta Electricity Market,” 2016.

Shafiee, S., et al., “Considering Thermodynamic Characteristics of a CAES Facility in Self-scheduling in Energy and Reserve Markets,” 2017.

Shahmohammadi, A., et al., “Market Equilibria and Interactions Between Strategic Generation, Wind, and Storage.” 2017.

Shi, Y., et al., "Using Battery Storage for Peak Shaving and Frequency Regulation: Joint Optimization for Superlinear Gains," forthcoming.

Sioshansi, R., “When Energy Storage Reduces Social Welfare,” Energy Economics, 2014.

Sioshansi, R., "Welfare Impacts of Electricity Storage and the Implications of Ownership Structure," 2010.

Sioshansi, R., and P. Denholm, “Benefits of Colocating Concentrating Solar Power and Wind,” 2013.

Sioshansi, R., and P. Denholm, “The Value of Concentrating Solar Power and Thermal Energy Storage,” 2010.

Sioshansi, R. et. al., “Estimating the Value of Electricity Storage in PJM: Arbitrage and Some Welfare Effects.” 2009.

Tuohy, A., et al., “Storage and demand-side options for integrating wind power,” 2014.

Wang, Y., et al., “Look-Ahead Bidding Strategy for Energy Storage,” 2017.

Wang Y., et al., "Stochastic coordinated operation of wind-battery energy storage system considering battery degradation", 2016.

Wankmüller F., et al., “Impact of Battery Degradation on Energy Arbitrage Revenue of Grid-level Energy Storage,” 2017.

Xi, X., and R. Sioshansi, "A Dynamic Programming Model of Energy Storage and Transformer Deployments to Relieve Distribution Constraints," 2016.

Xi, X., et. al., "A Stochastic Dynamic Programming Model for Co-optimization of Distributed Energy Storage," 2014.

Xu, B., et al., “Scalable Planning for Energy Storage in Energy and Reserve Markets,” 2017.

Xu, B., et al., “Factoring the Cycle Aging Cost of Batteries Participating in Electricity Markets,” accepted 2017, forthcoming.

Xu, B., et al., “A Comparison of Policies on the Participation of Storage in U.S. Frequency Regulation Markets,” 2016.

Zamani-Dehkordi, P., et al., “Price impact assessment for large-scale merchant energy storage facilities,” 2017.

Section 5: Categorization by Research that Incorporates Policy Goals

This section includes papers and other documents related to existing or planned policies which incorporate storage. This can include policies specifically targeted at storage or which includes storage along with other technologies (such as some renewable portfolio standards). The section also includes papers which model storage value against scenarios which include other clean energy policies, such as renewable portfolio standards.

California Storage Policies

Click on short reference to get to full reference and links.

These studies were intended to inform California storage policy development:

California ISO (CAISO), “Benefits Analysis of Large Energy Storage,” 2017.

DNV-GL, "Energy Storage Cost-effectiveness Methodology and Results," 2013.

Edmunds, T. et. al., “The Value of Energy Storage and Demand Response for Renewable Integration in California,” 2017.

Electric Power Research Institute (EPRI), “Cost-Effectiveness of Energy Storage in California,” 2013.

These studies incorporate California storage policy targets or test additions to the targets:

California ISO (CAISO), “Benefits Analysis of Large Energy Storage,” 2017.

Eichman, J. et. al., “Operational Benefits of Meeting California’s Energy Storage Targets,” 2015.

Other California policy relevant studies or documents:

Electric Power Research Institute (EPRI), “Energy Storage Valuation in California: Policy, Planning and Market Information Relevant to the StorageVET™ Model,” 2016.

Massachusetts Storage Policies

Massachusetts Department of Energy Resources (DOER), "State of Charge: Massachusetts Energy Storage Initiative Study," 2016.

[*Recommends storage portfolios*]

Renewable Portfolio Standards or Clean Energy Standards

The studies listed below generally evaluate storage value against different existing and proposed renewable energy standards or clean energy standards.

Bistline, J., "Economic and Technical Challenges of Flexible Operations under Large-Scale Variable Renewable Deployment," 2017.

California ISO (CAISO), "Benefits Analysis of Large Energy Storage," 2017.

Denholm, P. et. al., "Analysis of Concentrating Solar Power with Thermal Energy Storage in a California 33% Renewable Scenario," 2013.

Edmunds, T. et. al., "The Value of Energy Storage and Demand Response for Renewable Integration in California," 2017.

[*Models CPUC 2012 LTPP version of California 33% RPS scenario in 2022*]

Eichman, J. et. al., "Operational Benefits of Meeting California's Energy Storage Targets," 2015.

[*Models CPUC 2014 LTPP versions of California 33% and 40% RPS scenarios in 2024*]

Hawaiian Electric Companies, "PSIP Update Report: December 2016," Vol. 1-4, 2016.

Jorgenson, J. et. al., "Estimating the Value of Utility-Scale Solar Technologies in California Under a 40% Renewable Portfolio Standard," 2014.

Solomon, A. A., et al., "Investigating the Impact of Wind–Solar Complementarities on Energy Storage Requirement and the Corresponding Supply Reliability Criteria." 2016.

Solomon, A. A., et al., "The Role of Large-Scale Energy Storage Design and Dispatch in the Power Grid: A Study of Very High Grid Penetration of Variable Renewable Resources," 2014.

Low-Carbon Policies

Click on short reference to get to full reference and links.

de Sisternes, F., et al., “The contribution of energy storage to climate change mitigation in the electricity sector,” 2016.

Denholm, P. et. al., “Decarbonizing the Electric Sector: Combining Renewable and Nuclear Energy using Thermal Storage,” 2012.

Nelson, J., et al., “High-Resolution Modeling of the Western North American Power System Demonstrates Low-Cost and Low-Carbon Futures,” 2012.

Strbac, G. et. al., "Strategic Assessment of the Role and Value of Energy Storage Systems in the UK Low Carbon Energy Future," 2012.

Section 6: Categorization by Technology

This section organizes references by energy storage technologies modeled.

Click on short reference to get to full reference and links.

Batteries and Flywheels

Augustine, C. et. al., “Renewable Electricity Futures Study. Volume 2: Renewable Electricity Generation and Storage Technologies.” 2012.

Arteaga, J., et al., “Overview of Lithium-Ion Grid-Scale Energy Storage Systems,” 2017.

Benini, M., et al., “Battery energy storage systems for the provision of primary and secondary frequency regulation in Italy,” 2016.

Bruninx, K., and E. Delarue, “Improved energy storage system and unit commitment scheduling,” 2017.

California ISO (CAISO), “Moorpark Sub-Area Local Capacity Alternative Study,” 2017.

Carrión, M., et al., “Primary Frequency Response in Capacity Expansion with Energy Storage,” IEEE Transactions on Power Systems, 2017.

Chang, J., et al., "The Value of Distributed Electricity Storage in Texas: Proposed Policy for Enabling Grid-Integrated Storage Investments," 2015.

Chen. Y. et. al., “Incorporating short-term stored energy resource into Midwest ISO energy and ancillary service market,” 2011.

Cho, K.T. et. al., “Optimization and Analysis of High-Power Hydrogen/Bromine-Flow Batteries for Grid-Scale Energy Storage,” 2013.

Cole, W., et al., “SunShot 2030 for Photovoltaics (PV): Envisioning a Low-Cost PV Future.” 2017.

Cole, W., et al., “2017 Standard Scenarios Report: A U.S. Electricity Sector Outlook.” 2017.

Cole, W., et al., “Utility-Scale Lithium-Ion Storage Cost Projections for Use in Capacity Expansion Models,” 2016.

Crawford, A.J., et al., “Comparative analysis for various redox flow batteries chemistries using a cost performance model.” 2015.

de Sisternes, F., et al., “The contribution of energy storage to climate change mitigation in the electricity sector,” 2016.

Denholm, P., et al., “Evaluating the Technical and Economic Performance of PV Plus Storage Power Plants” 2017.

Denholm, P., and R. Margolis “Energy Storage Requirements for Achieving 50% Solar Photovoltaic Energy Penetration in California” 2016.

Denholm, P., et al., “The Relative Economic Merits of Storage and Combustion Turbines for Meeting Peak Capacity Requirements under Increased Penetration of Solar Photovoltaics” 2015.

Dragicevic, T., et al., “Capacity Optimization of Renewable Energy Sources and Battery Storage in an Autonomous Telecommunication Facility,” 2014.

Dvorkin, Y., et al., “Ensuring Profitability of Energy Storage,” 2017.

Dvorkin, Y., et al., “Co-planning of Investments in Transmission and Merchant Energy Storage,” 2017.

Dvorkin, Y., “Can Merchant Demand Response Affect Investments in Merchant Energy Storage?” 2017.

EPRI, “Cost-Effectiveness of Energy Storage in California.” 2013.

Falugi, P., et al., “Application of Novel Nested Decomposition Techniques to Long-term Planning Problems,” 2016.

Fatouros, P., et al., “Stochastic Dual Dynamic Programming for Operation of DER Aggregators under Multidimensional Uncertainty,” in press.

Feldman, D., et al., “Exploring the Potential Competitiveness of Utility-Scale Photovoltaics plus Batteries with Concentrating Solar Power, 2015-2030,” 2016.

Fernandez-Blanco, R., et al., “Optimal Energy Storage Siting and Sizing: A WECC Case Study,” 2017.

Gevorgian, V. and Corbus, D., “Ramping Performance Analysis of the Kahuku Wind-Energy Battery Storage System,” 2013.

Giannelos, S., et al., “A new class of planning models for option valuation of storage technologies under decision-dependent innovation uncertainty,” 2017.

Hale, E., et al., “Capturing the Impact of Storage and Other Flexible Technologies on Electric System Planning,” 2016.

Click on short reference to get to full reference and links.

He, G., et al., "Optimal Bidding Strategy of Battery Storage in Power Markets Considering Performance-Based Regulation and Battery Cycle Life," 2016.

Hussein, A. A. et. al., "Distributed battery micro-storage systems design and operation in a deregulated electricity market," 2012.

Kazemi, M., et al., "Operation Scheduling of Battery Storage Systems in Joint Energy and Ancillary Services Markets," 2017.

Kazemi M., and H. Zareipour, "Long-term Scheduling of Battery Storage Systems in Energy and Regulation Markets Considering Battery's Lifespan," 2017.

Konstantelos, I., and G. Strbac, "Valuation of Flexible Investment Options under Uncertainty," 2015.

Konstantelos, I., et al., "Contribution of Energy Storage and Demand Response to Security of Distribution Networks," 2017.

Krishnamurthy D., et al., "Energy Storage Arbitrage Under Day-Ahead and Real-Time Price Uncertainty," 2017.

Lawder, M. T. et. al., "Battery Energy Storage System (BESS) and Battery Management System (BMS) for Grid-Scale Applications," 2014.

Leadbetter, J., and L. Swan. "Battery Storage System for Residential Electricity Peak Demand Shaving," 2012.

Li N., et al., "Flexible Operation of Batteries in Power System Scheduling with Renewable Energy," 2016.

Luburić, Z., et al., "Assessment of N-1 criteria using energy storage," 2017.

National Alliance for Advanced Technology Batteries (NAATBatt) –DNV GL, "Distributed Energy Storage Roadmap: Final Report," 2014.

Pacific Gas and Electric Company (PG&E), "EPIC Final Report - EPIC Project 1.01, Energy Storage End Uses: Energy Storage for Market Operations," 2016.

Palone, F., et al., "Commissioning and testing of the first Lithium-Titanate BESS for the Italian transmission grid," 2015.

Pandzic, H., et al., "Near-Optimal Method for Siting and Sizing of Distributed Storage in a Transmission Network," 2015.

Peterson, S.B. et al., "The Economics of Using PHEV Battery Packs for Grid Storage," 2010.

Qiu, T., et al., “Stochastic Multi-Stage Co-Planning of Transmission Expansion and Energy Storage,” 2017.

Sakti, A., et al., “Enhanced representations of lithium-ion batteries in power systems models and their effect on the valuation of energy arbitrage applications,” 2017.

Shi, Y., et al., "Using Battery Storage for Peak Shaving and Frequency Regulation: Joint Optimization for Superlinear Gains," forthcoming.

Strbac, G., et al., “Opportunities for Energy Storage: Assessing Whole-System Economic Benefits of Energy Storage in Future Electricity Systems,” 2017.

Wang, Y., et al., “Look-Ahead Bidding Strategy for Energy Storage,” 2017.

Wang Y., et al., "Stochastic coordinated operation of wind-battery energy storage system considering battery degradation", 2016.

Wankmüller F., et al., “Impact of Battery Degradation on Energy Arbitrage Revenue of Grid-level Energy Storage,” 2017.

Xi, X., and R. Sioshansi, "A Dynamic Programming Model of Energy Storage and Transformer Deployments to Relieve Distribution Constraints," 2016.

Xi, X., et. al., "A Stochastic Dynamic Programming Model for Co-optimization of Distributed Energy Storage," 2014.

Xu, B., et al., “Scalable Planning for Energy Storage in Energy and Reserve Markets,” 2017.

Xu, B., et al., “Modeling of Lithium-Ion Battery Degradation for Cell Life Assessment,” accepted 2016, forthcoming.

Xu, B., et al., “Factoring the Cycle Aging Cost of Batteries Participating in Electricity Markets,” accepted 2017, forthcoming.

Xu, B., et al., “A Comparison of Policies on the Participation of Storage in U.S. Frequency Regulation Markets,” 2016.

Zamani-Dehkordi, P., et al., “Price impact assessment for large-scale merchant energy storage facilities,” 2017.

Thermal Energy Storage (non-CSP)

Cole, W., et al., “Optimization and Advanced Control of Thermal Energy Storage Systems.” 2012.

Compressed Air Energy Storage

Click on short reference to get to full reference and links.

Augustine, C. et. al., “Renewable Electricity Futures Study. Volume 2: Renewable Electricity Generation and Storage Technologies.” 2012.

Denholm, P., and R. Sioshansi, “The value of compressed air energy storage with wind in transmission-constrained electric power systems,” 2009.

Drury, E., et al., “Value of Compressed Air Energy Storage in Energy and Reserve Markets,” 2011.

Fertig, E., and Apt, J., “Economics of compressed air energy storage to integrate wind power: A case study in ERCOT,” 2011.

Keles, D. et. al., “Compressed-air energy storage power plant investments under uncertain electricity prices: an evaluation of compressed-air energy storage plants in liberalized energy markets,” 2012.

Lund, H. et. al., “Optimal operation strategies of compressed air energy storage (CAES) on electricity spot markets with fluctuating prices,” 2009.

Madlener, R., and J. Latz, “Economics of centralized and decentralized compressed air energy storage for enhanced grid integration of wind power,” 2013.

Mathias, J., et al., “Bulk Energy Storage in California.” 2016.

Mauch, B. et. al., “Can a wind farm with CAES survive in the day-ahead market?” 2012.

Salgi, G. and Lund, H., “System behaviour of compressed-air energy-storage in Denmark with a high penetration of renewable energy sources,” 2008

Shafiee, S., et al., “Risk-Constrained Bidding and Offering Strategy for a Merchant Compressed Air Energy Storage Plant,” 2017.

Shafiee, S., et al., “Considering Thermodynamic Characteristics of a CAES Facility in Self-scheduling in Energy and Reserve Markets,” 2017.

Sioshansi, R., et. al., "A Comparative Analysis of the Value of Pure and Hybrid Electricity Storage," 2011.

Swider, D. J., “Compressed Air Energy Storage in an Electricity System With Significant Wind Power Generation,” 2007.

Wang, Y., et al., “Look-Ahead Bidding Strategy for Energy Storage,” 2017.

Yucekaya, A., “The operational economics of compressed air energy storage system under uncertainty,” 2013.

Zamani-Dehkordi, P., et al., “Price impact assessment for large-scale merchant energy storage facilities,” 2017.

Concentrating Solar Power with Thermal Energy Storage

Augustine, C. et. al., “Renewable Electricity Futures Study. Volume 2: Renewable Electricity Generation and Storage Technologies.” 2012.

Denholm, P., et. al., “Analysis of Concentrating Solar Power with Thermal Energy Storage in a California 33% Renewable Scenario,” 2013.

Denholm, P. et. al., “Value of CSP with Thermal Energy Storage in the Western United States,” 2014.

Denholm, P., and M. Hummon, “Simulating the Value of Concentrating Solar Power with Thermal Energy Storage in a Production Cost Model,” 2012.

Denholm, P., and S. Ong, “Thermal Energy Storage as an Enabling Technology for Renewable Energy,” 2012.

Denholm, P., and M. Mehos, “Enabling Greater Penetration of Solar Power via the Use of Thermal Energy Storage” 2011.

Feldman, D., et al., “Exploring the Potential Competitiveness of Utility-Scale Photovoltaics plus Batteries with Concentrating Solar Power, 2015-2030,” 2016.

Jorgenson, J., et. al., “Estimating the Value of Utility-Scale Solar Technologies in California Under a 40% Renewable Portfolio Standard,” 2014.

Madaeni, S. H., et. al., “How Thermal Energy Storage Enhances the Economic Viability of Concentrating Solar Power,” 2012.

Sioshansi, R., and P. Denholm, “Benefits of Colocating Concentrating Solar Power and Wind,” 2013.

Sioshansi, R., and P. Denholm., “The Value of Concentrating Solar Power and Thermal Energy Storage,” 2010.

Pumped Storage

Augustine, C. et. al., “Renewable Electricity Futures Study. Volume 2: Renewable Electricity Generation and Storage Technologies.” 2012.

Brown, P. D. et. al., “Optimization of Pumped Storage Capacity in an Isolated Power System With Large Renewable Penetration,” 2008.

Bruninx, K., et al., “Coupling Pumped Hydro Energy Storages with Unit Commitment,” 2016.

California ISO (CAISO), “Benefits Analysis of Large Energy Storage,” 2017.

Click on short reference to get to full reference and links.

de Sisternes, F., et al., "The contribution of energy storage to climate change mitigation in the electricity sector," 2016.

Deb, R., "Operating Hydroelectric Plants and Pumped Storage Units in a Competitive Environment," 2000.

Department of Energy (DOE), "Hydropower Vision: A New Chapter for America's 1st Renewable Electricity Source." 2016.

Ding, H. et. al. "Stochastic Optimization of the Daily Operation of Wind Farm and Pumped-Hydro- Storage Plant," 2012.

Connolly, D. et. al, "Practical Operation Strategies for Pumped Hydroelectric Energy Storage (PHES) Utilizing Electricity Price Arbitrage." 2011.

Ela, E. et. al., "Role of Pumped Storage Hydro Resources in Electricity Markets and System Operation," 2013.

Electric Power Research Institute (EPRI), "Quantifying the Value of Hydropower in the Electric Grid: Final Repor, 2013.

Garcia -Gonzalez, J. et. al., "Stochastic Joint Optimization of Wind Generation and Pumped-Storage Units in an Electricity Market," 2008.

Kanakasabapathy, P. and Shanti Swarup, K., "Bidding Strategy for Pumped-Storage Plant in Pool-Based Electricity Market." 2010.

Kirby, B. et. al., "Modeling and Analysis of Advanced Pumped Storage Hydro Plants," 2011.

Kirby, B., "Co-Optimizing Energy and Ancillary Services from Energy Limited Hydro and Pumped Storage Plants," 2012.

Koritarov, V., et al., "Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the United States," 2014.

Koritarov, V., et. al., "Modeling and Simulation of Advanced Pumped - Storage Hydropower Technologies and their Contributions to the Power System," 2013.

Krad, I. et. al., "Quantifying the Operational Benefits of Conventional and Advanced Pumped Storage Hydro on Reliability and Efficiency," 2014.

Lu, N. et. al., "Pumped-Storage Hydro-Turbine Bidding Strategies in a Competitive Electricity Market," 2004.

Mathias, J., et al., "Bulk Energy Storage in California." 2016.

Mills, A., and R. Wiser., "Strategies for Mitigating the Reduction in Economic Value of Variable Generation with Increasing Penetration Levels," 2014.

Muche, T. "A real option-based simulation model to evaluate investments in pump storage plants," 2009.

Rajat, D., "Operating Hydroelectric Plants and Pumped Storage Units in a Competitive Environment." 2000.

Rangoni, B., "A contribution on electricity storage: The case of hydro-pumped storage appraisal and commissioning in Italy and Spain," 2012.

Schill, W.P. and Kemfert, C., "Modeling strategic electricity storage: The Case of Pumped Hydro Storage in Germany," 2011.

Steffen, B., "Prospects for pumped-hydro storage in Germany," 2012.

Tuohy, A., and M. O'Malley., "Impact of Pumped Storage on Power Systems with Increasing Wind Penetration," 2009.

Tuohy, A., and M. O'Malley., "Pumped storage in systems with very high wind penetration," 2011.

Ward, M., " Resource Commitment and Dispatch in the PJM Wholesale Electricity Market," 2011.

Zhang, N. et. al., "Planning Pumped Storage Capacity for Wind Power Integration," 2013.

Section 7: Categorization by Geography and Organization – United States

This section organizes studies of the United States by geographical region as well as by states and ISOs/RTOs.

National Studies

Click on short reference to get to full reference and links.

Akhil, A.A. et. al., "DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA," 2015.

Augustine, C. et. al., "Renewable Electricity Futures Study.Volume 2: Renewable Electricity Generation and Storage Technologies," 2012.

Cole, W., et al., "SunShot 2030 for Photovoltaics (PV): Envisioning a Low-Cost PV Future." 2017.

Cole, W., et al., "2017 Standard Scenarios Report: A U.S. Electricity Sector Outlook." 2017.

Cole, W., et al., "Utility-Scale Lithium-Ion Storage Cost Projections for Use in Capacity Expansion Models," 2016.

Department of Energy (DOE), "Hydropower Vision: A New Chapter for America's 1st Renewable Electricity Source." 2016.

Department of Energy (DOE), Electricity Advisory Committee (EAC), "2014 Storage Plan Assessment," 2014.

Hale, E., et al., "Capturing the Impact of Storage and Other Flexible Technologies on Electric System Planning," 2016.

Kintner-Meyer, M., et al., "National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase II: WECC, ERCOT, EIC, Volume 1: Technical Analysis," 2013.

Koritarov, V., et al., "Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the United States," 2014.

Sioshansi, R., et. al., “Dynamic Programming Approach to Estimate the Capacity Value of Energy Storage. IEEE Transactions on Power Systems,” 2014.

Arizona

Arizona Public Service (APS), 2017 Integrated Resource Plan, 2017.

Sioshansi, R., and P. Denholm, “The Value of Concentrating Solar Power and Thermal Energy Storage,” 2010.

Tucson Electric Power Company (TEP), 2017 Integrated Resource Plan, 2017.

[*see other Arizona utility IRPs in same docket*]

California State

California Public Utilities Commission (CPUC), "Decision 13-10-040, Decision adopting energy storage procurement framework and design program," 2013.

DNV-GL, "Energy Storage Cost-effectiveness Methodology and Results," 2013.

Denholm, P., et al., “Evaluating the Technical and Economic Performance of PV Plus Storage Power Plants” 2017.

Denholm, P., and R. Margolis “Energy Storage Requirements for Achieving 50% Solar Photovoltaic Energy Penetration in California” 2016.

Denholm, P. et. al., “Analysis of Concentrating Solar Power with Thermal Energy Storage in a California 33% Renewable Scenario,” 2013.

Denholm, P. and M. Mehos, “Enabling Greater Penetration of Solar Power via the Use of Thermal Energy Storage” 2011.

Edmunds, T. et. al., “The Value of Energy Storage and Demand Response for Renewable Integration in California,” 2017.

Eichman, J. et. al., “Operational Benefits of Meeting California’s Energy Storage Targets,” 2015.

Electric Power Research Institute (EPRI), “Energy Storage Valuation in California: Policy, Planning and Market Information Relevant to the StorageVET™ Model,” 2016.

Electric Power Research Institute (EPRI), “Cost-Effectiveness of Energy Storage in California: Application of the Energy Storage Valuation Tool to Inform the California Public Utility Commission Proceeding,” 2013.

Jorgenson, J. et. al., “Estimating the Value of Utility-Scale Solar Technologies in California Under a 40% Renewable Portfolio Standard,” 2014.

Click on short reference to get to full reference and links.

Koritarov, V., et al., "Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the United States," 2014.

Madaeni, S. H. et. al., "How Thermal Energy Storage Enhances the Economic Viability of Concentrating Solar Power," 2012.

Mathias, J., et al., "Bulk Energy Storage in California." 2016.

Mills, A., and R. Wiser, "Strategies for Mitigating the Reduction in Economic Value of Variable Generation with Increasing Penetration Levels," 2014.

Solomon, A. A., et al., "Investigating the Impact of Wind–Solar Complementarities on Energy Storage Requirement and the Corresponding Supply Reliability Criteria." 2016.

Solomon, A. A., et al., "The Role of Large-Scale Energy Storage Design and Dispatch in the Power Grid: A Study of Very High Grid Penetration of Variable Renewable Resources," 2014.

California ISO (CAISO)

California ISO (CAISO), "Moorpark Sub-Area Local Capacity Alternative Study," 2017.

California ISO (CAISO), "Benefits Analysis of Large Energy Storage," 2017.

California Public Utilities Commission (CPUC), California Energy Commission (CEC) and California ISO (CAISO), "Energy Storage Roadmap," 2014.

Denholm, P., and R. Margolis "Energy Storage Requirements for Achieving 50% Solar Photovoltaic Energy Penetration in California" 2016.

Denholm, P., and R. Sioshansi, "The value of compressed air energy storage with wind in transmission-constrained electric power systems," 2009.

Drury, E., et al., "Value of Compressed Air Energy Storage in Energy and Reserve Markets," 2011.

Edmunds, T., "The Value of Energy Storage and Demand Response for Renewable Integration in California," 2017.

Eichman, J. et. al., "Operational Benefits of Meeting California's Energy Storage Targets," 2015.

Electric Power Research Institute (EPRI), "Energy Storage Valuation in California: Policy, Planning and Market Information Relevant to the StorageVET™ Model," 2016.

Electric Power Research Institute (EPRI), "Cost-Effectiveness of Energy Storage in California," 2013.

Krishnamurthy D., et al., “Energy Storage Arbitrage Under Day-Ahead and Real-Time Price Uncertainty,” 2017.

Madaeni, S. H., et al., “Estimating the Capacity Value of Concentrating Solar Power Plants with Thermal Energy Storage: A Case Study of the Southwestern United States,” 2013.

Madaeni, S. H., et al., “How Thermal Energy Storage Enhances the Economic Viability of Concentrating Solar Power,” 2012.

Mathias, J., et al., “Bulk Energy Storage in California.” 2016.

Pacific Gas and Electric Company (PG&E), "EPIC Final Report - EPIC Project 1.01, Energy Storage End Uses: Energy Storage for Market Operations," 2016.

Sioshansi, R., and P. Denholm, “The Value of Concentrating Solar Power and Thermal Energy Storage,” 2010.

Hawaii

Hawaiian Electric Companies, “PSIP Update Report: December 2016,” Vol. 1-4, 2016.

Ellison, J. et. al., “Maui Energy Storage Study,” 2012.

Gevorgian, V. and Corbus, D., “Ramping Performance Analysis of the Kahuku Wind-Energy Battery Storage System,” 2013.

Iowa

Black & Veatch Corporation., “Iowa Stored Energy Plant Economic Feasibility Analysis, Final Report,” 2005.

ISO-New England (ISO-NE)

Xu, B., et al., “Factoring the Cycle Aging Cost of Batteries Participating in Electricity Markets,” accepted 2017, forthcoming.

New Mexico

New Mexico Renewable Energy Storage Task Force, “Final Report,” 2013.

Madaeni, S. H., et al., “Estimating the Capacity Value of Concentrating Solar Power Plants with Thermal Energy Storage: A Case Study of the Southwestern United States,” 2013.

Sioshansi, R., and P. Denholm, “The Value of Concentrating Solar Power and Thermal Energy Storage,” 2010.

Click on short reference to get to full reference and links.

New York ISO (NYISO)

Drury, E., et al., “Value of Compressed Air Energy Storage in Energy and Reserve Markets,” 2011.

Kazemi, M., et al., “Operation Scheduling of Battery Storage Systems in Joint Energy and Ancillary Services Markets,” 2017.

Kazemi M., and H. Zareipour, “Long-term Scheduling of Battery Storage Systems in Energy and Regulation Markets Considering Battery’s Lifespan,” 2017.

Walawalkar, R. et. al., “Economics of Electric Energy Storage for Energy Arbitrage and Regulation in New York,” 2007.

New York State

New York State Energy Research and Development Authority (NYSERDA), “Clean Energy Fund Investment Plan: Energy Storage Chapter,” 2017.

New York State Energy Research and Development Authority (NYSERDA), “Guide to Estimating Benefits and Market Potential for Electricity Storage in New York (With Emphasis on New York City),” 2007.

Phelps, J.,”NYSERDA Energy Storage and NY-BEST Program: Market Characterization and Assessment”, 2017.

Massachusetts

Massachusetts Department of Energy Resources (DOER), "State of Charge: Massachusetts Energy Storage Initiative Study," 2016.

Midcontinent ISO (MISO)

Center for Energy and Environment (Minnesota), “The Context for Energy Storage to Facilitate Renewable Electricity in Minnesota,” 2016.

Chen. Y. et. al., “Incorporating short-term stored energy resource into Midwest ISO energy and ancillary service market,” 2011.

Drury, E., et al., “Value of Compressed Air Energy Storage in Energy and Reserve Markets,” 2011.

Midcontinent Independent System Operator (MISO), Energy Storage Study, MISO, Policy Studies, 2014.

Rastler, D., “MISO Energy Storage Study Phase 1 Report,” 2011.

Sakti A., et al., “Enhanced representations of lithium-ion batteries in power systems models and their effect on the valuation of energy arbitrage applications,” 2017.

University of Minnesota's Energy Transition Lab, et al., “Modernizing Minnesota’s Grid: An Economic Analysis of Energy Storage Opportunities,” 2017.

Minnesota

University of Minnesota's Energy Transition Lab, et al., “Modernizing Minnesota’s Grid: An Economic Analysis of Energy Storage Opportunities,” 2017.

Center for Energy and Environment (Minnesota), “The Context for Energy Storage to Facilitate Renewable Electricity in Minnesota,” 2016.

Minnesota Department Of Commerce/Minnesota Legislative Energy Commission, Minnesota’s 2025 Energy Action Plan, 2016.

PJM RTO

Denholm, P., and T. Mai, “Timescales of Energy Storage Needed for Reducing Renewable Energy Curtailment,” 2017.

Denholm, P., and R. Sioshansi, “The value of compressed air energy storage with wind in transmission-constrained electric power systems,” 2009.

Drury, E., et al., “Value of Compressed Air Energy Storage in Energy and Reserve Markets,” 2011.

Salles, M. B. C., et al., “Potential Arbitrage Revenue of Energy Storage Systems in PJM during 2014,” 2015.

Sioshansi, R., et. al., "A Comparative Analysis of the Value of Pure and Hybrid Electricity Storage," 2011.

Sioshansi, R. et. al., “Estimating the Value of Electricity Storage in PJM: Arbitrage and Some Welfare Effects,” 2009.

Ward, M., "Resource Commitment and Dispatch in the PJM Wholesale Electricity Market," 2011.

Xi, X., and R. Sioshansi, "A Dynamic Programming Model of Energy Storage and Transformer Deployments to Relieve Distribution Constraints," 2016.

Xi, X., et. al., "A Stochastic Dynamic Programming Model for Co-optimization of Distributed Energy Storage," 2014.

ERCOT (Texas)

Click on short reference to get to full reference and links.

Chang, J. et al., "The Value of Distributed Electricity Storage in Texas: Proposed Policy for Enabling Grid-Integrated Storage Investments," 2015.

de Sisternes, F., et al., "The contribution of energy storage to climate change mitigation in the electricity sector," 2016.

Denholm, P. et. al., "Decarbonizing the Electric Sector: Combining Renewable and Nuclear Energy using Thermal Storage," 2012.

Denholm, P. and Hand, M., "Grid Flexibility and Storage Required to Achieve Very High Penetration of Variable Renewable Electricity," 2011.

Denholm, P., and R. Sioshansi, "The value of compressed air energy storage with wind in transmission-constrained electric power systems," 2009.

Fertig, E., and Apt, J., "Economics of compressed air energy storage to integrate wind power: A case study in ERCOT," 2011.

Kintner-Meyer, M., et al., "National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase II: WECC, ERCOT, EIC, Volume 1: Technical Analysis," 2013.

Liu, Y., et al., "Multistage Stochastic Investment Planning with Multiscale Representation of Uncertainties and Decisions," forthcoming.

Sioshansi, R., "Emissions Impacts of Wind and Energy Storage in a Market Environment," 2011.

Sioshansi, R., "Increasing the Value of Wind with Energy Storage," 2011.

Sioshansi, R., "Welfare Impacts of Electricity Storage and the Implications of Ownership Structure," 2010.

Sioshansi, R., and P. Denholm, "Benefits of Colocating Concentrating Solar Power and Wind," 2013.

Sioshansi, R., and P. Denholm, "The Value of Concentrating Solar Power and Thermal Energy Storage," 2010.

Western Electric Coordinating Council (WECC)

Denholm, P. et. al., "Analysis of Concentrating Solar Power with Thermal Energy Storage in a California 33% Renewable Scenario," 2013. [*California study using WECC model*]

Ecofys, "Energy Storage Opportunities and Challenges: A West Coast Perspective White Paper." 2014.

Eichman, J. et. al., "Operational Benefits of Meeting California's Energy Storage Targets," 2015. [*California study using WECC model*]

Fernandez-Blanco, R., et al., "Optimal Energy Storage Siting and Sizing: A WECC Case Study," 2017.

Jorgenson, J. et al., "Estimating the Value of Utility-Scale Solar Technologies in California Under a 40% Renewable Portfolio Standard," 2014. [*California study using WECC model*]

Kintner-Meyer, M., et al., "National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase II: WECC, ERCOT, EIC, Volume 1: Technical Analysis," 2013.

Kintner-Meyer, M.C.W., et al., "National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase 1, WECC," 2012.

Koritarov, V., et al., "Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the United States," 2014.

Koritarov, V. et. al., "Modeling and Simulation of Advanced Pumped - Storage Hydropower Technologies and their Contributions to the Power System," 2013.

Oikonomou, K., et al., "Energy Storage in the Western Interconnection: Current Adoption, Trends and Modeling Challenges," 2017.

Individual Utilities

California ISO (CAISO), "Moorpark Sub-Area Local Capacity Alternative Study," 2017. (Southern California Edison)

Denholm, P., et al., "The Relative Economic Merits of Storage and Combustion Turbines for Meeting Peak Capacity Requirements under Increased Penetration of Solar Photovoltaics" 2015.

Denholm, P., et. al., "Impact of Wind and Solar on the Value of Energy Storage," 2013.

Denholm, P., et. al., "The Value of Energy Storage for Grid Applications," 2013.

Madaeni, S. H., et al., "Estimating the Capacity Value of Concentrating Solar Power Plants with Thermal Energy Storage: A Case Study of the Southwestern United States," 2013.

Madaeni, S. H., et al., "How Thermal Energy Storage Enhances the Economic Viability of Concentrating Solar Power," 2012.

Nourai A., "Installation of the First Distributed Energy Storage System (DESS) at American Electric Power (AEP)," 2007.

Click on short reference to get to full reference and links.

Rittershausen, J., and McDonagh, M., "Moving Energy Storage from Concept to Reality: Southern California Edison's Approach to Evaluating Energy Storage" 2010.

Wu, D., et al.. "Assessment of Energy Storage Alternatives in the Puget Sound Energy System, Volume 2: Energy Storage Evaluation Tool," 2013.

Section 8: Categorization by Geography and Organization – English Language Non-U.S. Studies

Click on short reference to get to full reference and links.

Australia

Hessami, M.A., and D. R. Bowly, "Economic feasibility and optimisation of an energy storage system for Portland Wind Farm (Victoria, Australia)," 2011.

Canada

Chitsaz, H., et al., "Electricity price forecasting for operational scheduling of behind-the-meter storage systems," 2017. [*Ontario market*]

Nasrolahpour, E., et al., "A bilevel model for participation of a storage system in energy and reserve markets," 2017. [*Alberta market*]

Nasrolahpour, E., et al., "Impacts of ramping inflexibility of conventional generators on strategic operation of energy storage facilities," 2016. [*Alberta market*]

Nasrolahpour, E., et al., "Bidding strategy for an energy storage facility," 2016. [*Alberta market*]

Nasrolahpour, E., et al., "Strategic sizing of energy storage facilities in electricity markets," 2016. [*Alberta market*]

Pearre, N. S. and L. G. Swan., "Renewable electricity and energy storage to permit retirement of coal-fired generators in Nova Scotia," 2013.

Shafiee, S., et al., "Economic Assessment of a Price-Maker Energy Storage Facility in the Alberta Electricity Market," 2016.

Zamani-Dehkordi, P., et al., "Price impact assessment for large-scale merchant energy storage facilities," 2017. [*Alberta market*]

Denmark

Salgi, G. and Lund, H., “System behaviour of compressed-air energy-storage in Denmark with a high penetration of renewable energy sources,” 2008.

European Commission

European Commission, Directorate-General for Energy, “The future role and challenges of Energy Storage,” DG ENER Working Paper, 2013.

France

He, X. et. al., “Coupling electricity storage with electricity markets: a welfare analysis in the French market,” 2012.

He, X. et. al., “Compressed Air Energy Storage multi-stream value assessment on the French energy market,” 2011.

Germany

Schill, W.P. and Kemfert, C., “Modeling strategic electricity storage: The Case of Pumped Hydro Storage in Germany,” 2011.

Steffen, B., “Prospects for pumped-hydro storage in Germany,” 2012.

Zucker A. and Hinchliffe T., "Optimum sizing of PV-attached electricity storage according to power market signals - A case study for Germany and Italy," 2014.

Italy

Benini, M., et al., “Battery energy storage systems for the provision of primary and secondary frequency regulation in Italy,” 2016.

Fattori, F., et al., “High Solar Photovoltaic Penetration in the Absence of Substantial Wind Capacity: Storage Requirements and Effects on Capacity Adequacy,” 2017.

Palone, F., et al., “Commissioning and testing of the first Lithium-Titanate BESS for the Italian transmission grid,” 2015.

Zucker A. and Hinchliffe T., "Optimum sizing of PV-attached electricity storage according to power market signals - A case study for Germany and Italy," 2014.

Japan

Esteban, M. et. al., “Estimation of the energy storage requirement of a future 100% renewable energy system in Japan,” 2012.

Click on short reference to get to full reference and links.

Spain

Rangoni, B. et. al., “A contribution on electricity storage: The case of hydro-pumped storage appraisal and commissioning in Italy and Spain,” 2012.

United Kingdom

Strbac, G., et al., “Opportunities for Energy Storage: Assessing Whole-System Economic Benefits of Energy Storage in Future Electricity Systems,” 2017.

Strbac, G., et. al., "Strategic Assessment of the Role and Value of Energy Storage Systems in the UK Low Carbon Energy Future," 2012.

Section 9: Categorization by Model Type

This section organizes the bibliography by analytical model type, and also indicates which types of storage technologies are modeled. In several sections, a table indicates which modeling tool was used. While there are many papers describing the various model structures identified here, only a few are focused particularly on storage modeling applications.

Click on short reference to get to full reference and links.

Tool Surveys

Hoffman, M.G., et al., "Analysis Tools for Sizing and Placement of Energy Storage for Grid Applications - A Literature Review," 2010.

Navigant Consulting, "Survey of Modeling Capabilities and Needs for the Stationary Energy Storage Industry," May 2014.

Zucker, A., et. al., "Assessing Storage Value in Electricity Markets: A literature review," 2013.

Storage Technology/Price-Taker Model – Deterministic

A common model structure is called an "engineering model" of an energy storage system, or a "price-taker" model because it uses fixed market prices as inputs to conduct revenue maximization. The more sophisticated version of these models conduct dynamic optimization using a linear program or mixed integer program. The table below lists selected models used in the papers cited.

Denholm, P., et al., "Evaluating the Technical and Economic Performance of PV Plus Storage Power Plants" 2017.

Denholm, P., et. al., "Impact of Wind and Solar on the Value of Energy Storage," 2013.

Denholm, P., et. al., "The Value of Energy Storage for Grid Applications," 2013.

Denholm, P., and R. Sioshansi, "The value of compressed air energy storage with wind in transmission-constrained electric power systems," 2009.

Drury, E., et al., "Value of Compressed Air Energy Storage in Energy and Reserve Markets," 2011.

Eichman, J., et. al., “Operational Benefits of Meeting California’s Energy Storage Targets,” 2015.

Electric Power Research Institute (EPRI), “Energy Storage Valuation in California: Policy, Planning and Market Information Relevant to the StorageVET™ Model,” 2016.

Electric Power Research Institute (EPRI), “Cost-Effectiveness of Energy Storage in California,” 2013.

Fatouros, P., et al., “Stochastic Dual Dynamic Programming for Operation of DER Aggregators under Multidimensional Uncertainty,” in press.

Koritarov, V., et al., “Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the United States,” 2014.

Madaeni, S. H., et al., “Estimating the Capacity Value of Concentrating Solar Power Plants with Thermal Energy Storage: A Case Study of the Southwestern United States,” 2013.

Madaeni, S. H., et al., “How Thermal Energy Storage Enhances the Economic Viability of Concentrating Solar Power,” 2012.

Sakti A., et al., “Enhanced representations of lithium-ion batteries in power systems models and their effect on the valuation of energy arbitrage applications,” 2017.

Salles, M. B. C., et al., “Potential Arbitrage Revenue of Energy Storage Systems in PJM during 2014,” 2015.

Sioshansi, R., and P. Denholm, “Benefits of Colocating Concentrating Solar Power and Wind,” 2013.

Sioshansi, R., et. al., "A Comparative Analysis of the Value of Pure and Hybrid Electricity Storage," 2011.

Sioshansi, R., and P. Denholm, “The Value of Concentrating Solar Power and Thermal Energy Storage,” 2010.

Sioshansi, R. et. al., “Estimating the Value of Electricity Storage in PJM: Arbitrage and Some Welfare Effects.” 2009.

Strbac, G., et al., “Opportunities for Energy Storage: Assessing Whole-System Economic Benefits of Energy Storage in Future Electricity Systems,” 2017.

University of Minnesota's Energy Transition Lab, et al., “Modernizing Minnesota’s Grid: An Economic Analysis of Energy Storage Opportunities,” 2017.

Click on short reference to get to full reference and links.

Wu, D., et al.. "Assessment of Energy Storage Alternatives in the Puget Sound Energy System, Volume 2: Energy Storage Evaluation Tool," 2013.

Xu, B., et al., "Factoring the Cycle Aging Cost of Batteries Participating in Electricity Markets," accepted 2017, forthcoming.

Table 9–1
Selected storage papers using price-taker models and specific tools

Study	Price-Taker Tool
Eichman et al., 2015	NREL model
EPRI, 2013	EPRI Energy Storage Valuation Tool (ESVT)
Massachusetts DOER, 2016	EPRI ESVT
University of Minnesota et al., 2017	EPRI ESVT

Storage Technology/Price-Taker Model – With Uncertainty

Drury, E., et al., "Value of Compressed Air Energy Storage in Energy and Reserve Markets," 2011.

Kazemi, M., et al., "Operation Scheduling of Battery Storage Systems in Joint Energy and Ancillary Services Markets," 2017.

Kazemi, M., and H. Zareipour, "Long-term Scheduling of Battery Storage Systems in Energy and Regulation Markets Considering Battery's Lifespan," 2017.

Krishnamurthy, D., et al., "Energy Storage Arbitrage Under Day-Ahead and Real-Time Price Uncertainty," 2017.

Madaeni, S. H., et al., "How Thermal Energy Storage Enhances the Economic Viability of Concentrating Solar Power," 2012.

Shafiee, S., et al., "Considering Thermodynamic Characteristics of a CAES Facility in Self-scheduling in Energy and Reserve Markets," 2017.

Sioshansi, R., and P. Denholm, "The Value of Concentrating Solar Power and Thermal Energy Storage," 2010.

Sioshansi, R. et. al., "Estimating the Value of Electricity Storage in PJM: Arbitrage and Some Welfare Effects." 2009.

Xi, X., and R. Sioshansi, "A Dynamic Programming Model of Energy Storage and Transformer Deployments to Relieve Distribution Constraints," 2016.

Xi, X., et. al., "A Stochastic Dynamic Programming Model for Co-optimization of Distributed Energy Storage," 2014.

Wang Y., et al., "Stochastic coordinated operation of wind-battery energy storage system considering battery degradation," 2016.

Wankmüller F., et al., "Impact of Battery Degradation on Energy Arbitrage Revenue of Grid-level Energy Storage," 2017.

Production Cost – Deterministic

The most common power system models used for economic and operational analysis of storage are production cost models. These types of models have been in use for many years in utility and regional planning functions as well as for price forecasting. The table below lists selected models used in the papers cited.

California ISO (CAISO), "Benefits Analysis of Large Energy Storage," 2017.

Denholm, P., et al., "Evaluating the Technical and Economic Performance of PV Plus Storage Power Plants" 2017.

Denholm, P., et al., "The Relative Economic Merits of Storage and Combustion Turbines for Meeting Peak Capacity Requirements under Increased Penetration of Solar Photovoltaics" 2015.

Denholm, P. et. al., "Analysis of Concentrating Solar Power with Thermal Energy Storage in a California 33% Renewable Scenario," 2013.

Denholm, P. et. al., "Value of CSP with Thermal Energy Storage in the Western United States," 2014.

Denholm, P. and M. Hummon, "Simulating the Value of Concentrating Solar Power with Thermal Energy Storage in a Production Cost Model," 2012.

DNV-GL, "Energy Storage Cost-effectiveness Methodology and Results," 2013.

Eichman, J. et. al., "Operational Benefits of Meeting California's Energy Storage Targets," 2015.

Jorgenson, J. et. al., "Estimating the Value of Utility-Scale Solar Technologies in California Under a 40% Renewable Portfolio Standard," 2014.

Kintner-Meyer, M., et al., "National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase II: WECC, ERCOT, EIC, Volume 1: Technical Analysis," 2013.

Kintner-Meyer, M.C.W., et al., "National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase 1, WECC," 2012.

Koritarov, V., et al., "Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the United States," 2014.

Click on short reference to get to full reference and links.

Koritarov, V. et. al., "Modeling and Simulation of Advanced Pumped - Storage Hydropower Technologies and their Contributions to the Power System," 2013.

Massachusetts Department of Energy Resources (DOER), "State of Charge: Massachusetts Energy Storage Initiative Study," 2016.

University of Minnesota's Energy Transition Lab, et al., "Modernizing Minnesota's Grid: An Economic Analysis of Energy Storage Opportunities," 2017.

Table 9–2
Selected storage papers using production cost models and specific tools

Study	Production Cost Tool
CAISO 2017	GridView (ABB)
Edmunds et al., 2017	PLEXOS (Energy Exemplar)
Eichman et al., 2015	PLEXOS (Energy Exemplar)
Jorgenson et al., 2014	PLEXOS (Energy Exemplar)
Denholm et al., 2013	PLEXOS (Energy Exemplar)
Koritarov et al., 2013, 2014	PLEXOS (Energy Exemplar)
Denholm and Hummon, 2012	PLEXOS (Energy Exemplar)
University of Minnesota et al., 2017	WIS:dom (Vibrant Clean Energy)

Production Cost – Stochastic

Edmunds, T. et. al., "The Value of Energy Storage and Demand Response for Renewable Integration in California," 2017.

Li, N., et al., "Flexible Operation of Batteries in Power System Scheduling with Renewable Energy," 2016.

Market Equilibrium – Competitive

Mills, A., and R. Wiser, "Strategies for Mitigating the Reduction in Economic Value of Variable Generation with Increasing Penetration Levels," 2014.

Shahmohammadi, A., et al., "Market Equilibria and Interactions Between Strategic Generation, Wind, and Storage." 2017.

Sioshansi, R., "When Energy Storage Reduces Social Welfare," Energy Economics, 2014.

Sioshansi, R., "Emissions Impacts of Wind and Energy Storage in a Market Environment," 2011.

Sioshansi, R., "Welfare Impacts of Electricity Storage and the Implications of Ownership Structure," 2010.

Bidding Strategies and Strategic Behavior

Chitsaz, H., et al., "Electricity price forecasting for operational scheduling of behind-the-meter storage systems," 2017.

Shafiee, S., et al., "Developing Bidding and Offering Curves of a Price-maker Energy Storage Facility Based on Robust Optimization," in press.

Shafiee, S., et al., "Risk-Constrained Bidding and Offering Strategy for a Merchant Compressed Air Energy Storage Plant," 2017.

Shafiee, S., et al., "Economic Assessment of a Price-Maker Energy Storage Facility in the Alberta Electricity Market," 2016.

Shahmohammadi, A., et al., "Market Equilibria and Interactions Between Strategic Generation, Wind, and Storage," 2017.

Sioshansi, R., "When Energy Storage Reduces Social Welfare," Energy Economics, 2014.

Sioshansi, R., "Emissions Impacts of Wind and Energy Storage in a Market Environment," 2011.

Sioshansi, R., "Increasing the Value of Wind with Energy Storage," 2011.

Sioshansi, R., "Welfare Impacts of Electricity Storage and the Implications of Ownership Structure," 2010.

Sioshansi, R. et. al., "Estimating the Value of Electricity Storage in PJM: Arbitrage and Some Welfare Effects." 2009.

Capacity Valuation – LOLE/ELCC

Konstantelos, I., et al., "Contribution of Energy Storage and Demand Response to Security of Distribution Networks," 2017.

Sioshansi, R., et. al., "Dynamic Programming Approach to Estimate the Capacity Value of Energy Storage," 2014.

Strbac, G., et al., "Opportunities for Energy Storage: Assessing Whole-System Economic Benefits of Energy Storage in Future Electricity Systems," 2017.

Capacity Valuation – Approximation Methods

Denholm, P., et al., "Evaluating the Technical and Economic Performance of PV Plus Storage Power Plants" 2017.

Denholm, P., et al., "The Relative Economic Merits of Storage and Combustion Turbines for Meeting Peak Capacity Requirements under Increased Penetration of Solar Photovoltaics" 2015.

Click on short reference to get to full reference and links.

Denholm, P., and R. Sioshansi, "The value of compressed air energy storage with wind in transmission-constrained electric power systems," 2009.

Jorgenson, J., et. al., "Estimating the Value of Utility-Scale Solar Technologies in California Under a 40% Renewable Portfolio Standard," 2014.

Madaeni, S. H., et al., "Estimating the Capacity Value of Concentrating Solar Power Plants with Thermal Energy Storage: A Case Study of the Southwestern United States," 2013.

Madaeni, S. H., et. al., "How Thermal Energy Storage Enhances the Economic Viability of Concentrating Solar Power," 2012.

Sioshansi, R., et. al., "Dynamic Programming Approach to Estimate the Capacity Value of Energy Storage," 2014.

Sioshansi, R., and P. Denholm, "The Value of Concentrating Solar Power and Thermal Energy Storage," 2010.

Capacity Expansion/Portfolio Planning

This section includes some utility Integrated Resource Plans (IRPs) which provide methodological description of storage analysis and modeling, and which select storage in future portfolios.

Arizona Public Service (APS), 2017 Integrated Resource Plan, 2017.

Bistline, J., "Economic and Technical Challenges of Flexible Operations under Large-Scale Variable Renewable Deployment," 2017.

Cole, W., et al., "SunShot 2030 for Photovoltaics (PV): Envisioning a Low-Cost PV Future," 2017.

Cole, W., et al., "2017 Standard Scenarios Report: A U.S. Electricity Sector Outlook," 2017.

Cole, W., et al., "Utility-Scale Lithium-Ion Storage Cost Projections for Use in Capacity Expansion Models," 2016.

de Sisternes, F., et al., "The contribution of energy storage to climate change mitigation in the electricity sector," 2016.

Denholm, P., and R. Margolis, "Energy Storage Requirements for Achieving 50% Solar Photovoltaic Energy Penetration in California" 2016.

Department of Energy (DOE), "Hydropower Vision: A New Chapter for America's 1st Renewable Electricity Source." 2016.

Falugi, P., et al., "Application of Novel Nested Decomposition Techniques to Long-term Planning Problems," 2016.

Giannelos, S., et al., “A new class of planning models for option valuation of storage technologies under decision-dependent innovation uncertainty,” 2017.

Hale, E., et al., “Capturing the Impact of Storage and Other Flexible Technologies on Electric System Planning,” 2016.

Hawaiian Electric Companies, “PSIP Update Report: December 2016,” Vol. 1-4, 2016.

Konstantelos, I., and G. Strbac, “Valuation of Flexible Investment Options under Uncertainty,” 2015.

Liu, Y., et al., “Multistage Stochastic Investment Planning with Multiscale Representation of Uncertainties and Decisions,” forthcoming.

Mills, A., and R. Wiser, “Strategies for Mitigating the Reduction in Economic Value of Variable Generation with Increasing Penetration Levels,” 2014.

Midcontinent Independent System Operator (MISO), “Energy Storage Study, MISO, Policy Studies,” 2014.

Strbac, G., et al., “Opportunities for Energy Storage: Assessing Whole-System Economic Benefits of Energy Storage in Future Electricity Systems,” 2017.

Tucson Electric Power Company (TEP), 2017 Integrated Resource Plan, 2017.

Table 9–3
Selected resource plans and storage papers using capacity expansion models and specific tools

Study	Capacity Expansion Tool
Arizona Public Service (APS), 2017	Ventyx Strategist
Hawaiian Electric Companies, 2016	Ascend Analytics (for final 2016 portfolio)
Mills and Wiser, 2014	Research model
MISO 2014	EPRI EGEAS
University of Minnesota et al., 2017	VCE WIS:dom
EPRI/MISO 2011	EPRI EGEAS

Click on short reference to get to full reference and links.

Low-Carbon System Models

Augustine, C. et. al., "Renewable Electricity Futures Study. Volume 2: Renewable Electricity Generation and Storage Technologies." 2012.

de Sisternes, F., et al., "The contribution of energy storage to climate change mitigation in the electricity sector," 2016.

Strbac, G., et al., "Strategic Assessment of the role and value of energy storage Systems in the UK low carbon energy Future," 2012.

Other Modeling Methods

Muche, T., "A real option-based simulation model to evaluate investments in pump storage plants." 2009.

Wu, D., et al.. "An Energy Storage Assessment: Using Optimal Control Strategies to Capture Multiple Services," 2015.

Section 10: Full Set of References in Alphabetical Order

This section provides the full references along with web-links to files (when available) and DOI.

Akhil, A., G. Huff, A. Currier, B. Kaun, D. Rastler, S. Chen, A. Cotter, D. Bradshaw, and W. Guantlett, "DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA," Albuquerque, NM and Livermore, CA: Sandia National Laboratories, February 2015 (revised). [Online]. Available: http://www.sandia.gov/ess/publications/SAND2015-1002.pdf

Alam, M.J.E., K.M. Muttaqi, and D. Sutanto, "Mitigation of Rooftop Solar PV Impacts and Evening Peak Support by Managing Available Capacity of Distributed Energy Storage Systems," IEEE Transactions on Power Systems, 28 (4):3874–84, 2013. https://doi.org/10.1109/TPWRS.2013.2259269.

Arizona Public Service (APS), 2017 Integrated Resource Plan, April 2017. [Online] Available: http://edocket.azcc.gov/Docket/DocketDetailSearch?docketId=18939#docket-detail-container2.

Arteaga, J., H. Zareipour and V. Thangadurai, "Overview of Lithium-Ion Grid-Scale Energy Storage Systems," Current Sustainable/Renewable Energy Reports, pp.1-12. Springer International Publishing, August 2017. https://doi.org/10.1007/s40518-017-0086-0

Augustine, C., et al., "Renewable Electricity Futures Study: Volume 2: Renewable Electricity Generation and Storage Technologies." Golden, CO: National Renewable Energy Laboratory, NREL Report No. TP-6A20-52409-2, December 2010. http://dx.doi.org/10.1016/j.esd.2010.09.007 [Online]. Available: https://www.nrel.gov/docs/fy12osti/52409-2.pdf

Barton, J.P., and D.G. Infield, "Energy storage and its use with intermittent renewable energy," IEEE Trans Energy Convers, 19:441–8, 2004. http://refhub.elsevier.com/S0196-8904(14)00701-8/h0050

Beaudin, M., H. Zareipour, A. Schellenberglabe and W. Rosehart, "Energy storage for mitigating the variability of renewable electricity sources: An updated review," Energy for Sustainable Development, no. 14, December 2010. http://dx.doi.org/10.1016/j.esd.2010.09.007

Benini, M., S. Canevese, D. Cirio and A. Gatti, "Battery energy storage systems for the provision of primary and secondary frequency regulation in Italy," in Proceedings of Environment and Electrical Engineering (EEEIC), 2016 IEEE 16th International Conference, June 7-10, 2016. http://dx.doi.org/10.1109/EEEIC.2016.7555748

Benitez, L. E., P. C. Benitez and G. C. van Kooten, "The economics of wind power with energy storage," *Energy Economics*, no. 30, p. 1973–1989, July 2008. http://dx.doi.org/10.1016/j.eneco.2007.01.017

Bhatnagar, D., and V. Loose, "Evaluating Utility Procured Electric Energy Storage Resources: A Perspective for State Electric Utility Regulators." Sandia National Laboratories, SAND2012-9422, Albuquerque, NM, November 2012. [Online]. Available: http://www.sandia.gov/ess/publications/SAND2012-9422.pdf

Bistline, J., "Economic and Technical Challenges of Flexible Operations under Large-Scale Variable Renewable Deployment," Energy Economics, 64 (Supplement C):363–72, 2017. https://doi.org/10.1016/j.eneco.2017.04.012.

Bose, S., D.F. Gayme, U. Topcu, and K. M. Chandy, "Optimal Placement of Energy Storage in the Grid", Proc. of the 51st IEEE Conference on Decision and Control, pp. 5605 – 5612, Maui, HI, Dec. 2012.

Pearre, N.S., and L.G. Swanm, Black & Veatch Corporation. Iowa Stored Energy Plant Economic Feasibility Analysis, Final Report. March 2005. Centennial, CO: Black & Veatch. doi:10.1016/j.apenergy.2014.04.050

Brown, P. D., J. A. P. Lopes, and M. A. Matos, "Optimization of Pumped Storage Capacity in an Isolated Power System With Large Renewable Penetration," IEEE Transactions on Power Systems, vol. 23, pp. 523–531, May 2008. http://dx.doi.org/10.1109/TPWRS.2008.919419

Bruninx, K., Y. Dvorkin, E. Delarue, H. Pandzic, W. D'haeseleer and D. S. Kirschen, "Coupling Pumped Hydro Energy Storages with Unit Commitment," IEEE Transactions on Sustainable Energy, Vol 7, No 2, pp 786 – 796, April, 2016. https://doi.org/10.1109/TSTE.2015.2498555

Bruninx, K., and E. Delarue, "Improved energy storage system and unit commitment scheduling," 2017 IEEE Manchester PowerTech, Manchester, UK, June 2017, pp. 1-6. https://doi.org/10.1109/PTC.2017.7981000

Byrne, R.H., and C.A. Silva-Monroy,"Estimating the Maximum Potential Revenue for Grid Connected Electricity Storage: Arbitrage and Regulation." Sandia National Laboratories, Technical Report SAND2012-3863. Albuquerque, NM, December 2012. [Online]. Available: http://www.sandia.gov/ess/publications/SAND2012-3863.pdf

California ISO (CAISO), "Moorpark Sub-Area Local Capacity Alternative Study," August 16, 2017[Online]. Available: https://www.caiso.com/Documents/Aug16_2017_MoorparkSub-AreaLocalCapacityRequirementStudy-PuentePowerProject_15-AFC-01.pdf

California ISO (CAISO), "Benefits Analysis of Large Energy Storage," Section 6.5 in "2016-2017 Transmission Plan," March 17, 2017. [Online]. Available: http://www.caiso.com/Documents/Board-Approved_2016-2017TransmissionPlan.pdf.

California Public Utilities Commission (CPUC), California Energy Commission (CEC) and California ISO (CAISO), "Energy Storage Roadmap," 2014. [Online]. Available: http://www.caiso.com/informed/Pages/CleanGrid/EnergyStorageRoadmap.aspx

California Public Utilities Commission (CPUC), "Decision 13-10-040, Decision Adopting Energy Storage Procurement Framework and Design Program." October 17, 2013. [Online]. Available: http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M079/K533/79533378.PDF

Carnegie, R., D. Gotham, D. Nderitu, and P. Preckel, "Utility Scale Energy Storage Systems: Benefits, Applications and Technologies." State Utility Forecasting Group. June 2013. [Online]. Available: http://www.purdue.edu/discoverypark/energy/assets/pdfs/SUFG/publications/SUFG%20Energy%20Storage%20Report.pdf

Carrión, M., Y. Dvorkin, and H. Pandžić, "Primary Frequency Response in Capacity Expansion with Energy Storage," IEEE Transactions on Power Systems, early access, 2017. https://doi.org/10.1109/TPWRS.2017.2735807

Castillo, A. and D.F. Gayme, "Evaluating the Effects of Real Power Losses in Optimal Power Flow Based Storage Integration," IEEE Transactions on Control of Network Systems (published online) Early Access DOI:10.1109/TCNS.2017.2687819, Mar. 2017

Castillo, A., X. Jiang, and D. F. Gayme, "Lossy DC OPF for Optimizing Congested Grids with Renewable Energy and Storage," Proc. of the American Control Conference, pp. 4342 – 4347, Portland, OR, June 2014.

Castillo, A. and D.F. Gayme, "Grid-scale energy storage applications in renewable energy integration: A survey." Energy Conversion and Management, vol. 87, pp. 885 – 894, November 2014. http://dx.doi.org/10.1016/j.enconman.2014.07.063

Castillo, A., and D. F. Gayme, "Profit Maximizing Storage Allocation in Power Grids." 52nd IEEE Conference on Decision and Control, Florence, Italy, December 10-13, 2013. http://dx.doi.org/10.1109/CDC.2013.6759919

Celli G., S. Mocci, F. Pilo and M. Loddo, "Optimal Integration of Energy Storage in Distribution Networks." Proceedings of IEEE Power Tech Conference, Bucharest, Romania, June 28-July 2. http://dx.doi.org/10.1109/PTC.2009.5282268

Center for Energy and Environment (Minnesota), "The Context for Energy Storage to Facilitate Renewable Electricity in Minnesota," Prepared by Martha Hewett and Josh Quinnell, July 2016 [Online] Available: https://www.mncee.org/getattachment/Resources/Resource-Center/Technical-Reports/The-Context-for-Energy-Storage-to-Facilitate-Renew/The-Context-for-Energy-Storage-in-Minnesota_final.pdf.

Chang, J., M. Davis, I. Karkatsouli, J. Marshal, L. Regan, K. Spees and J. Pfeifenberger, "The Value of Distributed Electricity Storage in Texas: Proposed Policy for Enabling Grid-Integrated Storage Investments." March 2015. [Online]. Available: http://www.brattle.com/system/publications/pdfs/000/005/126/original/The_Value_of_Distributed_Electricity_Storage_in_Texas_-_Proposed_Policy_for_Enabling_Grid-Integrated_Storage_Investments_Full_Technical_Report.pdf?1426377384.

Chen. Y., M. Keyser, H. Tackett, and M. Xingwang, "Incorporating Short-Term Stored Energy Resource Into Midwest ISO Energy and Ancillary Service Market." IEEE Trans. Power Syst., vol. 26, no. 2, pp. 829–838, May 2011. http://dx.doi.org/10.1109/TPWRS.2010.2061875

Chitsaz, H., P. Zamani-Dehkordi, H. Zareipour, and P. Parikh, "Electricity price forecasting for operational scheduling of behind-the-meter storage systems," IEEE Transactions on Smart Grid, in press, 2017. DOI: 10.1109/TSG.2017.2717282

Cho, K.T., P. Albertus, V. Battaglia, A. Kojic, V. Srinivasan and A. Z Weber, "Optimization and Analysis of High-Power Hydrogen/Bromine-Flow Batteries for Grid-Scale Energy Storage." *Energy Technology*, October 2013. DOI: 10.1002/ente.201300108

Cole, W., B. Frew, P. Gagnon, J. Richards, Y. Sun, J. Zuboy, and R. Margolis, "SunShot 2030 for Photovoltaics (PV): Envisioning a Low-Cost PV Future." NREL/TP-6A20-68105. 2017. Golden, CO: National Renewable Energy Laboratory. [Online]. Available: https://www.nrel.gov/docs/fy17osti/68105.pdf.

Cole, W., J. Kody, M. Powell, and T. F. Edgar, "Optimization and Advanced Control of Thermal Energy Storage Systems." Reviews in Chemical Engineering 28 (2–3):81–99, 2012 https://doi.org/10.1515/revce-2011-0018.

Cole, W., T. Mai, P. Donohoo-Vallett, J. Richards, and P. Das, "2017 Standard Scenarios Report: A U.S. Electricity Sector Outlook." Technical Report NREL/TP-6A20-68548. 2017. Golden, CO: National Renewable Energy Laboratory. [Online]. Available: https://www.nrel.gov/docs/fy18osti/68548.pdf.

Cole, W., C. Marcy, V. Krishnan, and R. Margolis, "Utility-Scale Lithium-Ion Storage Cost Projections for Use in Capacity Expansion Models," 2016 North American Power Symposium (NAPS), 1–6. 2016. Denver, CO: IEEE. https://doi.org/10.1109/NAPS.2016.7747866.

Connolly, D., H. Lund, P. Finn, B.V. Mathiesen,. and M. Leahy., "Practical Operation Strategies for Pumped Hydroelectric Energy Storage (PHES) Utilizing Electricity Price Arbitrage." *Energy Policy* (39); pp. 4189–4196, July 2011. http://dx.doi.org/10.1016/j.enpol.2011.04.032

Connolly, D., H Lund, B. Mathiesen, E. Pican and M. Leahy, "The technical and economic implications of integrating fluctuating renewable energy using energy storage." *Renewable Energy*, pp. 47-60, July 2012. http://dx.doi.org/10.1016/j.renene.2011.11.003

Crawford, A.J., V.V. Viswanathan, D.E. Stephenson, W. Wang, E.C. Thomsen, D.M. Reed, B. Li, P.J. Balducci, M.C.W. Kintner-Meyer and V.L. Sprenkle. "Comparative analysis for various redox flow batteries chemistries using a cost performance model." Journal of Power Sources, 293:388-399, 2015. doi:10.1016/j.jpowsour.2015.05.066

Culver, W.J., "High-Value Energy Storage for the Grid: A Multi-Dimensional Look." *The Electricity Journal*, Volume 23, Issue 10, pp. 59-71, December 2010. http://dx.doi.org/10.1016/j.tej.2010.11.002

de Sisternes, F., J. Jenkins, and A. Botterud, "The contribution of energy storage to climate change mitigation in the electricity sector," Applied Energy, Vol. 175, pp. 368-379, 2016. http://dx.doi.org/10.1016/j.apenergy.2016.05.014

Deb, R., "Operating Hydroelectric Plants and Pumped Storage Units in a Competitive Environment," The Electricity Journal, pp. 24-32, April 2000. http://dx.doi.org/10.1016/S1040-6190(00)00093-2

Delille, G., B. François and G. Malarange. "Dynamic Frequency Control Support by energy storage to reduce the impact of Wind and Solar generation on isolated power systems," Transactions on Sustainable Energy, no. 3, October 2012. [Online]. Available: http://l2ep.univ-lille1.fr/pagesperso/francois/IEEE_trans_on_sust_energy_06268312.pdf

Denholm, P., and T. Mai,"Timescales of Energy Storage Needed for Reducing Renewable Energy Curtailment" NREL Technical Report No. TP-6A20-68960. September 2017 [Online]. Available: https://www.nrel.gov/docs/fy17osti/68960.pdf.

Denholm, P., J. Eichman, and R. Margolis, "Evaluating the Technical and Economic Performance of PV Plus Storage Power Plants" NREL Technical Report No. TP-6A20-68737. August 2017 [Online]. Available: https://www.nrel.gov/docs/fy17osti/68737.pdf

Denholm, P. and R. Margolis "Energy Storage Requirements for Achieving 50% Solar Photovoltaic Energy Penetration in California" NREL Technical Report No. TP-6A20-66595. August 2016 [Online]. Available: https://www.nrel.gov/docs/fy16osti/66595.pdf.

Denholm, P., V. Diakov, and R. Margolis, "The Relative Economic Merits of Storage and Combustion Turbines for Meeting Peak Capacity Requirements under Increased Penetration of Solar Photovoltaics" NREL Technical Report No. TP-6A20-64841. September 2015 [Online]. Available: https://www.nrel.gov/docs/fy15osti/64841.pdf.

Denholm, P., Y.H. Wan, M. Hummon, M. Mehos,"Value of CSP with Thermal Energy Storage in the Western United States." Energy Procedia. Proceedings of the SolarPACES 2013 International Conference, Vol. 49, 2014; pp. 1622-1631; NREL Report No. CP-6A20-60027, Las Vegas, Nevada,17-20 September 2013. http://dx.doi.org/10.1016/j.egypro.2014.03.171

Denholm, P., J Jorgenson, M. Hummon, D. Palchak, B. Kirby, O. Ma, and M. O'Malley, Impact of Wind and Solar on the Value of Energy Storage. NREL Technical Report No. TP-6A20-60568. November 2013. [Online]. Available: https://www.nrel.gov/docs/fy14osti/60568.pdf

Denholm,P., J. Jorgenson, M. Hummon, T. Jenkin, D. Palchak, B. Kirby, O. Ma, and Mark O'Malley, "The Value of Energy Storage for Grid Applications." NREL Technical Report NREL/TP-6A20-58465, May 2013. [Online]. Available: https://www.nrel.gov/docs/fy13osti/58465.pdf

Denholm, P., and M. Hummon, "Simulating the Value of Concentrating Solar Power with Thermal Energy Storage in a Production Cost Model." NREL Technical Report No. TP-6A20-56731, November 2012. [Online]. Available: http://www.nrel.gov/docs/fy13osti/56731.pdf

Denholm, P., A. Dillon, E. Drury, G. Glatzmaier, J. Logan, M. Melaina, J. Neubauer, D. Reindl, S. Santhanagopalan, K. Smith, D. Steward, and S. Succar, "Energy Storage for Power Grids and Electric Transportation: A Technology Assessment." NREL Technical Report No. TP-6A20-51252, March 2012. [Online]. Available: http://digital.library.unt.edu/ark:/67531/metadc86619/m1/1/high_res_d/R42455_2012Mar27.pdf

Denholm, P., "Energy Storage to Reduce Renewable Energy Curtailment." Proceedings of the 2012 IEEE Power and Energy Society General Meeting, 22-26 July 2012, San Diego, California. Piscataway, NJ: Institute of Electrical and Electronics Engineers (IEEE) 4 pp.; NREL Technical Report No. CP-6A20-53533, July 2012. [Online]. Available: http://dx.doi.org/10.1109/PESGM.2012.6345450

Denholm, P., S. Ong, "Thermal Energy Storage as an Enabling Technology for Renewable Energy." Proceedings of the World Renewable Energy Forum, 13-17 May 2012, Denver, Colorado (CD-ROM). Boulder, CO: American Solar Energy Society (ASES), NREL Technical Report No. CP-6A20-54796. [Online]. Available: https://ases.conference-services.net/resources/252/2859/pdf/SOLAR2012_0631_full%20paper.pdf

Denholm, P., J. King, C. Kutscher, and P. Wilson, "Decarbonizing the Electric Sector: Combining Renewable and Nuclear Energy using Thermal Storage." *Energy Policy*. Vol. 44, May 2012; pp. 301-311; NREL Technical Report No. JA-6A20-53118, May 2012. http://dx.doi.org/10.1016/j.enpol.2012.01.055

Denholm, P. and M. Mehos, "Enabling Greater Penetration of Solar Power via the Use of Thermal Energy Storage" NREL Technical Report No. TP-6A20-52978. November 2011. [Online]. Available: https://www.nrel.gov/docs/fy12osti/52978.pdf.

Denholm, P., and M. Hand, "Grid Flexibility and Storage Required to Achieve Very High Penetration of Variable Renewable Electricity." *Energy Policy*. Vol. 39(3), pp. 1817-1830; NREL Technical Report No. JA-6A20-49400, March 2011. http://dx.doi.org/10.1016/j.enpol.2011.01.019

Denholm, P. "Enabling Technologies for High Penetration of Wind and Solar Energy. Paper No. ES2011-54500." Proceedings of ASME 2011 5th International Conference on Energy Sustainability & 9th Fuel Cell Science, Engineering and Technology Conference (ESFuelCell2011), Washington, D.C.., New York, NY: American Society of Mechanical Engineers (ASME) pp. 1451-1458; NREL Technical Report No. CP-6A20-50868, August 2011. http://dx.doi.org/10.1115/ES2011-54500

Denholm, P., E. Ela, B. Kirby, and M. Milligan, "Role of Energy Storage with Renewable Electricity Generation." NREL Technical Report No. PR-6A2-49396, April 2010. [Online]. Available: https://www.nrel.gov/docs/fy10osti/47187.pdf

Denholm, P., Y. H. Wan, M. Hummon, and M. Mehos, "Analysis of Concentrating Solar Power with Thermal Energy Storage in a California 33% Renewable Scenario," NREL Report No. TP-6A20-58186, March 2013. [Online]. Available: https://www.nrel.gov/docs/fy13osti/58186.pdf

Denholm, P., and R.M. Margolis, "Evaluating the Limits of Solar Photovoltaics (PV) in Electric Power Systems Utilizing Energy Storage and Other Enabling Technologies," *Energy Policy*, 35, 4424-4433, September 2007. http://dx.doi.org/10.1016/j.enpol.2007.03.004

Denholm, P., and R. Sioshansi, "The value of compressed air energy storage with wind in transmission-constrained electric power systems," Energy Policy, Vol 37, No 8, pp 3149-3158, August 2009. http://dx.doi.org/10.1016/j.enpol.2009.04.002

Department of Energy (DOE), "Hydropower Vision: A New Chapter for America's 1st Renewable Electricity Source." Technical Report DOE/GO-102016-4869. Washington, D.C.: U. S. Department of Energy, 2016. [Online]. Available: http://energy.gov/eere/water/articles/hydropower-vision-new-chapter-america-s-1st-renewable-electricity-source.

Department of Energy (DOE), Electricity Advisory Committee (EAC), "2016 Storage Plan Assessment: Recommendations for the U.S. Department of Energy," September 2016. [Online]. Available: https://energy.gov/sites/prod/files/2016/10/f33/2016%20EAC%20Storage%20Plan%20Assessment%20Recommendations%20for%20the%20U%20S%20Department%20of%20Energy%20%28September%202016%29.pdf

Department of Energy (DOE), Electricity Advisory Committee (EAC), "2014 Storage Plan Assessment." September 2014. [Online]. Available: http://energy.gov/sites/prod/files/2014/10/f18/2014StoragePlanAssessment-Recs-for-DOE-Sep2014.pdf

Ding, H., Hu, Z. and Yonghua, S., "Stochastic Optimization of the Daily Operation of Wind Farm and Pumped-Hydro- Storage Plant." Renewable Energy (48); pp. 571–578, December 2012. http://dx.doi.org/10.1016/j.renene.2012.06.008

DNV-GL, "Energy Storage Cost-effectiveness Methodology and Results," Final Project Report, Energy Research and Development Division, Final Project Report, DNV GL Energy and Sustainability, August 2013, CEC 500-2014-068. [Online]. Available: http://www.energy.ca.gov/2014publications/CEC-500-2014-068/CEC-500-2014-068.pdf.

Dragicevic, T., H. Pandzic, D. Skrlec, I. Kuzle, J. Guerrero, and D. Kirschen, "Capacity Optimization of Renewable Energy Sources and Battery Storage in an Autonomous Telecommunication Facility," IEEE Transactions on Sustainable Energy, Vol 5, No 4, pp 1367-1378, October 2014. http://dx.doi.org/10.1109/TSTE.2014.2316480

Drury, E., P. Denholm, and R. Sioshansi, "Value of Compressed Air Energy Storage in Energy and Reserve Markets," Energy. Vol 36, No 8, pp 4959-4973, NREL Report No. JA-6A20-50640. August 2011. http://dx.doi.org/10.1016/j.energy.2011.05.041

Dvorkin, Y., R. Fernandez-Blanco, D. S. Kirschen, H. Pandzic, J. P. Watson, and C. A. Silva-Monroy, "Ensuring Profitability of Energy Storage," IEEE Transactions on Power Systems, Vol 32, No 1, pp. 611 – 623, 2017. https://doi.org/10.1109/TPWRS.2016.2563259

Dvorkin, Y., R. Fernandez Blanco, Y. Wang, B. Xu, D. Kirschen, H. Pandzic, J. P. Watson, C. A. Silva-Monroy, "Co-planning of Investments in Transmission and Merchant Energy Storage," IEEE Transactions on Power Systems, early access, 2017. https://doi.org/10.1109/TPWRS.2017.2705187

Dvorkin, Y., "Can Merchant Demand Response Affect Investments in Merchant Energy Storage?" IEEE Transactions on Power Systems, early access, 2017. https://doi.org/10.1109/TPWRS.2017.2753140

Ecofys, "Energy Storage Opportunities and Challenges: A West Coast Perspective White Paper." Performed by Ecofys under contract to EDF Renewable Energy with feedback from Advisory Panel members. April 2014. [Online]. Available: http://www.ecofys.com/files/files/ecofys-2014-energy-storage-white-paper.pdf.

Edmunds, T., A. Lamont, V. Bulaevskaya, C. Meyers, J. Mirocha, A. Schmidt, M. Simpson, S. Smith, P. Sotorrio, P. Top, and Y. Yao, Lawrence Livermore National Laboratory (LLNL). 2017. The Value of Energy Storage and Demand Response for Renewable Integration in California. California Energy Commission. Publication number: CEC-500-2017-014. [Online]. Available: http://www.energy.ca.gov/2017publications/CEC-500-2017-014/CEC-500-2017-014.pdf.

Eichman, J., P. Denholm, J. Jorgenson and U. Helman, "Operational Benefits of Meeting California's Energy Storage Targets," National Renewable Energy Laboratory (NREL), Technical Report NREL/TP-5400-65061, December 2015, [Online]. Available: http://www.nrel.gov/docs/fy16osti/65061.pdf.

Ela, E., B. Kirby, A. Botterud, C. Milostan, I. Krad, and V. Koritarov, "Role of Pumped Storage Hydro Resources in Electricity Markets and System Operation: Preprint." NREL Report No. CP-5500-58655. May 2013. [Online]. Available: http://www.nrel.gov/docs/fy13osti/58655.pdf.

Electric Power Research Institute (EPRI), "StorageVET™ Software User Guide: User and Technical Documentation for the Storage Value Estimation Tool," EPRI, Palo Alto, CA: 2016. 3002009357. [Online]. Available: www.storagevet.com.

Electric Power Research Institute (EPRI), "Energy Storage Valuation in California: Policy, Planning and Market Information Relevant to the StorageVET™ Model. EPRI, Palo Alto, CA: 2016. 3002009362. [Online]. Available: www.storagevet.com.

Electric Power Research Institute (EPRI), "Cost-Effectiveness of Energy Storage in California: Application of the Energy Storage Valuation Tool to Inform the California Public Utility Commission Proceeding R. 10-12-007." EPRI, Palo Alto, CA: 2013. 3002001162. Technical Update, June 2013. [Online]. Available: http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002001162

Electric Power Research Institute (EPRI), "Quantifying the Value of Hydropower in the Electric Grid: Final Report." EPRI, Palo Alto, CA: February 2013. 1023144. [Online]. Available: http://www.epri.com/Our-Work/Pages/EPRI-Project-on-Hydropower-Value-in-the-Electric-Grid.aspx

Ellison, J., D. Bhatnagar, and B. Karlson, "Maui Energy Storage Study." SAND2012-10314. Albuquerque, NM: Sandia National Laboratories, 2012. [Online]. Available: http://www.sandia.gov/ess/publications/SAND2012-10314.pdf

Esteban, M., Q. Zhang and A. Utama, "Estimation of the energy storage requirement of a future 100% renewable energy system in Japan." vol. Energy Policy, no. 47, August 2012. http://dx.doi.org/10.1016/j.enpol.2012.03.078

Eurelectric, "Decentralised Storage: Impact on future distribution grids." June 2012. [Online]. Available: http://www.eurelectric.org/media/53340/eurelectric_decentralized_storage_finalcover_dcopy-2012-030-0574-01-e.pdf

European Commission, Directorate-General for Energy, "The future role and challenges of Energy Storage," DG ENER Working Paper, 2013. [Online]. Available: https://ec.europa.eu/energy/sites/ener/files/energy_storage.pdf

Exarchakos, L., M. Leach, and G. Exarchakos, "Modelling electricity storage systems management under the influence of demand-side management programmers." Int. J. Energy Res., 33: 62–76. doi: 10.1002/er.1473, November 2008. [Online]. Available: http://onlinelibrary.wiley.com/doi/10.1002/er.1473/full

Eyer J., "Electric Utility Transmission and Distribution Upgrade Deferral Benefits from Modular Electricity Storage." SAND2009-4070. Sandia National Laboratories, Albuquerque, New Mexico, 2011. [Online]. Available: http://prod.sandia.gov/techlib/access-control.cgi/2009/094070.pdf

Eyer, J., and G. Corey, "Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide." (SAND2010-0815). Albuquerque, NM: Sandia National Laboratories. February 2010. [Online]. Available: http://www.sandia.gov/ess/publications/SAND2010-0815.pdf

Falugi, P., I. Konstantelos, and G. Strbac, "Application of Novel Nested Decomposition Techniques to Long-term Planning Problems," PSCC 2016, Genoa. DOI: 10.1109/PSCC.2016.7540872

Fatouros P., I. Konstantelos, D. Papadaskalopoulos, and G. Strbac, "Stochastic Dual Dynamic Programming for Operation of DER Aggregators under Multidimensional Uncertainty," IEEE Transactions on Sustainable Energy, pp. 1-11, in press. DOI: 10.1109/TSTE.2017.2764065

Fattori, F., N. Anglani, I. Staffell and S. Pfenninger, "High Solar Photovoltaic Penetration in the Absence of Substantial Wind Capacity: Storage Requirements and Effects on Capacity Adequacy," Energy, July 2017. https://doi.org/10.1016/j.energy.2017.07.007.

Feldman, D., R. Margolis, P. Denholm, and J. Stekli "Exploring the Potential Competitiveness of Utility-Scale Photovoltaics plus Batteries with Concentrating Solar Power, 2015-2030" NREL Technical Report No. TP-6A20-66592. August 2016. [Online]. Available: https://www.nrel.gov/docs/fy16osti/66592.pdf.

Fernandez-Blanco, R., Y. Dvorkin, B. Xu, Y. Wang, and D. S. Kirschen, "Optimal Energy Storage Siting and Sizing: A WECC Case Study," IEEE Transactions on Sustainable Energy, Vol. 8, No. 2, pp 733-743, 2017. https://doi.org/10.1109/TSTE.2016.2616444

Fertig, E., and J. Apt, "Economics of compressed air energy storage to integrate wind power: A case study in ERCOT," Energy Policy, 39(5), 2330-2342, May 2011. http://dx.doi.org/10.1016/j.enpol.2011.01.049

Figueiredo, F.C., P.C. Flynn, and E.A. Cabral, "The Economics of Energy Storage in 14 Deregulated Power Markets." Energy Studies Review (14); pp. 131–152, 2006. [Online]. Available: https://www.researchgate.net/profile/Peter_Flynn/publication/254625559_The_Economics_of_Energy_Storage_in_14_Deregulated_Power_Markets/links/556e24a708aeccd7773f6b3f.pdf

Garc´ıa-Gonz´alez, J., R. M. R. de la Muela, L. M. Santos, and A. M. Gonz´alez, "Stochastic Joint Optimization of Wind Generation and Pumped-Storage Units in an Electricity Market." IEEE Transactions on Power Systems, vol. 23, pp. 460–468, May 2008. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=4494596

Gauthier D., B. François, G. Malarange, J-L Fraisse, "Energy Storage Systems In Distribution Grids: New Assets To Upgrade Distribution Networks Abilities." CIRED 20th International Conference on Electricity Distribution, Prague, 8-11, June 2009. [Online]. Available: https://www.researchgate.net/profile/Bruno_Francois/publication/224593277_Energy_storage_systems_in_distribution_grids_New_assets_to_upgrade_distribution_network_abilities/links/00b49518d52d118728000000.pdf

Gayme, D. F., and U. Topcu, “Optimal Power Flow with Large-Scale Energy Storage Integration,” IEEE Transactions on Power Systems, vol. 28, no. 2, pp. 709 – 717, May 2013.

Gayme, D. F., and U. Topcu, “Optimal Power Flow with Distributed Energy Storage Dynamics,” Proc. of the American Control Conference, pp. 1536 – 1542, San Francisco, CA, June 2011.

Gevorgian, V., and D. Corbus, “Ramping Performance Analysis of the Kahuku Wind-Energy Battery Storage System.” NREL Report No. MP-5D00-59003, November 2013. [Online]. Available: http://www.nrel.gov/docs/fy14osti/59003.pdf

Giannelos, S., I. Konstantelos, and G. Strbac, “A new class of planning models for option valuation of storage technologies under decision-dependent innovation uncertainty,” IEEE PowerTech 2017, Manchester, 2017. DOI: 10.1109/PTC.2017.7979750

Graves, F., T. Jenkin, and D. Murphy, “Opportunities for electricity storage in deregulating markets,” The Electricity Journal (12); pp. 46–56. October 1999. http://dx.doi.org/10.1016/S1040-6190(99)00071-8

Hale, E., B. Stoll, and T. Mai, “Capturing the Impact of Storage and Other Flexible Technologies on Electric System Planning,” NREL/TP-6A20-65726. Golden, CO: National Renewable Energy Laboratory, 2016. https://doi.org/10.2172/1253712.

Hawaiian Electric Companies, “PSIP Update Report: December 2016,” Vol. 1-4, December 23, 2016. [Online] Available: https://www.hawaiianelectric.com/about-us/our-vision.

[Energy storage included in capacity expansion portfolios; energy storage technology survey in Appendix G.]

He, G., Q. Chen, C. Kang, P. Pinson and Q. Xia, “Optimal Bidding Strategy of Battery Storage in Power Markets Considering Performance-Based Regulation and Battery Cycle Life,” IEEE Transactions on Smart Grid, vol. 7, no. 5, pp. 2359-2367, Sept. 2016. https://doi.org/10.1109/TSG.2015.2424314

He, X., E. Delarue, W. D'haeseleer and J.-M. Glachant, “Coupling electricity storage with electricity markets: a welfare analysis in the French market.” KU Leuven (Working Paper), January2012. [Online]. Available: https://www.mech.kuleuven.be/en/tme/research/energy_environment/Pdf/WP_ENE_2012_01

He, X., R. Lecomte, A. Nekrassov, E. Delarue and E. Mercier, “Compressed Air Energy Storage multi-stream value assessment on the French energy market.” in PowerTech, IEEE, Trondheim, June 2011. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6019395

Hennessy, T., and M. Kuntz, "The multiple benefits of integrating electricity storage with wind energy." Power Engineering Society General Meeting, 2005. IEEE , vol., no., pp.1952,1954 Vol. 2, 12-16, June 2005. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=1489366

Hessami, M.-A., and D.R. Bowly, "Economic feasibility and optimisation of an energy storage system for Portland Wind Farm." Applied Energy, 88(8), 2755-2763, August 2011. doi: 10.1016/j.apenergy.2010.12.013

Hittinger E., J.F. Whitacre and J. Apt, "What properties of grid energy storage are most valuable?" J Power Sour 2012, 206:436–49. http://refhub.elsevier.com/S0196-8904(14)00701-8/h0265

Hoffman, M.G., M.C.W. Kintner-Meyer, A. Sadovsky and J.G. DeSteese, "Analysis Tools for Sizing and Placement of Energy Storage for Grid Applications - A Literature Review," PNNL-19703, Pacific Northwest National Laboratory, Richland, WA., 2010 [Online]. Available: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19703.pdf

Hussein, A. A., N. Kutkut, Z. J. Shen, and I. Batarseh, "Distributed battery micro-storage systems design and operation in a deregulated electricity market." IEEE Trans. Sustain. Energy, vol. 3, no. 3, pp. 545–555, July 2012. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6193196

Jorgenson, J., P. Denholm, and M. Mehos, "Estimating the Value of Utility Scale Solar Technologies in California Under a 40% Renewable Portfolio Standard" NREL Report No. TP-6A20-61685, May 2014. [Online]. Available: https://www.nrel.gov/docs/fy14osti/61685.pdf.

Kaldellis, J., D. Zafikaris and E. Kondili, "Optimum sizing of photovoltaic-energy storage systems for autonomous small islands," Electrical Power and Energy Systems, 2009.

Kapsali, M., J. Anagnostopoulos and J. Kaldellis, "Wind powered pumped-hydro storage systems for remote islands: A complete sensitivity analysis based on economic perspectives," Applied Energy, November 2012. http://dx.doi.org/10.1016/j.apenergy.2012.05.054

Kanakasabapathy, P. and K. Shanti Swarup, "Bidding Strategy for Pumped-Storage Plant in Pool-Based Electricity Market," Energy Conversion and Management (51:3); pp. 572–579, March 2010. http://dx.doi.org/10.1016/j.enconman.2009.11.001

Kazemi, M., H. Zareipour, N. Amjady, W.D. Rosehart, and M. Ehsan, "Operation Scheduling of Battery Storage Systems in Joint Energy and Ancillary Services Markets," IEEE Transactions on Sustainable Energy, Vol 8, No 4, pp 1726-1735, May 2017. https://doi.org/10.1109/TSTE.2017.2706563

Kazemi M., and H. Zareipour, "Long-term Scheduling of Battery Storage Systems in Energy and Regulation Markets Considering Battery's Lifespan," IEEE Transactions on Smart Grid, Vol PP, No 99, pp 1-1, July 2017. https://doi.org/10.1109/TSG.2017.2724919

Keane, A., L. F. Ochoa, C. L.T. Borges, G. W. Ault, A. Alarcon-Rodriguez, R. Currie, F. Pilo, C. Dent, and G. P. Harrison, "State-of-the-Art Techniques and Challenges Ahead for Distributed Generation Planning and Optimization." IEEE Task Force on Distributed Generation Planning and Optimization, September 2012. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6307952

Keles, D., R. Hartel, D. Möst and W. Fichtner, "Compressed-air energy storage power plant investments under uncertain electricity prices: an evaluation of compressed-air energy storage plants in liberalized energy markets." The Journal of Energy Markets, vol. 5, no. 1, pp. 53-84, 2012. http://search.proquest.com/openview/6fc811aa18d0ebbb1fff9d7fe7ac260c/1?pq-origsite=gscholar

Kintner-Meyer, M., P. Balducci, W. Colella, M. Elizondo, C. Jin, T. Nguyen, V. Viswanathan and Y. Zhang, "National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase II: WECC, ERCOT, EIC, Volume 1: Technical Analysis," Pacific Northwest National Laboratories, September 2013. [Online]. Available: http://energyenvironment.pnnl.gov/pdf/National_Assessment_Storage_PHASE_II_vol_1_final.pdf

Kintner-Meyer, M.C.W., P.J. Balducci, W.G. Colella, M.A. Elizondo, C. Jin, T.B. Nguyen, V.V. Viswanathan, and Y. Zhang, "National Assessment of Energy Storage for Grid Balancing and Arbitrage: Phase 1, WECC," PNNL-21388, 2012, Pacific Northwest National Laboratory, Richland, WA. [Online]. Available: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21388.pdf

Kirby, B., "Energy Storage Management for VG Integration." PR-5500-53295. Golden, CO: National Renewable Energy Laboratory." October 2011. [Online]. Available: http://www.nrel.gov/docs/fy12osti/53295.pdf.

Kirby, B., "Co-Optimizing Energy and Ancillary Services from Energy Limited Hydro and Pumped Storage Plants." Palo Alto, CA: EPRI, HydroVision, July 2012. [Online]. Available: http://www.consultkirby.com/files/Preprinted_HydroVision_2012-_Cooptimizing_Energy_AS_from_Energy_Limited_PS_Plants.pdf

Kirsch, L.D., "Compensating Electrical Storage Resources." The Electricity Journal, Volume 24, Issue 4, May 2011, Pages 72-77, May 2011. http://dx.doi.org/10.1016/j.tej.2011.04.008

Konstantelos, I., and G. Strbac, "Valuation of Flexible Investment Options under Uncertainty," IEEE Transactions on Power Systems, vol. 30, no. 2, pp. 1047-1055, Mar. 2015. DOI: 10.1109/TPWRS.2014.2363364

Konstantelos, I., P. Djapic, G. Strbac, P. Papadopoulos and A. Laguna, "Contribution of Energy Storage and Demand Response to Security of Distribution Networks," CIRED 2017, Glasgow. [Online]. Available: https://www.researchgate.net/publication/316140511_Contribution_of_Energy_Storage_and_Demand-Side_Response_to_Security_of_Distribution_Networks

Koritarov, V., T. Guo, E. Ela, B. Trouille, J. Feltes and M. Reed, "Modeling and Simulation of Advanced Pumped - Storage Hydropower Technologies and their Contributions to the Power System." Argonne National Laboratory, Energy Exemplar, LLC, National Renewable Energy Laboratory, MWH Americas, Inc., Siemens PTI, Inc., U.S. Department of Energy, 2013. [Online]. Available: http://energyexemplar.com/wp-content/uploads/2013/06/koritarov-et-al-2014_hv-paper_final2.pdf

Koritarov, V., T. Veselka T., J. Gasper, B. Bethke, A. Botterud, J. Wang, M. Mahalik, Z. Zhou, C. Milostan, J. Feltes, Y. Kazachkov Y., T. Guo, G. Liu, B. Trouille, P. Donalek, K. King, E. Ela, B. Kirby. I. Krad, V. Gevorgian, "Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the United States," Argonne National Laboratory Report ANL/DIS-14/7, Argonne, IL, June 2014. [Online]. Available: http://ceeesa.es.anl.gov/projects/psh/ANL-DIS-14-7_Advanced_PSH_Final_Report.pdf

Korpaas, M., A. T. Holen and R. Hildrum, "Operation and sizing of energy storage for wind power plants in a market system." Electrical power & energy systems, 25, October 2003. http://dx.doi.org/10.1016/S0142-0615(03)00016-4

Krad, I., E. Ela, and V. Koritarov, "Quantifying the Operational Benefits of Conventional and Advanced Pumped Storage Hydro on Reliability and Efficiency: Preprint," NREL Report No. CP-5D00-60806, July 2014. [Online]. Available: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6939040&tag=1

Krishnamurthy D., C. Uckun, Z. Zhou, P. Thimmapuram, and A. Botterud, "Energy Storage Arbitrage Under Day-Ahead and Real-Time Price Uncertainty," IEEE Transactions on Power Systems, in press, Apr. 2017. https://doi.org/10.1109/TPWRS.2017.2685347

Kumaraswamy, K., and J. Cotrone, "Evaluating the Regulation Market Maturity for Energy Storage Devices." The Electricity Journal, Volume 26, Issue 10, pp. 75–83, December 2013. http://dx.doi.org/10.1016/j.tej.2013.11.003

Lawder, M. T., B. Suthar, P. W. C. Northrop, S. De, C. M. Hoff, O, Leitermann, M.L. Crow, S. Santhanagopalan, and V.R. Subramanian, "Battery Energy Storage System (BESS) and Battery Management System (BMS) for Grid-Scale Applications." Proceedings of the IEEE. Vol. 102(6), pp. 1014-1030; NREL Report No. JA-5400-62288, June 2014. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6811152

Leadbetter, J., and L. Swan, "Battery Storage System for Residential Electricity Peak Demand Shaving," *Energy and Buildings* 55 (December):685–92, 2012. https://doi.org/10.1016/j.enbuild.2012.09.035.

Li N., C. Uckun, E. Constantinescu, J.R. Birge, K.W. Hedman, and A. Botterud, "Flexible Operation of Batteries in Power System Scheduling with Renewable Energy," IEEE Transactions on Sustainable Energy, Vol. 7, No. 2, pp. 685-696, 2016, http://dx.doi.org/10.1109/TSTE.2015.2497470

Liu, Y., Sioshansi, R., and Conejo, A. J., "Multistage Stochastic Investment Planning with Multiscale Representation of Uncertainties and Decisions." Forthcoming in IEEE Transactions on Power Systems. http://dx.doi.org/10.1109/TPWRS.2017.2694612

Loisel, R., "Power system flexibility with electricity storage technologies: A technical–economic assessment of a large-scale storage facility." International Journal of Electrical Power & Energy Systems, Volume 42, Issue 1, November 2012, Pages 542–552, November 2012. http://dx.doi.org/10.1016/j.ijepes.2012.04.058

Loisel, R., A. Mercier, C. Gatzen, N. Elms, H. Petric, "Valuation framework for large scale electricity storage in a case with wind curtailment." Energy Policy, Volume 38, Issue 11, November 2010, Pages 7323–7337, November 2010. http://dx.doi.org/10.1016/j.enpol.2010.08.007

Lu, N., J. H. Chow and A. A. Desrochers, "Pumped-Storage Hydro-Turbine Bidding Strategies in a Competitive Electricity Market." IEEE Transactions on Power Systems, v, 19, pp. 834 - 841, 2004. [Online]. Available: https://www.researchgate.net/profile/Ning_Lu4/publication/4055790_Pumped-storage_hydro-turbine_bidding_strategies_in_a_competitive_electricity_market/links/53fdecaa0cf22f21c2f8676e.pdf

Luburić, Z., H. Pandžić, T. Plavšić, Lj.Teklić, and V. Valentić, "Assessment of N-1 criteria using energy storage," Proceedings of Environment and Electrical Engineering and 2017 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS Europe), 2017 IEEE International Conference, June 6-9, 2017. http://dx.doi.org/10.1109/EEEIC.2017.7977587

Lund, H., G. Salgi, B. Elmegaard, and A. N. Andersen, "Optimal operation strategies of compressed air energy storage (CAES) on electricity spot markets with fluctuating prices.' Applied Thermal Engineering, Volume 29, Issues 5–6, April 2009, pp. 799–806. DOI: 10.1016/j.applthermaleng.2008.05.020

Madaeni, S. H., R. Sioshansi, and P. Denholm, "How Thermal Energy Storage Enhances the Economic Viability of Concentrating Solar Power." Proceedings of the IEEE. Vol 100, No 2, pp 335-347, February 2012; NREL Report No. JA-6A20-50316. http://dx.doi.org/10.1109/JPROC.2011.2144950

Madaeni, S. H., R. Sioshansi, and P. Denholm, "Estimating the Capacity Value of Concentrating Solar Power Plants with Thermal Energy Storage: A Case Study of the Southwestern United States," IEEE Transactions on Power Systems, Vol 28, No 2, pp 1205-1215, May 2013. http://dx.doi.org/10.1109/TPWRS.2012.2207410

Madlener, R., and J. Latz, "Economics of centralized and decentralized compressed air energy storage for enhanced grid integration of wind power." Applied Energy, no. 101, pp. 299-309, January 2013. http://dx.doi.org/10.1016/j.apenergy.2011.09.033

Makarov, Y.V., P. Du, M.C.W. Kintner-Meyer, C. Jin and H. Illian. "Sizing Energy Storage to Accommodate High Penetration of Variable Energy Resources," IEEE Transactions on Sustainable Energy, 3(1):34-40, 2012. doi:10.1109/TSTE.2011.2164101

Maitra, A., J. Carranza, B. Kaun, S. Chen, H. Kamath, M. Rylander, "Evaluation of Energy Storage In Distribution System," CIRED Workshop - Rome, 11-12 June 2014.

Marano, V., G. Rizzo and F. A. Tiano, "Application of dynamic programming to the optimal management of a hybrid power plant with wind turbines, photovoltaic panels and compressed air energy storage." Applied Energy, no. 97, pp. 849-859, September 2012. http://dx.doi.org/10.1016/j.apenergy.2011.12.086

Massachusetts Department of Energy Resources (DOER), "State of Charge: Massachusetts Energy Storage Initiative Study," September 2016. [Online]. Available: http://www.masscec.com/energy-storage-study.

Mathias, J., C. Doughty, and L. Kelly. Bulk Energy Storage in California. California Energy Commission. Publication Number: CEC-200-2016-006. 2016. [Online], Available: http://www.energy.ca.gov/2016publications/CEC-200-2016-006/CEC-200-2016-006.pdf

Mauch, B., P. M. S. Carvalho and J. Apt, "Can a wind farm with CAES survive in the day-ahead market?." Energy Policy, no. 48, pp. 584-593, September 2012. http://dx.doi.org/10.1016/j.enpol.2012.05.061

Midcontinent Independent System Operator (MISO), Energy Storage Study, MISO, Policy Studies, July 2014 [Online], Available: https://www.misoenergy.org/Library/Repository/Meeting%20Material/Stakeholder/Workshops%20and%20Special%20Meetings/2015/20151015%20Energy%20Storage%20Study%2020140701.pdf

Mills, A., and R. Wiser, "Strategies for Mitigating the Reduction in Economic Value of Variable Generation with Increasing Penetration Levels." Lawrence Berkeley National Laboratory, March 2014. [Online]. Available: https://emp.lbl.gov/sites/all/files/lbnl-6590e.pdf.

Minnesota Department Of Commerce/Minnesota Legislative Energy Commission, Minnesota's 2025 Energy Action Plan, August 2016. [Online]. Available: https://mn.gov/commerce/policy-data-reports/energy-data-reports/mn-action-plan.jsp.

Mokrian, P., and S. Moff, "A stochastic programming framework for the valuation of electricity storage." 26th USAEE/IAEE North American Conference. International Association for Energy Economics, Ann Arbor, MI [n.d.] http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.551.4134&rep=rep1&type=pdf

Muche, T., "A real option-based simulation model to evaluate investments in pump storage plants." Energy Policy, no. 37, pp. 4581-4682, November 2009. http://dx.doi.org/10.1016/j.enpol.2009.06.041

Nasrolahpour, E., J. Kazempour, H. Zareipour, and W. D. Rosehart, "A bilevel model for participation of a storage system in energy and reserve markets," IEEE Transactions on Sustainable Energy, (early access), September, 2017. DOI: 10.1109/TSTE.2017.2749434

Nasrolahpour, E., J. Kazempour, H. Zareipour, and W. D. Rosehart, "Impacts of ramping inflexibility of conventional generators on strategic operation of energy storage facilities," IEEE Transactions on Smart Grid, (early access), June, 2016. DOI: 10.1109/TSG.2016.2586892

Nasrolahpour, E., J. Kazempour, H. Zareipour, and W. D. Rosehart, "Bidding strategy for an energy storage facility," Power Systems Computation Conference (PSCC), pp 1-7, Genoa, Italy, June, 2016. DOI: 10.1109/PSCC.2016.7541016

Nasrolahpour, E., J. Kazempour, H. Zareipour, and W. D. Rosehart, "Strategic sizing of energy storage facilities in electricity markets," IEEE Transactions on Sustainable Energy, Vol 7, No 4, pp 1462-1472, April, 2016. DOI: 10.1109/TSTE.2016.2555289

Navigant Consulting, "Survey of Modeling Capabilities and Needs for the Stationary Energy Storage Industry," Prepared for: Energy Storage Association, May 2014. [Online]. Available: http://energystorage.org/system/files/resources/survey_of_modeling_capabilities_and_needs_for_the_stationary_energy_storage_industry_-_final_may_2014.pdf

National Alliance for Advanced Technology Batteries (NAATBatt) –DNV GL, "Distributed Energy Storage Roadmap: Final Report," Feb 17, 2014. [Online]. Available: http://naatbatt.org/wp-content/uploads/2015/03/NaatBatt_Report_FINAL_021814.pdf

Nekrassov, A., X. He and B. Prestat, "Efficiency analysis of incentive mechanisms for energy storage integration into electrical systems." IEEE PowerTech, Trondheim, June 2011. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6019170&tag=1

Nelson, J., J. Johnston, A. Mileva, M. Fripp, I. Hoffman, A. Petros-Good, C. Blanco, and D. M. Kammen, "High-Resolution Modeling of the Western North American Power System Demonstrates Low-Cost and Low-Carbon Futures." Energy Policy 43 (April):436–47, 2012. https://doi.org/10.1016/j.enpol.2012.01.031.

New Mexico Renewable Energy Storage Task Force , "Final Report," November 2013. [Online]. Available: http://www.emnrd.state.nm.us/ECMD/RenewableEnergy/documents/NMTaskForceReport20131118.pdf

New York State Energy Research and Development Authority (NYSERDA), "Clean Energy Fund Investment Plan: Energy Storage Chapter", 2017. [Online]. Available: https://www.nyserda.ny.gov/About/Clean-Energy-Fund

New York State Energy Research and Development Authority (NYSERDA), "Guide to Estimating Benefits and Market Potential for Electricity Storage in New York (With Emphasis on New York City)," 2007. [Online]. Available: http://www.nyserda.org/publications/8723_DUA_NYSERDAStorage_Report2.pdf

Neubauer, J, and M. Simpson, "Deployment of Behind-The-Meter Energy Storage for Demand Charge Reduction." NREL/TP-5400-63162. Golden, CO: National Renewable Energy Laboratory, 2015. [Online]. Available: http://www.nrel.gov/docs/fy15osti/63162.pdf.

Nourai, A., "Installation of the First Distributed Energy Storage System (DESS) at American Electric Power (AEP)." Sandia National Laboratories, SAND2007-3580, June 2007 [Online]. Available: http://prod.sandia.gov/techlib/access-control.cgi/2007/073580.pdf

Nyamdash, B., and E. Denny, "The impact of electricity storage on wholesale electricity prices." Energy Policy, no. 58, pp. 6-16, July 2013. http://dx.doi.org/10.1016/j.enpol.2012.11.033

Nyamdash, B., E. Denny and M. O'Malley, "The viability of balancing wind generation with large scale energy storage." Energy Policy, no. 38, November 2009. http://dx.doi.org/10.1016/j.enpol.2010.07.050

Oh, H. S. "Optimal Planning to Include Storage Devices in Power Systems." IEEE Transactions on Power Systems. Vol. 26(3), pp. 1118-1128; NREL Report No. JA-6A20-47130, August 2011. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5671526

Oikonomou, K., V. Satyal and M. Parvania, "Energy Storage in the Western Interconnection: Current Adoption, Trends and Modeling Challenges," in Proc. IEEE Power & Energy Society General Meeting, Chicago, IL, July 16-20, 2017.

Pacific Gas and Electric Company (PG&E), "EPIC Final Report - EPIC Project 1.01, Energy Storage End Uses: Energy Storage for Market Operations," September 13, 2016. [Online]. Available: https://www.pge.com/pge_global/common/pdfs/about-pge/environment/what-we-are-doing/electric-program-investment-charge/PGE-EPIC-Project-1.01.pdf.

Palone, F., G. Gemelli, M. Rebolini, E. Mocci, A. Necci, M. Pietrucci and A.C. Tortora, "Commissioning and testing of the first Lithium-Titanate BESS for the Italian transmission grid," in Proceedings of Environment and Electrical Engineering (EEEIC), 2015 IEEE 15th International Conference, June 10-13, 2015. http://dx.doi.org/10.1109/EEEIC.2015.7165305

Pandzic, H., Y. Wang, T. Qiu, Y. Dvorkin, and D. S. Kirschen, "Near-Optimal Method for Siting and Sizing of Distributed Storage in a Transmission Network," IEEE Transactions on Power Systems, Vol 30, No 5, pp. 2288 – 2300, September 2015. https://doi.org/10.1109/TPWRS.2014.2364257

Parvania, M., M. Fotuhi-Firuzabad, and M. Shahidehpour, "Comparative Hourly Scheduling of Centralized and Distributed Storage in Day-Ahead Markets." IEEE Transactions On Sustainable Energy, Vol. 5, No. 3, pp. 729-737, July 2014. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6740812

Pearre, N. S., and L. G. Swan, "Renewable electricity and energy storage to permit retirement of coal-fired generators in Nova Scotia." Sustainable Energy Technologies and Assessments, March 2013. http://dx.doi.org/10.1016/j.seta.2013.01.001

Peterson, S. B., J. F. Whitacre and J. Apt, "The Economics of Using PHEV Battery Packs for Grid Storage." Journal of Power Sources, 2010. 195: 2377-2384, April 2010. http://dx.doi.org/10.1016/j.jpowsour.2009.09.070

Phelps, J.," NYSERDA Energy Storage and NY-BEST Program: Market Characterization and Assessment", 2017. [Online]. Available: https://www.nyserda.ny.gov/About/Publications/EA-Reports-and-Studies/Other-Technical-Reports/NY-Data-Center-Market-Characterization.

Qiu, T., B. Xu, Y. Wang, **Y. Dvorkin,** and D. S. Kirschen, "Stochastic Multi-Stage Co-Planning of Transmission Expansion and Energy Storage," *IEEE Transactions on Power Systems*, Vol 32, No 1, pp 643 – 651, January 2017. https://doi.org/10.1109/TPWRS.2016.2553678

Rajat, D., "Operating Hydroelectric Plants and Pumped Storage Units in a Competitive Environment." The Electricity Journal (13:3); pp. 24–32, April 2010. http://dx.doi.org/10.1016/S1040-6190(00)00093-2

Rangoni, B., "A contribution on electricity storage: The case of hydro-pumped storage appraisal and commissioning in Italy and Spain." Utilities Policy, December 2012. http://dx.doi.org/10.1016/j.jup.2012.07.007

Rastler, D., "MISO Energy Storage Study Phase 1 Report." Palo Alto, CA: Electric Power Research Institute, November 2011. [Online]. Available: http://distwind.uwig.org/MISO_Energy_Storage_Study_Phase_1_Report.pdf

Rittershausen, J., and M. McDonagh, "Moving Energy Storage from Concept to Reality: Southern California Edison's Approach to Evaluating Energy Storage." Southern California Edison, 2010. [Online]. Available: https://www.edison.com/content/dam/eix/documents/innovation/smart-grids/Energy-Storage-Concept-to-Reality-Edison.pdf

Rugoloa, J. and M. J. Aziz, Electricity storage for intermittent renewable sources, Energy Environ. Sci., 2012, 5, 7151-7160, April 2012. DOI: 10.1039/C2EE02542F

Sakti A., K.G, Gallagher, N. Sepulveda, C, Uckun, C. Vergara, F. de Sisternes, D.W. Dees, A. Botterud, "Enhanced representations of lithium-ion batteries in power systems models and their effect on the valuation of energy arbitrage applications," Journal of Power Sources, Vol. 342, pp. 279-291, 2017. http://dx.doi.org/10.1016/j.jpowsour.2016.12.063

Salgi, G.,; H. Lund, "System behaviour of compressed-air energy-storage in Denmark with a high penetration of renewable energy sources." Applied Energy, Volume 85, Issue 4, pp. 182–189, April 2008. http://dx.doi.org/10.1016/j.apenergy.2007.07.006

Salles, M. B. C., M. J. Aziz, and W.W. Hogan, "Potential Arbitrage Revenue of Energy Storage Systems in PJM during 2014," December 5, 2015. [Online]. Available: https://www.hks.harvard.edu/fs/whogan/PES_paper_09_salles_final.pdf

Schill, W.-P., Kemfert, C., "Modeling strategic electricity storage: The Case of Pumped Hydro Storage in Germany." The Energy Journal (32); pp. 59–88. [Online]. Available: http://www.diw.de/documents/vortragsdokumente/220/diw_01.c.361061.de/v_2010_schill_modeling_eea.pdf

Schoenung S., and J. Eyer "Benefit/cost framework for evaluating modular energy storage," Technical Report SAND2008-0978. Sandia National Laboratories, 2008.

Shafiee, S., H. Zareipour and A. M. Knight, “Developing Bidding and Offering Curves of a Price-maker Energy Storage Facility Based on Robust Optimization,” IEEE Trans. Smart Grid, in press. DOI:10.1109/TSG.2017.2749437

Shafiee, S., H. Zareipour, A. M. Knight, N. Amjady, and B. Mohammadi-Ivatloo, “Risk-Constrained Bidding and Offering Strategy for a Merchant Compressed Air Energy Storage Plant,” IEEE Trans. Power Syst., vol. 32, no. 2, pp. 946–957, Mar. 2017.

Shafiee, S., P. Zamani-Dehkordi, H. Zareipour, and A. M. Knight, “Economic Assessment of a Price-Maker Energy Storage Facility in the Alberta Electricity Market,” Energy, vol. 111, pp. 537–547, Sep. 2016.

Shafiee, S., H. Zareipour, and A. Knight, “Considering Thermodynamic Characteristics of a CAES Facility in Self-scheduling in Energy and Reserve Markets,” IEEE Trans. Smart Grid, In Press, DOI: 10.1109/TSG.2016.2633280

Shahmohammadi, A., Sioshansi, R., Conejo, A. J., and Afsharnia, S., “Market Equilibria and Interactions Between Strategic Generation, Wind, and Storage.” Forthcoming in Applied Energy, 2017.

Shayesteh, E., D. F. Gayme, and M. Amelin, “System Reduction Techniques for Storage Allocation in larger Power Systems,” Int'l Journal of Electric Power and Energy Systems, vol. 95, pp. 108 – 117, Feb. 2018.

Shi, Y., B. Xu, D. Wang and B. Zhang, "Using Battery Storage for Peak Shaving and Frequency Regulation: Joint Optimization for Superlinear Gains," IEEE Transactions on Power Systems, vol. PP, no. 99, pp. 1-1. https://doi.org/10.1109/TPWRS.2017.2749512

Sigrist, L, E. Lobato, L. Rouco, “Energy storage systems providing primary reserve and peak shaving in small isolated power systems: an economic assessment,” Electr Power Energy Syst, 53:675–83, 2013. http://refhub.elsevier.com/S0196-8904(14)00701-8/h0230

Sioshansi, R., S.H. Madaeni and P. Denholm, “Dynamic Programming Approach to Estimate the Capacity Value of Energy Storage.” IEEE Transactions on Power Systems, Vol. 29 (1), pp. 395-403, NREL Report No. JA-6A20-58604, January 2014. http://dx.doi.org/10.1109/TPWRS.2013.2279839

Sioshansi, R., “Increasing the Value of Wind with Energy Storage,” The Energy Journal, Vol 32, No 2, pp 1-30, 2011. http://dx.doi.org/10.5547/ISSN0195-6574-EJ-Vol32-No2-1

Sioshansi, R., P. Denholm, and T. Jenkin, "A Comparative Analysis of the Value of Pure and Hybrid Electricity Storage." Energy Economics, Vol 33, No 1, pp 56-66, January, 2011. http://dx.doi.org/10.1016/j.eneco.2010.06.004

Sioshansi R., and P. Denholm, "The Value of Concentrating Solar Power and Thermal Energy Storage." IEEE Transactions on Sustainable Energy, Vol 1, No 3, pp 173-183, October, 2010. http://dx.doi.org/10.1109/TSTE.2010.2052078

Sioshansi, R., "Emissions Impacts of Wind and Energy Storage in a Market Environment." Environmental Science and Technology, Vol 45, No 24, pp 10728-10735, December, 2011. http://dx.doi.org/10.1021/es2007353

Sioshansi, R., "Welfare Impacts of Electricity Storage and the Implications of Ownership Structure." The Energy Journal, Vol 31, No 2, pp 173-198, 2010. https://doi.org/10.5547/ISSN0195-6574-EJ-Vol31-No2-7

Sioshansi, R., Denholm, P., Jenkin, T., Weiss, J., "Estimating the Value of Electricity Storage in PJM: Arbitrage and Some Welfare Effects." Energy Economics Vol 31, No 2, pp. 269–277, March 2009. http://dx.doi.org/10.1016/j.eneco.2008.10.005

Sioshansi, R., "When Energy Storage Reduces Social Welfare," Energy Economics, Vol 41, pp 106-116, January, 2014. http://dx.doi.org/10.1016/j.eneco.2013.09.027

Sioshansi R., and P. Denholm, "Benefits of Colocating Concentrating Solar Power and Wind," IEEE Transactions on Sustainable Energy, Vol 4, No 4, pp 877-885, October 2013. http://dx.doi.org/10.1109/TSTE.2013.2253619

Sjödin, A. E., D. F. Gayme, and U. Topcu, "Risk-mitigated Optimal Power Flow for Wind Powered Grids," Proc. of the American Control Conference, pp. 4431 – 4437, Montreal, QC, June 2012.

Solomon, A. A., D. M. Kammen, and D. Callaway. "The Role of Large-Scale Energy Storage Design and Dispatch in the Power Grid: A Study of Very High Grid Penetration of Variable Renewable Resources." Applied Energy 134 (December):75–89, 2014. https://doi.org/10.1016/j.apenergy.2014.07.095.

Solomon, A. A., D. M. Kammen, and D. Callaway. "Investigating the Impact of Wind–Solar Complementarities on Energy Storage Requirement and the Corresponding Supply Reliability Criteria." Applied Energy 168 (April):130–45, 2016. https://doi.org/10.1016/j.apenergy.2016.01.070.

Steffen, B., "Prospects for pumped-hydro storage in Germany." Energy Policy, no. 45, pp. 420-429, June 2012. http://dx.doi.org/10.1016/j.enpol.2012.02.052

Strbac, G., M. Aunedi, I. Konstantelos, R. Moreira, F Teng, R. Moreno, D. Pudjianto, A. Laguna, and P. Papadopoulos, "Opportunities for Energy Storage: Assessing Whole-System Economic Benefits of Energy Storage in Future Electricity Systems," IEEE PES Magazine, vol. 15, no. 5, pp. 32-41, Sep. 2017. DOI: 10.1109/MPE.2017.2708858

Strbac, G., M. Aunedi, D. Pudjianto, P. Djapic, F. Teng, A. Sturt, D. Jackravut, R. Sansom, V. Yufit, N. Brandon, "Strategic Assessment of the Role and Value of Energy Storage Systems in the UK Low Carbon Energy Future" - Report for the Carbon Trust by the Energy Futures Lab, Imperial College and EDF UK R&D Center, June 2012. [Online]. Available: http://www.efn-uk.org/l-street/politics-lib/gov-agents/index_files/ICLenergy-storage2012.pdf.

Swider, D. J., "Compressed Air Energy Storage in an Electricity System With Significant Wind Power Generation." IEEE Transactions on Energy Conversion, vol. 22, pp. 95–102, March 2007. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=4106018&tag=1

Su, H-I., and A. El Gamal, "Modeling and analysis of the role of fast-response energy storage in the smart grid," Proceedings of the 49th annual allerton conference on communication, control and computing, 2011. p. 719–26.

Su, H-I., and A. El Gamal, "Modeling and analysis of the role of energy storage for renewable integration: power balancing," IEEE Trans Power Syst, pp. :1–9, 2013. http://refhub.elsevier.com/S0196-8904(14)00701-8/h0150

Sun, Q., M.E. Cotterell, A. Beach and S. Grijalva, "Fundamental Value of Information and Strategy in Stochastic Management of Distributed Energy Storage," Proceedings of the 2012 North American Power Symposium (NAPS), 9-11 September 2012, Champaign, Illinois. Piscataway, NJ: Institute of Electrical and Electronics Engineers (IEEE), NREL Report No. CP-6A20-57689. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6336385

Tucson Electric Power Company (TEP), 2017 Integrated Resource Plan, April 3, 2017. [Online] Available: http://edocket.azcc.gov/Docket/DocketDetailSearch?docketId=18939#docket-detail-container2.

[Significant energy storage included in capacity expansion portfolios]

Tuohy, A., B. Kaun, and R. Entriken, "Storage and demand-side options for integrating wind power." WENE, 3: 93–109. 2014. doi:10.1002/wene.92

Tuohy, A., and M. O'Malley, "Impact of Pumped Storage on Power Systems with Increasing Wind Penetration." Power & Energy Society General Meeting, Calgary, Alberta, Canada: Institute of Electrical and Electronics Engineers, pp. 1-8, 26-30 July 2009. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5275839

Tuohy, A., and M. O'Malley, "Pumped storage in systems with very high wind penetration." Energy Policy, vol. 39, pp. 1965–1974, April 2011. http://dx.doi.org/10.1016/j.enpol.2011.01.026

University of Minnesota's Energy Transition Lab, Strategen Consulting, and Vibrant Clean Energy, Modernizing Minnesota's Grid: An Economic Analysis of Energy Storage Opportunities, Minnesota Energy Storage Strategy Workshop Final Report, July 11, 2017. [Online] Available: http://energytransition.umn.edu/wp-content/uploads/2017/07/Workshop-Report-Final.pdf.

Viswanathan, V., M. Kintner-Meyer, P. Balducci, C. Jin, "National Assessment of Energy Storage for Grid Balancing and Arbitrage." Phase II, Volume 2: Cost and Performance Characterization, Tech. Rep. PNNL-21388, Pacific Northwest National Laboratory, September 2013. [Online]. Available: http://energyenvironment.pnnl.gov/pdf/National_Assessment_Storage_PHASE_II_vol_2_final.pdf

Walawalkar, R., J. Apt and R. Mancini, "Economics of Electric Energy Storage for Energy Arbitrage and Regulation in New York." Energy Policy (35:2007); pp. 2558–2568, April 2007. http://dx.doi.org/10.1016/j.enpol.2006.09.005

Wang, Y., Y. Dvorkin, R. Fernandez-Blanco, B. Xu, T. Qiu, and D. S. Kirschen, "Look-Ahead Bidding Strategy for Energy Storage," IEEE Transactions on Sustainable Energy, Vol 8, No 3, pp. 1106 – 1117, July 2017. https://doi.org/10.1109/TSTE.2017.2656800

Wang, Y., Z. Zhou, A. Botterud, K. Zhang, and Q. Ding, "Stochastic coordinated operation of wind-battery energy storage system considering battery degradation", Journal of Modern Power Systems and Clean Energy, Vol. 4, No. 4, pp. 581-592, 2016. http://dx.doi.org/10.1007/s40565-016-0238-z

Wankmüller F., P. Thimmapuram, K.G. Gallagher, and A. Botterud, "Impact of Battery Degradation on Energy Arbitrage Revenue of Grid-level Energy Storage," Journal of Energy Storage, Vol. 10, pp. 55-66, 2017. http://dx.doi.org/10.1016/j.est.2016.12.004

Ward, M, "Resource Commitment and Dispatch in the PJM Wholesale Electricity Market," in Federal Energy Regulatory Commission Staff Technical Conference on Increasing Real-Time and Day-Ahead Market Efficiency through Improved Software, Washington, DC, June 2011. [Online]. Available: http://ferc.gov/CalendarFiles/20110628072854-Jun28-SesA2-Ward-PJM.pdf

Wilson, D., and L. Hughes, "Barriers to the Development of Electrical Energy Storage: A North American Perspective." The Electricity Journal, Volume 27, Issue 2, pp. 14–22, March 2014. http://dx.doi.org/10.1016/j.tej.2014.01.009

Wogrin, S. and D.F. Gayme, "Optimizing Storage Siting, Sizing and Technology Portfolios in Transmission-Constrained Networks," IEEE Transactions on Power Systems, vol. 30, no. 6, pp. 3304 – 3313, Nov. 2015. http://dx.doi.org/10.1109/TPWRS.2014.2379931

Wolfe, S., and A. Mensah, "Overcoming Challenges to High Penetration of Solar PV: Using Optimized Energy Storage and Distribution Grid Controls." The Electricity Journal, Volume 25, Issue 9, Pages 43-47, November 2012. http://dx.doi.org/10.1016/j.tej.2012.09.009

Wu, D., M.C.W Kintner-Meyer, T. Yang and P.J. Balducci, "Analytical Sizing Methods for behind-the-meter Battery Storage." Journal of Energy Storage 12:297-304, 2017. doi:10.1016/j.est.2017.04.009

Wu, D., C. Jin, P.J. Balducci and M.C.W. Kintner-Meyer. "An Energy Storage Assessment: Using Optimal Control Strategies to Capture Multiple Services." In IEEE Power and Energy Society General Meeting, July 26-30, 2015, Denver, Colorado, IEEE, Piscataway, NJ. doi:10.1109/PESGM.2015.7285820

Wu, D., C. Jin, P.J. Balducci and M.C.W. Kintner-Meyer. "Assessment of Energy Storage Alternatives in the Puget Sound Energy System, Volume 2: Energy Storage Evaluation Tool." PNNL-23039, 2013, Pacific Northwest National Laboratory, Richland, WA. [Online]. Available: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-23039.pdf

Xi, X., and R. Sioshansi, "A Dynamic Programming Model of Energy Storage and Transformer Deployments to Relieve Distribution Constraints." Computational Management Science, Vol 13, No 1, pp 119-146, January 2016. http://dx.doi.org/10.1007/s10287-014-0218-6

Xi, X., R. Sioshansi, and V. Marano, "A Stochastic Dynamic Programming Model for Co-optimization of Distributed Energy Storage." Energy Systems, Vol 5, No 3, pp 475-505, September 2014. http://dx.doi.org/10.1007/s12667-013-0100-6

Xu, B., Y. Wang, **Y. Dvorkin**, R. Fernandez-Blanco, C. A. Silva-Monroy, J. P. Watson, and D. S. Kirschen, "Scalable Planning for Energy Storage in Energy and Reserve Markets," *IEEE Transactions on Power Systems,* Vol 32, No 6, pp 4515 – 4527, November 2017. https://doi.org/10.1109/TPWRS.2017.2682790

Xu, B., A. Oudalov, A. Ulbig, G. Andersson and D. Kirschen, "Modeling of Lithium-Ion Battery Degradation for Cell Life Assessment," IEEE Transactions on Smart Grid, vol. PP, no. 99, pp. 1-1. https://doi.org/10.1109/TSG.2016.2578950

Xu, B., J. Zhao, T. Zheng, E. Litvinov and D. S. Kirschen, "Factoring the Cycle Aging Cost of Batteries Participating in Electricity Markets," IEEE Transactions on Power Systems, vol. PP, no. 99, pp. 1-1. https://doi.org/10.1109/TPWRS.2017.2733339

Xu, B., Y. Dvorkin, D. Kirschen, J-P. Watson, and C. Silva-Monroy, "A Comparison of Policies on the Participation of Storage in U.S. Frequency Regulation Markets," Proceedings of the 2016 IEEE PES General Meeting, Boston MA, July 2016. https://doi.org/10.1109/PESGM.2016.7741531

Xu, Y., L. Xie, and C. Singh, "Optimal scheduling and operation of load aggregator with electric energy storage in power markets." in Proc. North Amer. Power Symp. (NAPS), Sep. 26–28, 2010, pp. 1–7, September 2010. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5619601

Yucekaya, A. "The operational economics of compressed air energy storage system under uncertainty," Renewable and Sustainable Energy Reviews, no. 22, pp. 298 - 305, June 2013. http://dx.doi.org/10.1016/j.rser.2013.01.047

Zakeri, B., and S. Syri. "Electrical energy storage systems: A comparative life cycle cost analysis," Renewable and Sustainable Energy Reviews 42: 569-596, 2015. https://doi.org/10.1016/j.rser.2014.10.011

Zamani-Dehkordi, P., S. Shafiee, L. Rakai, A. M. Knight, and H. Zareipour, "Price impact assessment for large-scale merchant energy storage facilities," Energy, Vol 125, pp 27-43, April 2017. https://doi.org/10.1016/j.energy.2017.02.107

Zhang, N., C. Kang, D. S. Kirschen, Q. Xia, W. Xi, J. Huang, and Q. Zhang, "Planning Pumped Storage Capacity for Wind Power Integration." IEEE Transactions on Sustainable Energy, vol. 4, pp. 393–401, April 2013. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6392322

Zucker, A., Hinchliffe, and A. Spisto, "Assessing Storage Value in Electricity Markets." A literature review, European Commission, Joint Research Centre, Institute for Energy and Transport , Report EUR 26056 EN, September 2013. [Online]. Available: http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/29496/1/2013-10-09%20edf%20jrc%20power%20storage%20final%20%20%28online%20version%29%20.pdf

Zucker A. and Hinchliffe T., "Optimum sizing of PV-attached electricity storage according to power market signals - A case study for Germany and Italy." Applied Energy, August 2014. http://dx.doi.org/10.1016/j.apenergy.2014.04.038

The Electric Power Research Institute, Inc. (EPRI, www.epri.com) conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. An independent, nonprofit organization, EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including reliability, efficiency, affordability, health, safety and the environment. EPRI members represent 90% of the electric utility revenue in the United States with international participation in 35 countries. EPRI's principal offices and laboratories are located in Palo Alto, Calif.; Charlotte, N.C.; Knoxville, Tenn.; and Lenox, Mass.

Together...Shaping the Future of Electricity

Program:

Energy Storage and Distributed Generation

3002009356

Electric Power Research Institute
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com