EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Cost-Effectiveness of Energy Storage in California

Application of the EPRI Energy Storage Valuation Tool to Inform the California Public Utility Commission Proceeding R. 10-12-007

3002001162

Cost-Effectiveness of Energy Storage in California

Application of the EPRI Energy Storage Valuation Tool to Inform the California Public Utility Commission Proceeding R. 10-12-007

3002001162

Technical Update, June 2013

EPRI Project Manager

B. Kaun

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

DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITIES

THE FOLLOWING ORGANIZATION PREPARED THIS REPORT:

Electric Power Research Institute (EPRI)

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 prepared this report:

Electric Power Research Institute (EPRI)
3420 Hillview Avenue.
Palo Alto, CA 94304

Principal Investigators
B. Kaun
S. Chen

This report describes research sponsored by EPRI.

The authors would like to acknowledge the contribution of others who made this analysis possible: Haresh Kamath and Dan Rastler of EPRI for valuable guidance; Eric Cutter and Ben Haley of Energy & Environmental Economics (E3) for Energy Storage Valuation Tool development support; Aloke Gupta, Arthur O'Donnell and other CPUC technical staff for offering this opportunity and supporting the development of inputs for the analysis; Giovanni Damato and Chris Edgette from the California Energy Storage Alliance (CESA), Daidipya Patwa from PG&E, Armando Infanzon from SDG&E, and David Castle from SCE for informing inputs used by the CPUC technical staff.

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

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.

ABSTRACT

EPRI has developed an innovative methodology for quantifying the value of grid energy storage opportunities. The EPRI Energy Storage Valuation Tool (ESVT)—simulation software developed to support this methodology—enables preliminary economic analysis prior to more resource-intensive analytical efforts. This report describes applications of the methodology and tool to analyze a range of energy storage cases, including different uses, technologies, locations, and future electricity market scenarios. The analyses were performed to inform stakeholders of the California Public Utility Commission (CPUC) regulatory proceeding investigating the cost-effectiveness of energy storage in approximately 30 different cases.

These scenarios covered three different general use cases, including transmission-connected bulk energy storage, short-duration energy storage to provide ancillary services, and distribution-connected energy storage located at a utility substation. Within these use cases, several input sensitivities were tested for their impact on storage cost-effectiveness, including energy storage duration, technology, durability, market scenario, and project start year. The input assumptions were provided by the CPUC technical staff, with support from a core stakeholder working group, including energy storage and utility representatives.

The results of the analyses were reported using a number of technical and economic outputs and summarized in terms of lifetime net present value and breakeven capital cost of energy storage. Under the assumptions provided by the CPUC, the majority of cases returned benefit-to-cost ratios of greater than one, and the majority of cases returned breakeven capital cost of energy storage ranging from $1,000 to $4,000/kW installed. These results represent an early phase of energy storage valuation analysis, quantifying the direct costs and benefits over the lifetime of the energy storage system. The results do not consider indirect impacts on the functioning of the broader electric system or environmental impacts.

Keywords
Energy Storage Valuation
Energy Storage
California Public Utility Commission
Grid Analysis
Grid Energy Storage

EXECUTIVE SUMMARY

Introduction

EPRI has developed an innovative methodology for identifying and quantifying value for grid energy storage opportunities. The EPRI Energy Storage Valuation Tool (ESVT) was developed to support this methodology and enable preliminary cost-effectiveness analysis prior to more resource-intensive analytical efforts. This report describes results from the application of EPRI's valuation methodology and the ESVT to analyze prioritized cases in California, informing stakeholders of the California Public Utility Commission (CPUC) Energy Storage Order Instituting Rulemaking (OIR) Proceeding, R. 10-12-007. In total, EPRI investigated the value of storage in approximately 30 different use case scenarios, prioritized by the CPUC.

Background of Energy Storage Valuation

Historically, energy storage has been a challenging issue for regulators and policy-makers. Storage contains unique attributes that make apples-to-apples comparisons with conventional solutions challenging, including: 1) operation as both a generation and load source; 2) inherent limited duration of energy; 3) technical potential to support generation, transmission, and distribution systems with a single storage system, if appropriately located; 4) response and ramp speed for certain storage technologies exceeding that of conventional solutions; 5) limited commercial track record, limiting long-term understanding of the cost, performance, and safety implications of storage deployment.

Methodology for Energy Storage Valuation

EPRI has developed a four-step methodology for valuing storage, with emphasis on the grid services that storage can provide. This methodology is summarized below.

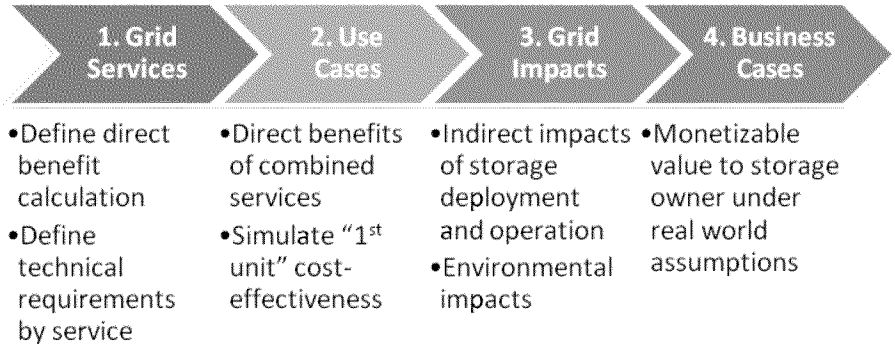

Figure ES-1
Overview of EPRI Energy Storage Valuation Methodology

The analyses in this report focus primarily on the first two steps of this methodology. The results for storage cost-effectiveness provide a comparison of direct, quantifiable benefits versus costs to all parties benefiting from storage operation, on a net present value basis. This is analogous to the Total Resource Cost (TRC) approach used in California. It is an analysis of the approximate technical potential of energy storage operation to provide multiple services to the electric system. The results DO NOT consider: 1) the indirect impacts of storage deployment levels on market prices, operation of other assets, or greenhouse gas emissions; 2) third-party business models, or regulatory considerations that may limit real-world monetization.

The goal of the analysis is to estimate the relative cost-effectiveness and expected operation of energy storage under a given sets of assumptions: 1) energy storage system technology and configuration; 2) grid services provided under each use case; 3) location of the storage system; 4) future market conditions; and 5) project start year. This information should help investigators to screen the cost-effectiveness of a large number of potential cases, prior to embarking on detailed exercises in network and production cost modeling, which tends to be resource-intensive.

The Energy Storage Valuation Tool (ESVT)

To provide the capability to screen the cost-effectiveness of energy storage at sufficient granularity, EPRI developed the Energy Storage Valuation Tool, with the development assistance of Energy and Environmental Economics (E3). This tool was used to produce all results in this report. The ESVT leverages three main categories of input data to simulate storage operation and provide cost-effectiveness results: 1) grid service technical requirements defined by electric system needs and benefit calculation inputs; 2) financial assumptions for the storage owner, including discount rate and tax assumptions; 3) the cost, performance, size, and configuration of a storage system technology. The ESVT then takes the user-provided information and simulates storage operation to meet all technical requirements of the grid service and maximize its remaining potential in the energy and ancillary service markets. The tool can provide a number of outputs from the simulation, including lifetime, annual, daily, and hourly valuation and operation data.

Overview of Analysis Scope

Stakeholders in the CPUC storage proceeding have identified several different potential use cases of energy storage. These use cases are listed in the table below. Due to time and resource constraints for this analysis project, EPRI was able to address only the three highlighted cases in the table. CPUC prioritized use cases based on perceived potential for high value and ease of adaptation to the ESVT.

Table ES-1
Prioritized CPUC Use Cases for EPRI Analysis (Highlighted)

Categories	Use Cases
Transmission-Connected Energy Storage	Bulk Storage System (aka Peaker Substitution)
	Ancillary Services
	On-Site Generation Storage
	On-Site Variable Energy Resource Storage
Distribution-Level Energy Storage	Distributed Peaker
	Distributed Storage Sited at Utility Substation
	Community Energy Storage
Demand-Side (Customer-Sited) Energy Storage	Customer Bill Management
	Customer Bill Management w/ Market Participation
	Behind the Meter Utility Controlled
	Permanent Load Shifting
	EV Charging

Analysis Inputs

Inputs to the ESVT analyses were provided by the CPUC technical staff, with advice provided by a core stakeholder group, including the California Energy Storage Alliance (CESA), Pacific Gas & Electric (PG&E), San Diego Gas & Electric (SDG&E), and Southern California Edison (SCE). EPRI provided analysis input guidance only sparingly, primarily to clarify the definitions of inputs required for ESVT analysis. Validation of inputs was not part of EPRI's scope in the analyses.

Summary of Outputs

Summary results from the analyses are provided below in two forms: 1) benefit-to-cost (B/C) ratio and 2) breakeven capital cost. B/C ratio is the net present value (NPV) of all direct, quantifiable benefits divided by the NPV of the direct, quantifiable costs of a defined energy storage system providing specific grid services over its lifetime. Breakeven capital cost is the estimated upfront capital cost of a storage system with certain defined performance characteristics, which would result in a B/C ratio of 1, or breakeven net present value. Breakeven capital costs are relevant only under the storage technology assumptions and cannot be compared side-by-side. The actual capital cost of different storage systems may vary widely, but the potential value may vary widely, too. This table summarizes all cases, including those with project start years in 2015 and 2020, but all breakeven capital costs are adjusted for inflation and displayed in 2013 dollars.

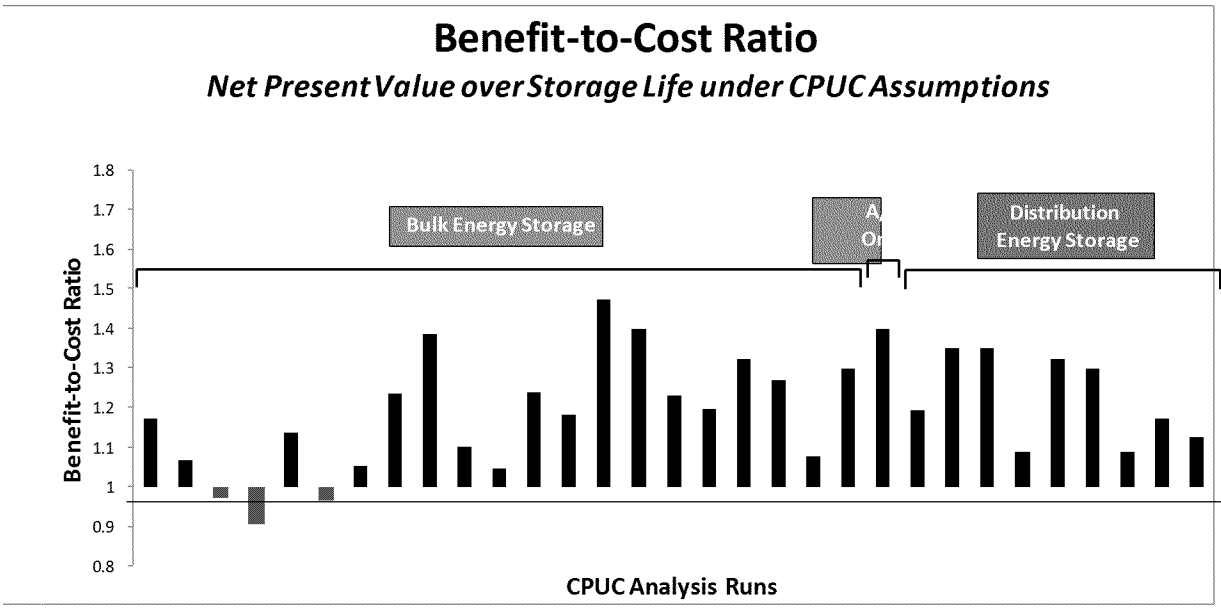

Figure ES-2
Benefit-to-Cost Ratios of All Analysis Runs

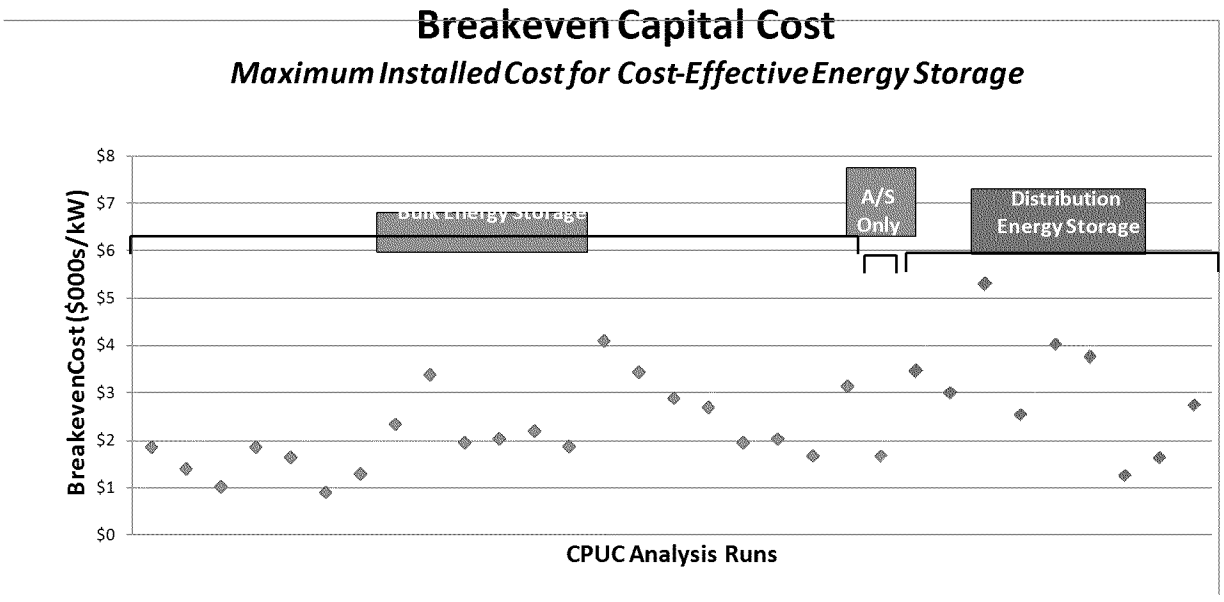

Figure ES-3
Energy Storage Breakeven Capital Cost of All Analysis Runs

Conclusions

At the summary level, under the cost and performance assumptions assumed by the CPUC, most analysis runs return B/C ratios of greater than 1.

Across the three use cases considered, it is difficult to draw strong conclusions about the relative cost-effectiveness between use cases. A disproportionate number of cases investigated the bulk storage use case.

1. Some of the other key conclusions from the analysis include: Storage system duration of 2 hours exceeded cost-effectiveness of 4 hours for assumed "base case" battery storage system
2. Storage system durability was relevant to cost-effectiveness. A storage system 10 year usable battery life had substantially better cost-effectiveness than 5 year usable battery life.
3. Regulation service provided a significant proportion of the value in most cases. Cases with a 2x price multiplier for storage providing "fast regulation" returned significantly more cost-effective results. In a case with no regulation service value, spinning reserve value compensated for part of the lost value, but at significantly reduced cost-effectiveness.
4. High energy and ancillary service prices result in more cost-effective results for energy storage.
5. Projects beginning in 2020 had better cost-effectiveness results than 2015, due primarily to technology cost reductions and higher value for capacity, energy, and ancillary services.

Important Caveats

- Only a limited, prioritized series of analysis runs were completed. Results do not represent exhaustive treatment of storage opportunities in California.
- Results are only valid under the CPUC input assumptions provided.
- Analysis is limited to direct, quantifiable costs and benefits under the input assumptions and grid services modeled in the simulation.
- Analysis does not specifically consider how levels of storage deployment affect cost-effectiveness or impact society.
- This project does not consider technical feasibility of energy storage projects, nor does it validate the cost and performance assumptions used in the analyses.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1
BACKGROUND OF THIS PROJECT

Summary of EPRI Project for California Public Utility Commission

In 2012, the California Public Utility Commission (CPUC) approached EPRI to leverage prior research in the area of energy storage valuation to technically inform stakeholders of an energy storage rulemaking proceeding. EPRI agreed to fund a limited valuation analysis of high priority cases to help validate EPRI's innovative storage valuation methodology and software, the Energy Storage Valuation Tool. EPRI agreed to perform analysis and reporting, with prioritized scenarios and inputs defined by the CPUC technical staff. EPRI analyzed approximately 30 cases for energy storage in California and the results are reported in this document.

Background of California Bill AB2514 and CPUC Energy Storage OIR Proceeding

Instruction to Investigate Storage Procurement Targets in California. In September 2010, former Governor Arnold Schwarzeneggar signed California Assembly Bill AB2514 into law. AB2514 required the California Public Utility Commission (CPUC) to open a new proceeding to "establish procurement targets, if any, for each load serving entity to procure viable and cost-effective energy storage systems and, by October 1, 2013, to adopt an energy storage procurement target, to be achieved by each load-serving entity by December 31, 2015, and a second procurement target to be achieved by December 31, 2020." [1] The proceeding is known commonly as the "CPUC Storage OIR," or Order Instituting Rulemaking, and is identified as R. 10-12-007.

CPUC Energy Storage Proceeding (R. 10-12-007) and Storage Cost-Effectiveness

Investigation of Storage Cost-Effectiveness. As directed in AB2514, one determination to be made by the CPUC is to assess the cost-effectiveness of energy storage systems. For several years, the Electric Power Research Institute (EPRI) has performed investigations into the value of energy storage performing different services to the grid, in various locations, and with multiple technologies, to understand where storage makes economic sense [2]. Since 2011, EPRI has been developing the Energy Storage Valuation Tool (ESVT) to assist in making these investigations more repeatable and user-friendly. The CPUC approached EPRI to provide technical assistance to the storage proceeding using the ESVT. EPRI agreed to perform an analysis of storage cost-effectiveness for the CPUC stakeholders with prioritized, limited scope. Inputs to the analysis were provided by the CPUC technical staff in collaboration with a core stakeholder group, and EPRI configured and performed analyses with the ESVT on a set of approximately 30 "runs" covering three use cases defined by stakeholder parties to the CPUC Storage OIR. Draft results of the initial analyses were presented in a public workshop on March 25, 2013. In the weeks that followed, comments were provided by the CPUC, and a small number of additional sensitivities were analyzed to provide additional depth to the analyses. This report summarizes the ESVT performance of cases, inputs, modeling details, and results found in the EPRI investigation of storage cost-effectiveness for the CPUC Storage OIR.

2
OVERVIEW OF ENERGY STORAGE VALUATION METHODOLOGY AND ENERGY STORAGE VALUATION TOOL

Challenges of Energy Storage Valuation

Energy storage valuation for grid use cases has historically been challenging, due to unique technology attributes, technology uncertainties, and regulatory challenges. EPRI has proposed a methodology for separating and clarifying analytical stages for storage valuation and developed the Energy Storage Valuation Tool (ESVT) to support this methodology by enabling user-friendly, customizable, and transparent storage value analysis.

Energy storage has unique advantages and limitations, and it does not fit neatly into the existing electric system asset categories. Conventional assets for the electric grid generally can be classified as generation, transmission, or distribution, and existing policy, regulation, and even technical tools have evolved around these distinctions. Fossil power plants are distinctly generation, and wires and transformers are distinctly transmission or distribution, depending on voltage class. In contrast, energy storage systems may be located on either the transmission or distribution network (or even on the customer side of the meter), and they have characteristics that sometimes bring value to generation and other times to transmission or distribution. As a result, it is often not possible to benchmark storage clearly with identical size, usage, and location against a conventional grid asset. Furthermore, there are business cases and regulatory complexities. Generation is deregulated, and generation companies make their business cases in the California Independent System Operator (CAISO) market, where transmission and distribution assets are allowed a regulated return on investment. The owners of these assets differ as well; independent power producers (IPPs) own most of the generation assets, and investor-owned utilities (IOUs) own most T&D assets in California.

Energy storage has promising drivers of growth, including increasing grid flexibility needs due to a trend toward higher quantities of variable wind and solar generation, and huge investment in battery R&D and manufacturing capacity, driven by the consumer electronics and electric vehicle industries. However, storage has remained too expensive to be justifiable for single-service usage, in most cases. As a result, advocates of energy storage and early adopters have taken an exhaustive approach to identifying the benefits of storage, listing dozens of benefits that energy storage may be able to provide to the electric system. Lists of such benefits have been relatively consistent in spirit, but the terminology and definitions have varied, and clear distinctions have been difficult to create. As a result, to perform high-fidelity analysis, care must be taken to ensure that benefits are distinct and do not overlap. Additionally, although certain identified services and benefits could be compatible to combine and perform with a single energy storage system, others may compete with one another or be otherwise incompatible. Clear definitions of requirements, benefit calculations, and multiple use compatibility are critical for reliable, repeatable analysis.

To address these issues and the confusion that can result, EPRI has proposed a methodology to clarify energy storage valuation by stage. The journey through stages of energy storage valuation is illustrated in the next section.

Energy Storage Valuation Stages

Before delving into valuation, it is important to clarify foundational terminology. In this report, a *grid service* is defined as a distinct function of a grid asset to support the electric system, which contains a set of 1) technical requirements and 2) benefit calculations. A *use case* is defined as an integrated set of grid services performed by a technology at a distinct site or location on the grid.

Storage Cost Versus Individual Grid Service Benefits

As previously mentioned, the foundational issue with the valuation of energy storage is that cost of storage typically exceeds benefit for individual grid service. In the example shown in Figure 2-1, a hypothetical battery storage system is located within a utility's distribution system. The energy storage may be technically capable of supporting a number of grid services, and no single grid service can support the cost of the storage system. Storage cost includes the fully integrated storage system, including storage technology, power electronics, controls, balance of plant, installation, commissioning, and integration in the electric system. Grid services are shown here for illustration, and definitions are provided in Chapter 3.

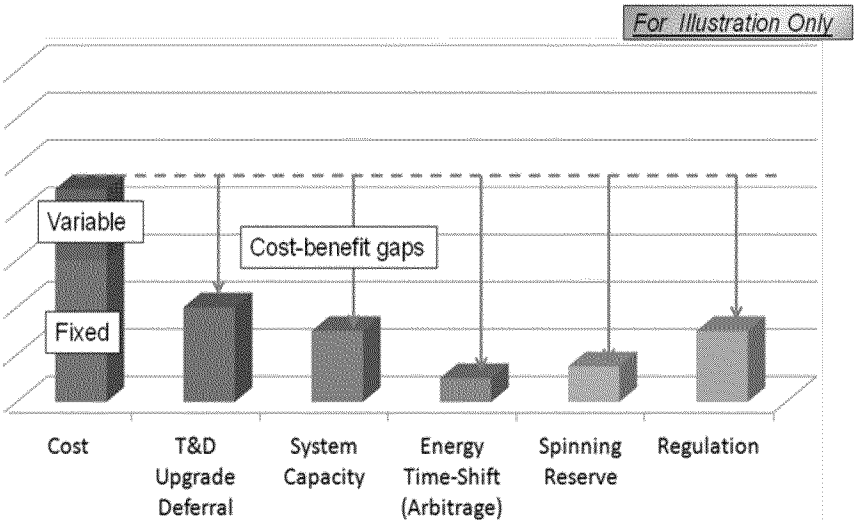

Figure 2-1
Comparison of Storage Cost Compared to Individual Grid Service Benefits

"Stacking" the Benefits of Energy Storage

Each of the services shown in the illustrative example may only require a fraction of the operational capability and availability of the energy storage system. For example, the "T&D Upgrade Deferral" may be triggered by a very small number of annual peak load events, perhaps 10 days per year. It is therefore possible that a storage system designed to offload a T&D asset during infrequent peaks may have significant opportunities to provide additional benefits to the electric system.

To begin to illustrate the potential value of the energy storage system in a use case, we can look at the potential of stacking the benefits from each grid service as a simple sum. This is illustrated in Figure 2-2.

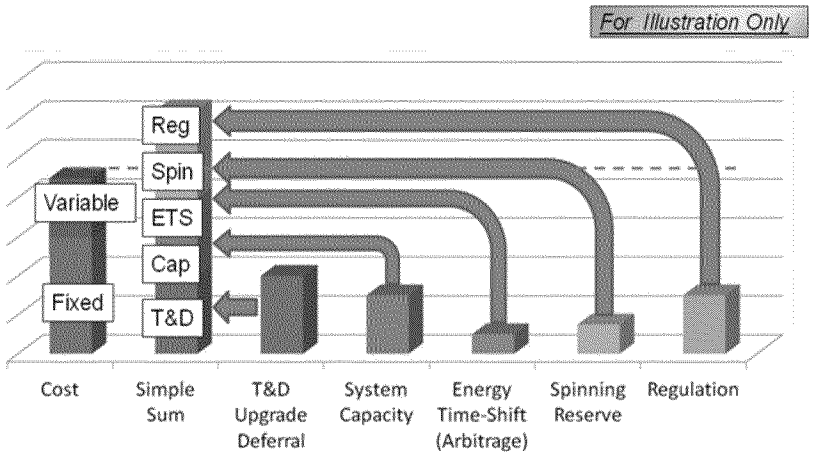

Figure 2-2
Benefit Stacking as a Simple Sum

If benefit stacking of this type were possible, the results provide a compelling look for storage in this illustration. The "simple sum" of benefits is the cost of storage. However, a simple sum of benefits does not account for the operational realities of energy storage on the grid. Returning to our example of the T&D Upgrade Deferral, the storage system may need to be reserved for a number of days each year to offset peak load hours because it has been installed in lieu of a line or transformer upgrade; therefore, its availability to perform other services should be constrained to meet this commitment prior to addressing other grid services that may provide additional value. Furthermore, it is not possible to perform all the other grid services simultaneously, and the energy storage scheduler would need to choose the most valuable service for the storage system to provide at any given time. The value for providing energy, regulation, spinning reserve, and other services typically changes from hour to hour.

Calculating "Technical Potential" of Storage

The next phase of storage valuation is defining "technical potential," which is the value that an energy storage system may be capable of providing from a technical-only perspective, with optimized operation to maximize value. Figure 2-3 illustrates "technical potential," which shows a reduction in value from a simple sum of individual benefits, because the value incorporates an optimized simulation of storage operation under the operational and availability constraints of providing multiple grid services. In a nutshell, the goal is to answer the following question: What are the direct, quantifiable costs and benefits of energy storage in a specific use case, aggregated across all electric system stakeholders of energy storage? This phase of the analysis is analogous to the Total Resource Cost (TRC) test in the California Standard Practices Manual. TRC test aggregates the benefits and costs of all electric system stakeholders, including utilities and ratepayers, into a single cost-effectiveness analysis.

Technical potential ignores any indirect costs or benefits of storage operation, such as environmental impacts or improvements in the operation of the electric system. It also ignores

business and regulatory complexities that affect energy storage valuation. These will be addressed in later phases.

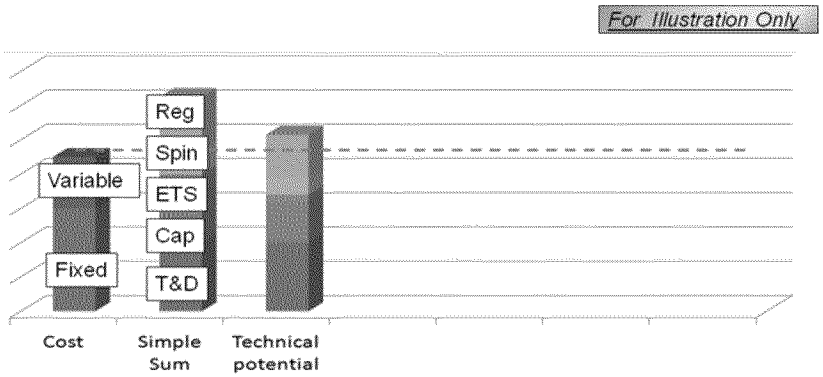

Figure 2-3
Energy Storage Valuation Technical Potential

Calculating "Monetizable Potential" of Storage

For an owner of energy storage, the cost-benefit calculation is more accurately shown by the monetizable potential in Figure 2-4. This is the portion of the direct, quantifiable value identified in the technical potential that the owner of the energy storage could actually be paid for. If there are third parties required or specific regulatory constraints, it may not be possible for the energy storage owner to capture all of the values that it creates in its operation.

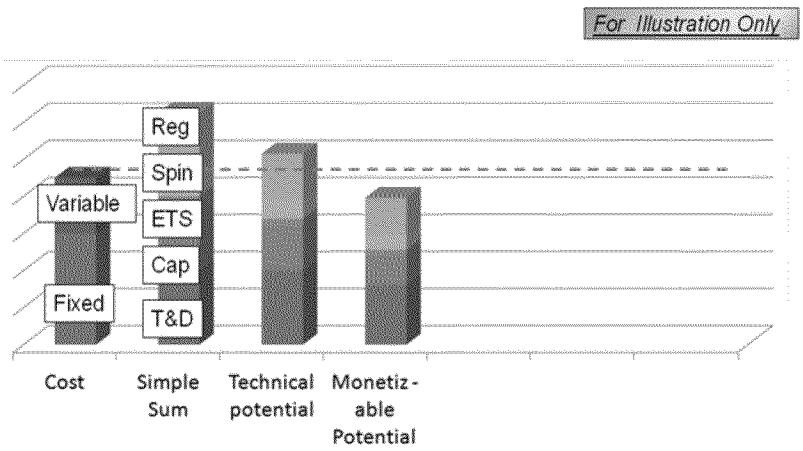

Figure 2-4
Energy Storage Valuation Monetizable Potential

The appearance of this value stacked bar may vary depending on market circumstances and the owner of the device. Each of the stacked values may shrink proportionally, as shown in the figure above, or perhaps certain sections will disappear entirely. For example, under current regulation, a utility owner may be challenged to own energy storage that makes money by performing market services, like frequency regulation and spinning reserve.

Calculating "Monetizable Potential (nth unit)" of Storage

The "monetizable potential" as discussed is still not the entire story of the business case for energy storage. Currently, the CPUC is investigating potential procurement targets of energy storage in the State of California. Under different energy storage deployment scenarios, the value of energy storage may change. Change in value may be more notable when energy storage performs grid services with shallow demand, where storage has low marginal cost of performing the service, giving it the potential to become a "price maker" and set the marginal value of performing the service. In this phase, we are interested in the monetizable value of energy storage after a certain number ("n" units) of energy storage have been deployed. This accounts for the extra competition present with energy storage on the grid. It is expected that the monetizable value of energy storage decreases as deployment increases. This is, essentially, the Law of Diminishing Marginal Returns from the field of economics. The cost-benefit comparison at this stage of analysis is illustrated in Figure 2-5.

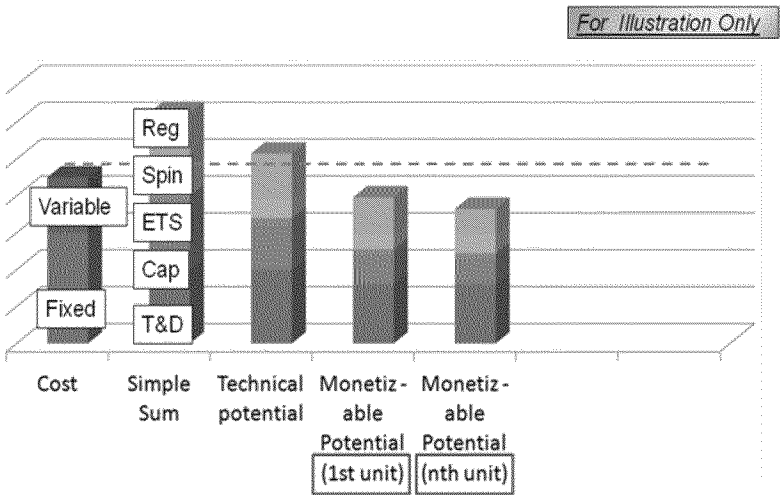

Figure 2-5
Energy Storage Valuation Monetizable Potential Under Deployment

Calculating Societal Benefits of Storage

Thus far, successive negative adjustments to the cost-effectiveness potential of an illustrative energy storage use case have been illustrated. However, energy storage may provide benefits to the electricity system and society, perhaps by improving utilization T&D assets, enabling the fossil generator fleet to operator more efficiently, or by increasing the levels of wind and solar that can be accommodated by the electricity system. Quantifying these benefits with high fidelity requires the usage of more detailed analysis tools that represent the existing generators, as well as the transmission and distribution systems. Currently, there is no "all-in-one" tool to answer all the relevant valuation questions for storage at the bulk electricity systems, but several studies have attempted to address pieces of this challenging area. Traditional production simulation tools are currently being enhanced and applied to understanding the effects of storage on the transmission system. These are long-term analysis projects with numerous assumptions, as well as long setup and run times, and modeling limitations, but the results of the analysis could be enormously valuable if model features fully support storage and the analyses were run properly.

An illustration of the costs and benefits of energy storage, including additional second-order and societal benefits, is illustrated in Figure 2-6.

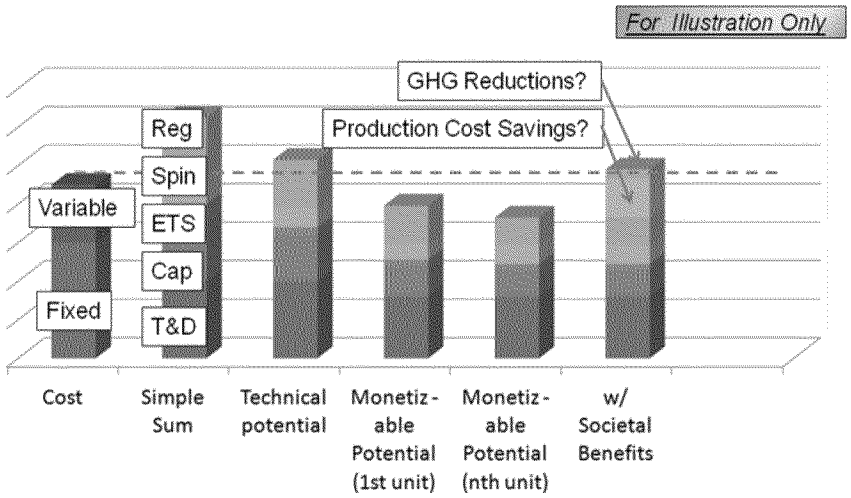

Figure 2-6
Energy Storage Valuation Monetizable Potential Under Deployment with Societal Benefits

Calculating Business Cases for Energy Storage

The ultimate stage of energy storage value analysis is the business case. The illustration in Figure 2-7 shows a gap where cost exceeds benefit for "Monetizable Potential (nth unit)." However, "w/ Societal Benefits" shows benefits exceeding cost.

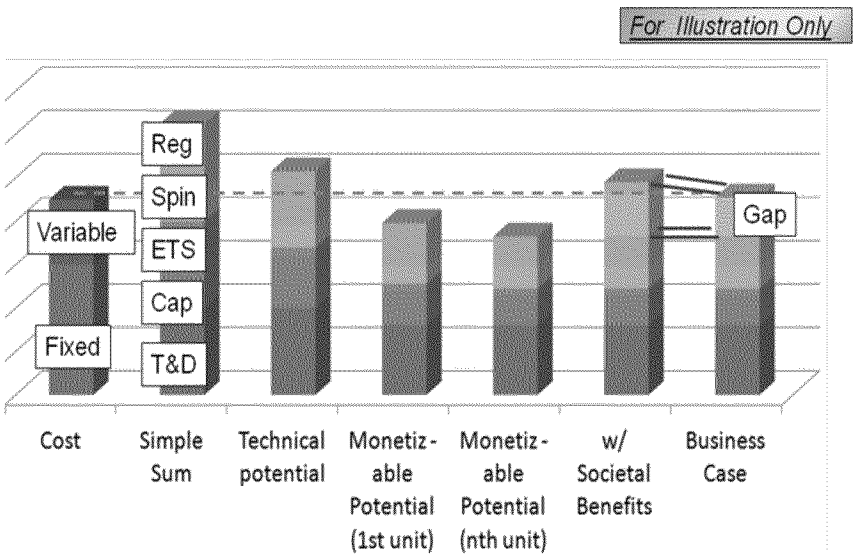

Figure 2-7
Energy Storage Business Cases

Because the storage owner is earning benefits equivalent to "Monetizable Potential (nth unit)," the owner would not have incentive to build a storage project in this case. For storage to show a feasible business case, the gap would have to be filled, either through a cost reduction or an increase in benefits. Ultimately, the real business cases for storage, not simulated technical

potential, monetizable potential, or societal benefits—will define the adoption potential for the technology.

The business case potential for storage is best considered after this journey through valuation, because each step informs the setup of the subsequent step.

Energy Storage Valuation Methodology

The preceding section illustrated the complexity of energy storage valuation and the need for a methodical approach to this analysis. This section summarizes an energy storage valuation methodology used to generate similar cost-benefit comparisons illustrated in the preceding section. An overview of the EPRI Energy Storage Valuation Methodology is illustrated in Figure 2-8.

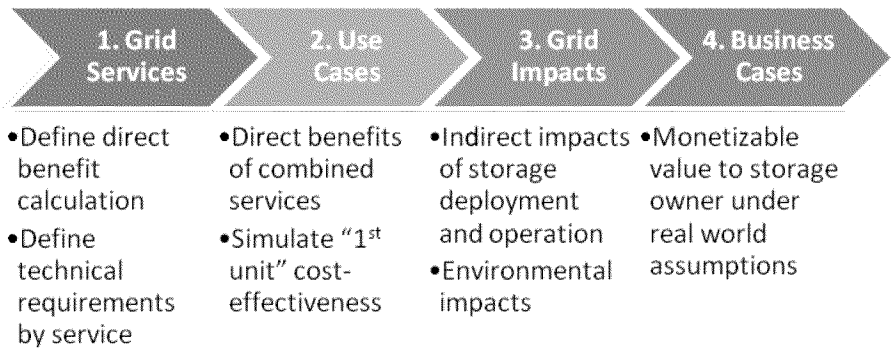

Figure 2-8
Overview of EPRI Energy Storage Valuation Methodology

Phase I: Define Grid Services

Phase 1 of the energy storage valuation methodology is defining grid services. Depending on the grid service in question, there will be a specific set of technical requirements and a benefit calculation expression.

For example, the technical requirement of a distribution investment deferral triggered by load growth may be expressed in terms of the minimum capacity, duration, and availability of the energy storage system. To achieve a deferral, the energy storage system would need to have sufficient capacity (power) to offset projected load growth on the deferred asset upgrade, sufficient duration of energy stored to address the length of expected peak load, and availability for all peak days. The specifics for these technical requirements may vary from site-to-site and utility-to-utility, and in some cases they may not be fully developed in terms of storage requirements, if the grid service has not been performed by storage in the past. Technical requirements for grid services administered through independent system operator (ISO) markets are typically more well-defined, although even they may have been developed with a resource-centric ("what the conventional asset can do") rather than a system-centric ("what the grid needs") perspective.

The benefit calculation for the distribution deferral service would be an expression that incorporates the time value of money for the expected length of the deferral of the overnight cost of the asset upgrade in this case. Once again, this would need to be validated on a site-specific

basis. For grid services that have a transparent ISO market, it is significantly simpler to calculate the value of the service by the price of market clearing.

For all grid services analyzed in this report, the technical requirements and benefit calculation methods are quantified.

Phase 2: Identify Feasible Use Cases

After the underlying grid services have been quantified, the next phase of the storage valuation methodology is to combine these services into a use case. The operation of the storage system is then simulated to follow a prioritization and optimization to understand its use case value.

The prioritization of service in the use case follows the duration of the commitment and severity of the penalty of not being available. In the previous example, the use case contains a T&D deferral, system capacity, and market services (energy, spinning reserve, and regulation service). Typically, it would be expected that the commitment of a distribution deferral would be multiple years, and the energy storage would be relied upon to offset load growth during peak load periods. As a result, the distribution deferral would take highest priority. System capacity is another high-priority grid service because it represents an avoided cost of not building a marginal fossil generator. However, this payment is typically paid yearly or monthly, so the term of commitment is not as great; also, there is significantly more resource diversity at the transmission system level than there is on a distribution feeder, so failure to be available to provide system capacity, while important, would likely be a lower priority than the distribution deferral service. Finally, the majority of market services are scheduled in the day-ahead ISO market. Depending on the opportunities available in the market, the storage system could then optimize its value by providing the most profitable services throughout the day.

The goal in Phase 2 of the methodology is to identify use cases with good prospects for cost-effectiveness. It also informs the understanding of key input sensitivities that could affect the cost-effectiveness of storage. This is the key phase of focus in the CPUC project.

Phase 3: Understand Grid Impacts

The purpose of Phase 3 of the methodology is to understand the potential grid impacts of different deployments of energy storage on the electric system. This phase will enable improved understanding of secondary and societal benefits (or costs) associated with operation of energy storage. Grid impact analysis, performed with load flow simulation or production cost simulation tools, among others, may improve understanding of answers to the following questions (and others):

1. What are the overall effects of different storage deployment scenarios on the total production cost of electricity?
2. What are the effects of storage deployment scenarios on greenhouse gas emissions?
3. How do energy storage deployment scenarios impact the value of grid services?
4. What are the effects of storage deployment scenarios on the operation of individual generators?
5. How do storage deployments affect the transmission system utilization and load factor?

Modeling of grid impacts can inform planners and operators of the potential effects of storage on the rest of the system and help them to use storage most effectively. These analyses can also inform regulators and policy-makers of the potential societal costs and benefits to energy storage deployments that are not necessarily monetizable by the energy storage owner.

Grid impact models often contain significant detail of the transmission system and generators. It can be very time-consuming to set up and run these analyses, and it is even more difficult to clearly convey the underlying assumptions to stakeholder. As a result, these analyses are necessarily limited to a subset of the potential scenarios of interest. For this reason, it is important to understand the cost-effectiveness potential of a use case prior to this level of detail to target grid impact analysis to validated use cases.

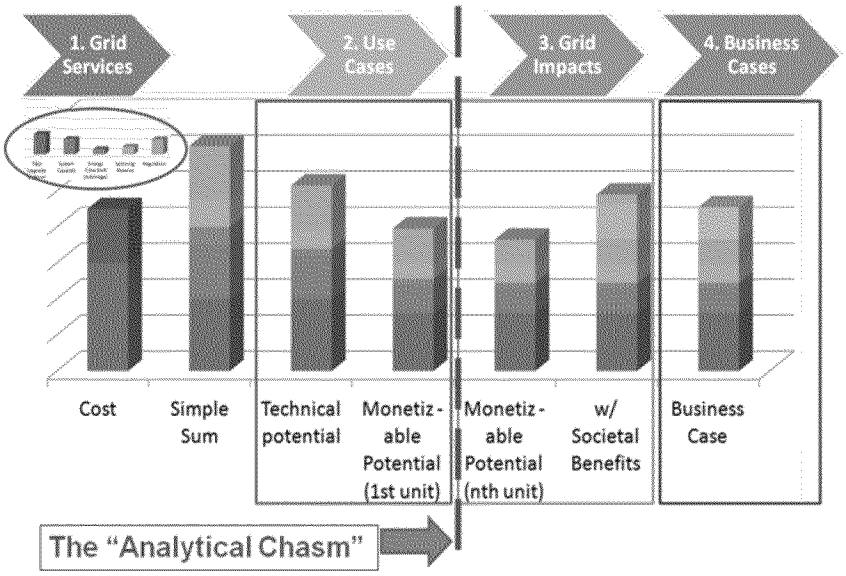

Figure 2-9
Grid Impact Analysis "Chasm"

The interface between Phase 2 and 3 of energy storage valuation methodology could be referred to as the "analytical chasm," illustrated in Figure 2-9. Due to the resource-intensity of Phase 3, it is possible for a grid impact analysis to be derailed if the key assumptions are not informed to sufficient depth and the scenarios of interest are not carefully crafted. As a result, grid impact analysis should be performed very judiciously.

Although the results in this report do not address the issues of grid impact analysis, they would be useful to inform specific cases and scenarios to test in a future analysis project that does address those issues.

Phase 4: Business Cases

The final stage of this energy storage valuation methodology is the understanding of real business cases under different scenarios. All previous phases build to this point, which seeks to understand the business realities facing an energy storage owner and may include a number of complex sources of value and cost, including real energy storage business models and economic effects of specific federal or state policies relevant to energy storage

Overview of Energy Storage Valuation Tool

The EPRI Energy Storage Valuation Tool (ESVT) is important for facilitating the valuation methodology summarized in the previous section.

ESVT Strengths

EPRI has developed the Energy Storage Valuation Tool Version 3.1 to enable the assessment of energy storage cost-effectiveness in different use cases. ESVT was designed with goals of **1) site-customizable, 2) user-friendly, and 3) model and input transparency**. With a step-by-step user interface, it guides the user through the necessary steps to define and enter data for energy storage use cases (see Figure 2-10).

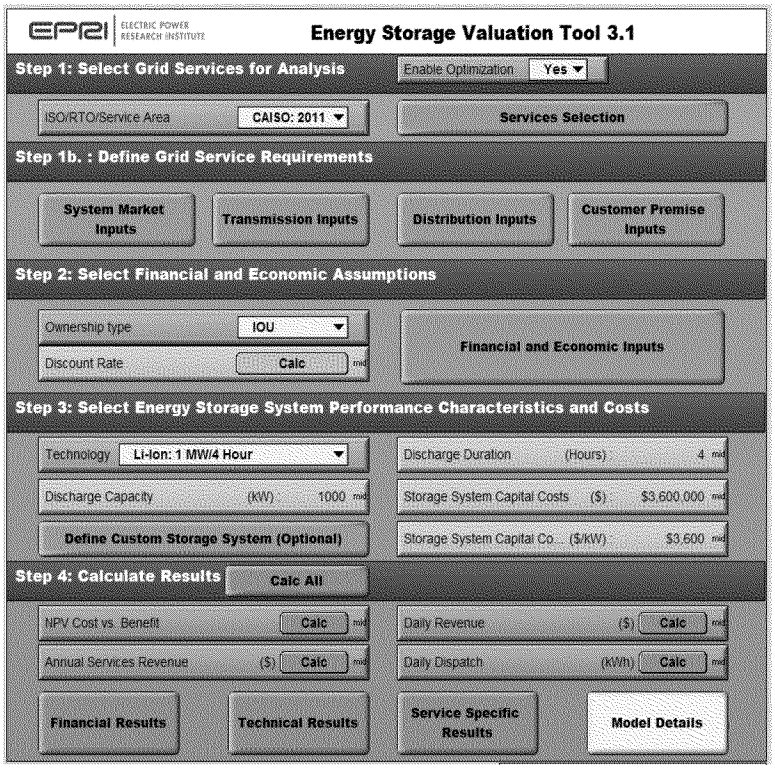

Figure 2-10
ESVT User Interface

Full scope of quantifiable grid services. ESVT calculates the value of energy storage use cases considering the full scope of the electricity system, including system/market, transmission, distribution, and customer services.

Supports a wide range of energy storage technologies. ESVT also models a wide range of pre-loaded storage technologies, including several battery technologies, compressed air energy storage (CAES), and pumped hydropower, leveraging EPRI's domain expertise in understanding the cost and perfomance of different storage technologies. It also models combustion turbine operation for business case comparison purposes. Input parameters of all technologies can be customized to best match the knowledge and expectations of cost and performance of the user.

Supports grid impact / production cost modeling analyses. ESVT can play an important role to inform grid impact analysis. Grid impact analysis should be set up with appropriate assumptions and scenarios that are more likely to result in energy storage cost-effectiveness. If there is little chance that a specific use case will result in cost-effectiveness, there is little justification for trying to understand the impacts of that use case under different levels of deployment. Where an ESVT analysis run can be set up and run in minutes-to-hours, a production simulation analysis run may take orders of magnitude additional effort, potentially days-to-weeks or longer. ESVT can be used to find high potential use case inputs and important sensitivities prior and in parallel to production cost modeling efforts.

How It Works—Inputs and Outputs

ESVT simulates energy storage operation for different use cases with compatible grid services, based on user selections of location-specific load and price data, owner financial characteristics, and technology performance and cost information. The ESVT simulation engine utilizes a hierarchical dispatch that prioritizes long-term commitments over shorter ones and co-optimizes for energy storage system profitability across services where decisions are made in the day-ahead market. A diagram of the key inputs, model operation, and outputs are displayed in Figure 2-11.

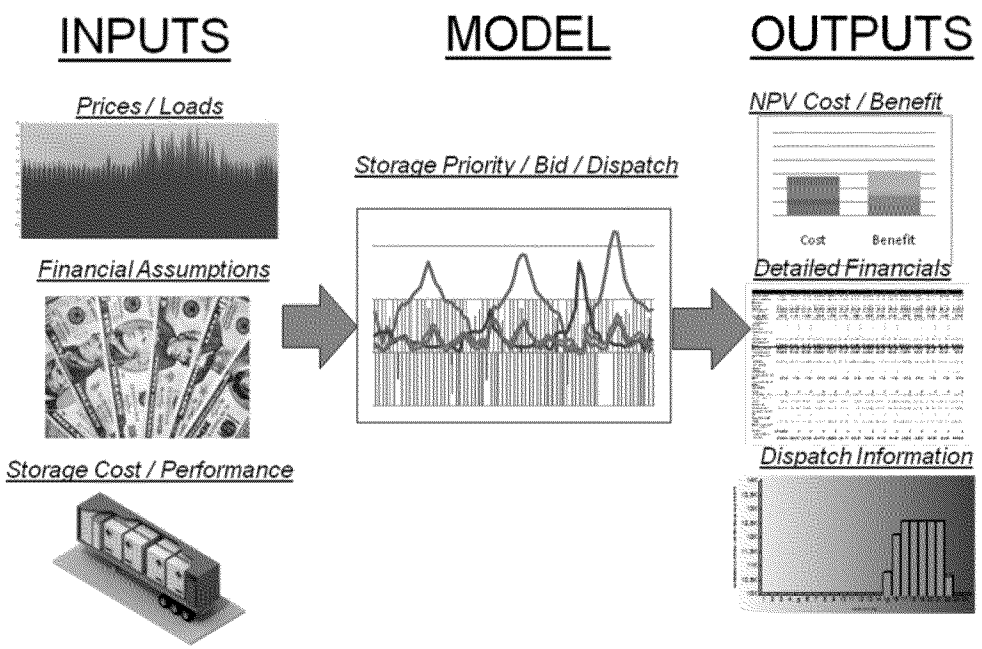

Figure 2-11
Diagram of ESVT Inputs, Model, Outputs

ESVT's outputs include financial results such as NPV, financial *pro forma* statement, technical simulation outputs, such as counting of battery cycles and their depth of discharge. It also provides an array of grid service-specific results, such as annual revenue by service (Figure 2-12) and hourly dispatch results (Figure 2-13). The tool calculates the potential value streams from chosen grid service, accounting for the site-specific benefits and technical requirements to provide the service.

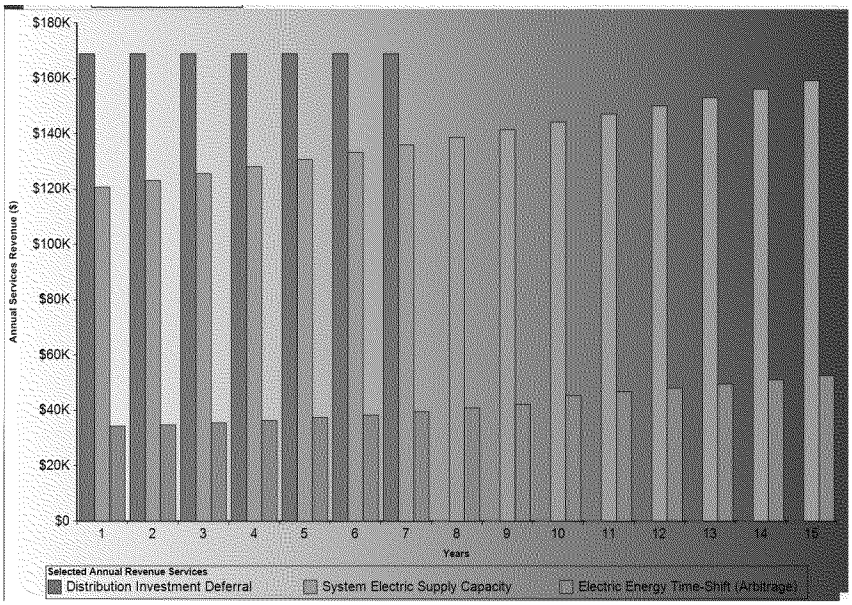

Figure 2-12
ESVT Example Output: Energy Storage Annual Revenue by Grid Service

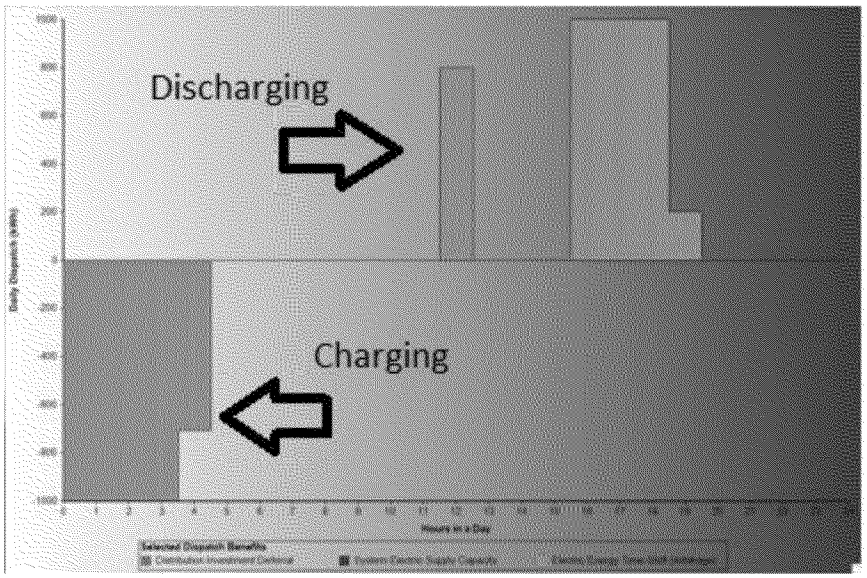

Figure 2-13
ESVT Example Output: Energy Storage Hourly Dispatch by Grid Service

The Energy Storage Valuation Tool development continues with an updated model (Version 4) expected in mid-2014. Version 3.1 (issued April 2013) is currently available for public purchase from www.epri.com (Product ID: 3002000312).

What ESVT does not do

ESVT was developed to support Phase 2: Feasible Use Cases, of the energy storage valuation methodology. As a result, it is not intended to quantify the indirect grid and societal impacts of energy storage deployment.

ESVT does not currently quantify the following:

1. Greenhouse gas impacts of storage deployment
2. Market price impacts of storage deployment
3. Asset utilization impacts for generators and transmission system

ESVT is a flexible tool for quickly assessing the relative cost-effectiveness of energy storage under different use cases, including a wide range of grid services, technologies, and market assumptions.

The output results of ESVT analyses, as provided in this report, represent an early phase of rigorous energy storage valuation efforts. The ESVT provides a user-friendly, transparent tool to pivot storage cost-effectiveness analyses and inform multi-stakeholder conversations, but it is not intended to replace the grid reliability analysis or production cost modeling tools.

3
APPLICATION OF ENERGY STORAGE VALUATION TOOL TO UNDERSTAND CPUC-DEFINED USE CASE COST-EFFECTIVENESS

Scope of this Analysis

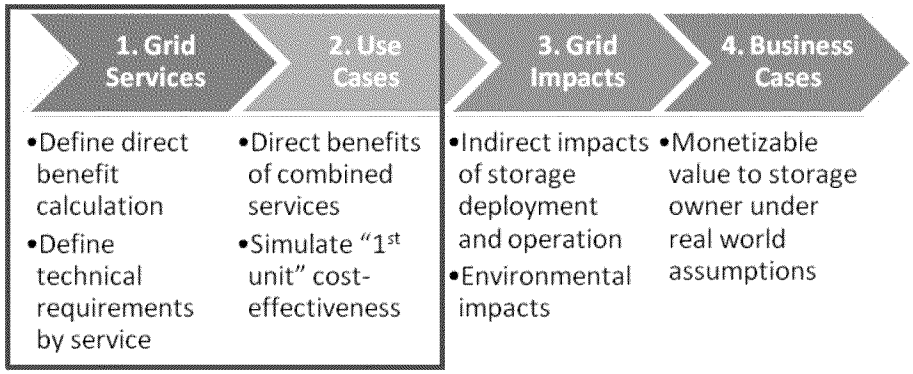

Figure 3-1
Energy Storage Valuation Methodology: Scope of CPUC Analysis

The scope of the EPRI analysis for the CPUC, as framed by the EPRI Energy Storage Valuation Methodology is displayed in Figure 3-1. For CPUC-defined use cases, EPRI performed Phase 1 and 2 of the methodology, described in detail in Chapter 2. The result of Phase 2 is an understanding of estimated cost-effectiveness for energy storage, considering only direct, quantifiable costs and benefits of energy storage operation, from a TRC perspective. Also, the results enable an assessment of relative cost-effectiveness between use cases, as well as the relative importance of different inputs to the cost-effectiveness outputs, i.e. sensitivity analysis. The Energy Storage Valuation Tool (ESVT) was designed to support the role required in Phase 2 of the methodology.

Summary of Defined CPUC Use Cases

Throughout the CPUC's energy storage OIR proceeding, there have been a number of concepts for energy storage use cases that have been defined to varying degrees. The use case concepts are listed in Table 3-1 and are described in more detail within the CPUC staff report from January 2013 [3]. Defined use cases cover a broad range of energy storage sites, uses, and technologies and may range in size from hundreds of megawatts to kilowatts and energy duration of tens of hours to only minutes. The highlighted items indicate the use cases that received focus in the EPRI analysis.

Table 3-1
List of CPUC-Defined Use Cases for Energy Storage and Cases Chosen for Analysis

Use Cases	Categories
Transmission-Connected Energy Storage	Bulk Storage System (aka Peaker Substitution)
	Ancillary Services
	On-Site Generation Storage
	On-Site Variable Energy Resource Storage
Distribution-Level Energy Storage	Distributed Peaker
	Distributed Storage Sited at Utility Substation
	Community Energy Storage
Demand-Side (Customer-Sited) Energy Storage	Customer Bill Management
	Customer Bill Management w/ Market Participation
	Behind the Meter Utility Controlled
	Permanent Load Shifting
	EV Charging

Prioritized CPUC Use Cases for Analysis

Due to the time and resource constraints of this analysis, it was necessary to prioritize a subset of the CPUC use cases and supporting scenarios. The goal of the prioritization of cases was to achieve sufficient depth and breadth to inform the stakeholders of technical potential for cost-effectiveness in some of the use cases that garnered significant interest. The CPUC technical staff ultimately directed the prioritized use cases, but the choice of priority should not be interpreted as favoring the chosen use cases over the other options. The relative clarity of use case and grid service definitions, as well as the availability of supporting data, factored into the ultimate decision of use case and scenario priorities by the CPUC, not necessarily the relative perception of value.

Bulk Storage Use Case (Peaker Substitution)

The bulk storage (peaker substitution) use case involves the comparison of energy storage to a gas-fired peaker generation unit. This use case considers energy storage that provides grid services that the peaker generation would have access to, including system capacity, energy sales (time-shift/arbitrage for storage), frequency regulation, spinning reserve, and non-spinning reserve. For this use case, the energy storage systems investigated were all 50 megawatts (MW) or larger in size.

Ancillary Service-Only Use Case

The frequency regulation use case assumes specialized usage of a large battery, flywheel, or other short-duration energy storage technology, to provide frequency regulation service to the CAISO system. Due to the potential for fast and accurate response and ramping capability of energy storage, these systems may generate an enhanced value compared to fossil generators,

which is expected to be monetizable in the CAISO market as a performance payment, resulting from FERC 755's frequency regulation pay-for-performance ruling.

Distribution Energy Storage at Substation Use Case

The distribution energy storage at substation use case assumes a similar usage of the energy storage system to the bulk storage use case, but with the added grid service of a distribution investment deferral. It assumes that the storage is located on the low voltage side of a substation transformer or line that requires an expensive upgrade triggered by slow load growth and infrequent peaks, which can be offset by the energy storage system for a few years. The use case assumes that the storage is also earning value by participating in the capacity and day-ahead energy and ancillary services markets. Due to regulatory issues raised previously, it may not be possible to monetize this use case currently, but the analysis intends to demonstrate the first-order technical potential for energy storage cost-effectiveness.

Process for Obtaining Analysis Inputs

All inputs for this analysis were provided by the CPUC technical staff. To generate these inputs, the technical staff (led by Aloke Gupta) sought to reach consensus from a core stakeholder group, which included representatives from the California Energy Storage Alliance (Giovanni Damato and Chris Edgette) and the three California investor-owned utilities, Pacific Gas & Electric (Daidipya Patwa), Southern California Edison (David Castle), and San Diego Gas & Electric (Armando Infanzon). The CPUC technical staff used its discretion to provide a final list of inputs and key input sensitivities to investigate in the analysis utilizing the Energy Storage Valuation Tool.

To support clarity of understanding, the CPUC held a weekly update teleconference between CPUC, EPRI, and CESA to clarify the inputs and status of the analysis. Prior to the draft results presentation on March 25, 2013, there were also two preliminary results meetings, which included the representatives from the investor-owned utilities, where there was opportunity to discuss the inputs and preliminary results in more detail and format the results of the analysis in a way that would be most valuable.

4
USE CASE 1: BULK ENERGY STORAGE MODELING, INPUTS, ANALYSIS, AND RESULTS

Details of Model Operation

Overview of the Use Case

In this use case, storage systems are used to replicate the operation objectives of a peaking fossil generator. It generates value to the electric system by offering peak system capacity (resource adequacy) while participating in the energy and ancillary services markets. Specifically, the services included in this use case are system capacity, electric energy time-shift (arbitrage), frequency regulation, spinning reserve, and non-spinning reserve.

Model Dispatch Logic

In general, storage dispatch in ESVT is based on the storage system's technical constraints (duration, capacity, efficiency, variable O&M cost).Dispatch is also based on the nature of the service in the use case (market participation requirement, expected length of availability, frequency of dispatch).ESVT dispatch logic prioritizes long-term commitment over short-term commitment first, then it maximizes total profitability for equivalent priority day-ahead market services using an dispatch optimization. In this use case, system capacity has higher priority than other services. Market and ancillary services are co-optimized on the same level.

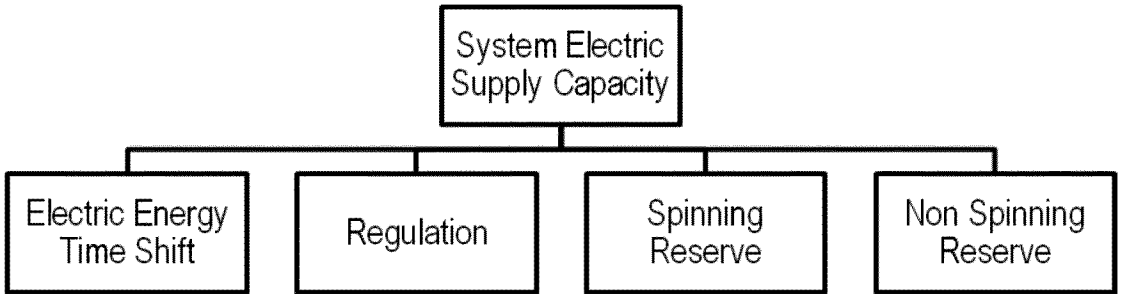

Figure 4-1
Use Case 1 Hierarchy for Bulk Storage Grid Services

Grid Services Included in This Use Case

In this section, we will discuss how each service in this use case is modeled in more detail.

System Electric Supply Capacity

Definition

System electric supply capacity is the use of energy storage in place of a combustion turbine (CT) to provide the system with peak generation capacity during peak hours. Storage systems

that can successfully fulfill the service requirements are compensated with the system capacity value, which is equal to the Cost of New Entry (CONE) in the resource balance year, which is derived with ESVT. The resource balance year is defined as the year when peak load demand meets available generation capacity.

Under ESVT assumptions, which is user defined, the storage system must have a minimum duration of 4 hours to qualify for this service. Capacity hour each months are defined as the top 20 load hours each month. Probability for storage to dispatch during capacity hour is 100%.

Dispatch Decision

The dispatch for system electric supply capacity has higher priority than other AS services but a lower priority than distribution investment deferral. The storage system is charged before capacity hours to ensure that it has enough energy at the beginning of capacity hour, and it discharges at full qualifying capacity during capacity hour.

Benefit Calculation

*System Electric Supply Capacity Benefit = Capacity Payment ($/kW-yr) * Storage Qualifying Capacity *Capacity Derate*

1. Capacity payment is different every year. The user can enter two values for this capacity payment: current year capacity value and resource balance year CONE. If the current year is the resource balance year, then the system capacity value and resource balance year CONE are the same. If not, the user can modify the input "Years Until Resource Balance Year" to let the model know how many years are between the current year and resource balance year; then the system capacity price will be escalated from current year to resource balance year.
2. Qualifying capacity is a measure to make sure that the battery has the required duration to meet system capacity requirement. The default assumption for the duration requirement is 4 hours, which means a 50-MW/2-hr battery would earn value as a 25-MW/4-hr battery for this service. The qualifying capacity in this case is 25 MW.
3. Capacity Derate occurs when, in the actual dispatch, there are circumstances where the consecutive peak load hours are longer than the storage duration or that the storage is required to do other higher-priority services, so the storage system is not able to meet requirements for all the capacity hours. In those cases, the storage system will be derated based on actual dispatch/qualifying capacity to reflect the real performance and compensation.

Electric Energy Time Shift

Definition

Electric Energy Time Shift is the use of storage to buy energy during low-price hours and sell during high-price hours.

Dispatch Decision

Electric Energy Time Shift has lower priority than System Electric Supply Capacity and Distribution Investment Deferral. After the storage system dispatches to fulfill the requirement for these two services, the remaining capacity is optimized between electric time shift and AS services. In a 24-hour window, the dispatch is optimized to "buy low and sell high."

Benefit Calculation

Electric Energy Time-Shift (Arbitrage) benefit = (Energy sales) – (Energy Cost) / (Roundtrip efficiency) – (Variable O&M)

1. Electricity Sales ($) = Hourly Discharge * Hourly Energy Prices. Discharge is the same every year, but the energy price escalates every year based on inflation and gas price escalation rate.
2. Energy Cost ($) = Hourly Discharge * Hourly Energy Prices. Charge is the same every year, but the energy price escalates every year based on inflation and gas price escalation rate.
3. Roundtrip Efficiency (%) = The roundtrip efficiency is defined as the total energy out divided by energy in, including losses in the power electronics, balance of plants, battery, and control equipment. Parasitic losses are assumed to be included in this metric for this analysis, but the user may separately define "housekeeping power" to decouple hourly parasitic losses from roundtrip efficiency.
4. Variable O&M = Hourly Discharge(kWh) * Variable O&M Cost.

Regulation Service

Definition

Regulation Service (or Frequency Regulation) is the use of storage to follow the Balancing Authority's (BA) Automatic Generation Control (AGC) signal to balance short-duration (seconds to minutes) imbalances to maintain the grid's fundamental system frequency (60 Hz in the U.S.).

Market Bidding and Dispatch

Regulation service has lower priority than system electric supply capacity. To provide this service, the storage system must have at least 15 minutes of capacity available. Its dispatch is on the same priority level and co-optimized with other ancillary services and electric energy time-shift to maximize market profit. The CPUC analysis is done for California electricity markets, which has a separate market and dispatch for regulation up and regulation down. Both storage system charging (load) and discharging (generation) may participate in Regulation in the ESVT simulation.

Also, due to intensity of calculation, this analysis did not take into account intra-hour (4 sec) dispatch in this case. Resulting hourly dispatch is calculated from regulation market bids by multiplying an intra-hour energy factor for regulation up and regulation down.

Benefit Calculation

Storage bids its available capacity (MW) into Regulation Up and Regulation Down markets. Storage is compensated based on hourly regulation market prices for following a dispatch signal. It also earns value based on day-ahead energy prices for energy discharged and is charged for energy that it consumes. The ability to bid regulation is based on the full difference between discharge and charge capacity.

Regulation Benefit = Regulation Market Revenue + Electricity Sales Revenue – Regulation Charging Cost – Variable O&M Cost

Synchronous Reserve (Spinning)

Definition

Synchronous reserve (spinning) is generation capacity that is already operating and synchronized to the system that can increase or decrease generation within 10 minutes. Synchronous reserves are procured by the ISO on an hour by hour basis in a competitive market. Energy storage may be capable of bidding in the synchronous reserve market to supply synchronous reserves.

Market Bidding and Dispatch

Synchronous reserve is on the same hierarchy level as other market services. Its bidding and dispatch is co-optimized with other day-ahead market services, including energy and ancillary services. Synchronous reserve does not dispatch, but the storage system must contain at least one hour of energy to qualify, in case it is called, due to a system contingency event. Both the storage system's charge and discharge capacity may be bid into this service. For example, idle storage with greater than one hour of energy may bid its rated capacity, and storage charging at full rated capacity may bid two times (2x) its rated capacity, because the storage can stop charging and begin discharging. Therefore, a 50MW storage system may bid 100MW of synchronous reserve.

Benefit Calculation

*Synchronous Reserve Benefit = Synchronous Reserve Bid*Synchronous Reserve Price*

Non-Synchronous (Non-spinning) Reserve

Definition

Non-synchronous (Non-spinning) reserve is an ancillary services product that consists of off-line generation that can be ramped up to capacity and synchronized to the grid in less than 10 minutes when responding to an event.

Market Bidding and Dispatch

The storage system must reserve at least one hour of duration and the storage capacity (MW) bid when it agrees to provide this reserve. The storage system may not be discharging at full capacity or otherwise obligated to possibly discharge during hours when it is providing this reserve.

Benefit Calculation

The storage system bids capacity into non-synchronous reserve markets and is paid based on hourly market clearing prices for its availability. The storage system attempts to maintain a full charge so that it can offer its full discharge capacity in all hours. If a system is discharged (based on a small probability of non-synchronous reserves being called), it also receives the energy price during the hour of discharge, which is represented by electricity sales in the NPV benefit table.

*Non-Synchronous Reserve Benefit = Non-Synchronous Reserve Bid *Non-Synchronous Reserve Price*

Summary of CPUC-Provided Inputs

ESVT requires various types of inputs ranging from system and market inputs to specific storage technical inputs. The inputs shown in this section were provided by CPUC staff and multiple stakeholders. The input collection process is described in more detail in section 3 of this report. In short, EPRI provided CPUC staff with an ESVT input template based on the services in the use case, and CPUC staff and stakeholders provided inputs based on the input template. Detailed input spreadsheets for this analysis were made public in the March 25 workshop at CPUC. This section seeks to highlight inputs provided by the CPUC staff.

Global Financial Assumptions

As illustrated above, ESVT accepts a wide range of different inputs. To simplify the inputs, a few financial assumptions are fixed throughout the use case. As shown in Table 4-1, global financial assumptions are used consistently in the base case and in the sensitivity analysis to make comparison easier. The discount rate, inflation, and tax rates stay the same throughout this analysis.

Table 4-1
Global Financial Assumptions

Input	2020	2015
Financial Model	IPP	IPP
Discount Rate	11.47%	11.47%
Inflation Rate	2%	2%
Fed Taxes	35%	35%
State Taxes	8.84%	8.84%

Market Inputs

To calculate the value of a storage system bidding in the ancillary services and energy markets, the price data from those markets are essential. ESVT takes one year of historical hourly price data (day-ahead market) as the basis for each of the market services. These data are then used to generate future-year prices based on user-provided price escalation rates. Based on the price data and other inputs, the model decides the optimal bidding and dispatch of the storage system for the project life.

The base case in this use case has a project start year in 2020. To generate the price input for the project start year, CPUC staff and stakeholders chose a reference year (2011) and escalate the reference year price with an escalation rate to reach 2020 prices. Later in this use case, a sensitivity analysis was conducted for project start year in 2015. The 2015 price inputs were generated in the same fashion, by escalating reference year (2011) price to 2015. Table 4-2 shows the average value of the price data used for the ancillary and energy services. The inputs of this report are hosted at the webpage of the CPUC Storage Proceeding [4].

Table 4-2
Summary Table of Market Prices

Input Type	Reference Year Avg. Price	Project Start Year 2020 Avg. Price*	Project Start Year 2015 Avg. Price
Energy ($/MWh)	30.62	39.96	34.47
Regulation Up ($/MW-hr)	9.20	12.01	10.36
Regulation Down ($/MW-hr)	6.93	9.04	7.80
Synchronous Reserve ($/MW-hr)	7.22	9.43	8.13
Non-Synchronous Reserve ($/MW-hr)	0.98	1.28	1.11

*Escalated from Reference Year to Start Year at "Energy & A/S Escalation Rate" input Market Price ESVT Model Input Summary for Base Case.

Alongside with the price inputs, several other inputs are needed to calculate the value of each market service, as illustrated earlier in this chapter in the model detail section. These additional inputs can be found in Table 4-3.

Table 4-3
Use Case 1 Market Inputs Table

Input Name	Inputs
Market Price/Load Reference Year	CAISO 2011
Project Start Year	2020
Escalation Rate from Ref. Year to Start Year	3%
Escalation Rate After Start Year	4%
Allow Load (Storage Charge) to Bid Regulation?	Yes
Regulation Pay for Performance Factor	1.0x (no adjustment to base case)
Hourly Energy Deviation for Regulation Up	11.34%
Hourly Energy Deviation for Regulation Down	13.43%
Allow Load (Charge) to Bid Spinning Reserve	Yes
System Capacity Value at Project Start Year 2020	161

Table 4-3 (continued)
Use Case 1 Market Inputs Table

System Capacity Value at Project Start Year 2015	75
Cost of New Entry (CONE)	161
Resource Balance Year	2020
System Capacity Storage Min Duration (hr)	4
Capacity Hours Reserved Per Month	20
Probability to Dispatch During Capacity Hours	100%

Storage Technology Inputs

For the base case, a battery with a capacity of 50 MW/2 hr was chosen. Table 4-4 lists the summary technology inputs provided by CPUC.

Table 4-4
Use Case 1 Technology Inputs

Technology	Battery	
Configuration	Capacity (MW)	50
	Nameplate Duration (hr)	2
	Plant Life (yrs)	20
Performance	Lifetime Battery Replacements*	1
	Roundtrip Efficiency (%)	83%
Cost	Capital Cost ($/kWh) in 2020	528
	Variable O&M Cost ($/kWh)	0.0003
	Fixed O&M Cost ($/kW-yr)	15
	Battery Replacement Cost	250

* Battery replacement cost is nominal $250/kWh in year of replacement across all years. Assumes that reductions in real battery-replacement cost will offset inflation.
**Inputs in this table are in 2020 dollars

Results of Base Case

Given the inputs shown in the sections above, the resulting stacked bar chart is shown in Figure 4-3. Based on the inputs provided by the CPUC working group, the base case for the bulk storage use case has a benefit-to-cost ratio of 1.17. The storage system generates a large part of its revenue from regulation service. The base case returned a breakeven capital cost of $842/kWh in 2013 real dollars. Breakeven capital cost is defined as the cost of the fully integrated storage system that would yield a benefit-to-cost ratio of 1.0 in the ESVT model.

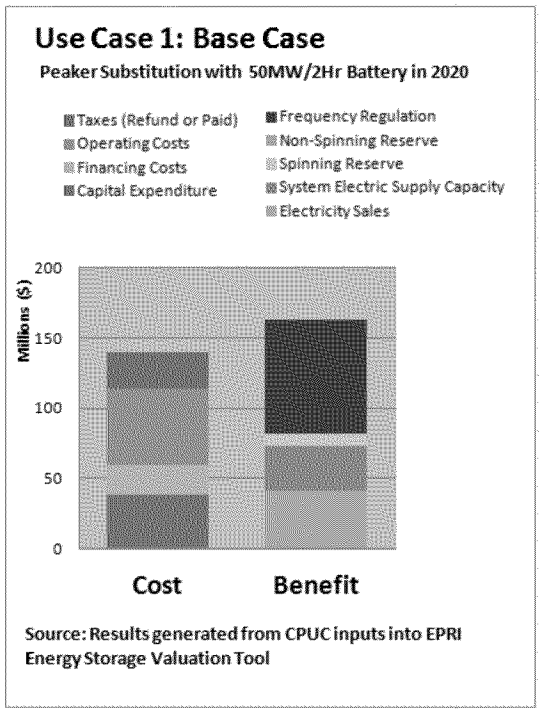

Figure 4-2
Use Case 1: Base Case Result

Overview of Scenarios and Sensitivities

The cost-effectiveness of a storage system providing a combination of grid services is dependent on an array of inputs. The result could look very different when there are changes in the technology cost, configuration, market conditions, and many other factors. The base case shows only one possible combination of those inputs. In order to further analyze the impact of different inputs on the result, EPRI was asked to run a series of sensitivity analyses. Detailed inputs were provided by CPUC to perform these modeling runs. In those sensitivity analysis modeling runs, all inputs are controlled to be identical to the base case while only the sensitivity variable is changed.

Specifically, the CPUC technical staff were interested in three key areas of sensitivity analysis—Energy Storage System Characteristics, Energy Market Conditions, and Project Start Year. Figure 4-4 provides an illustration of the sensitivity analysis performed.

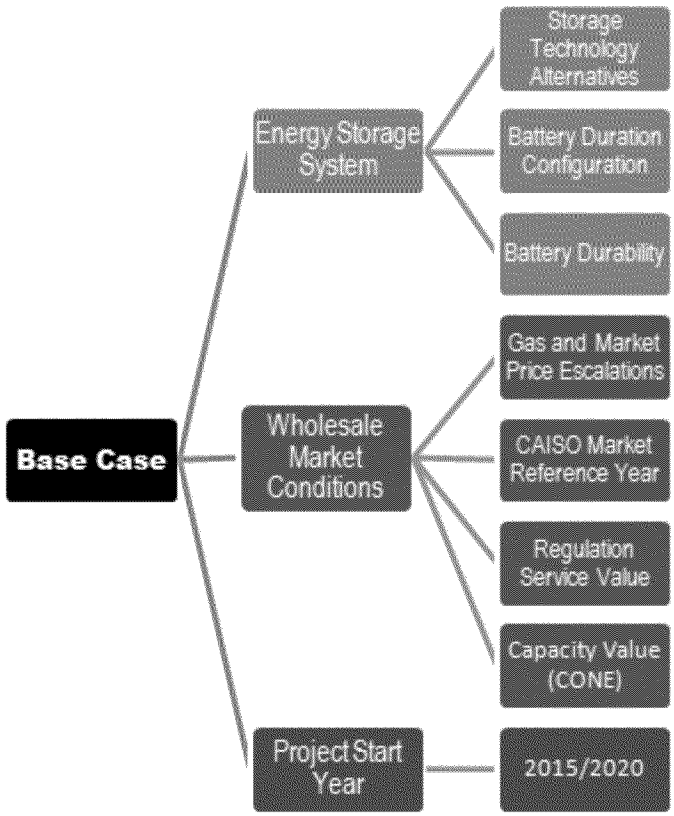

Figure 4-3
Sensitivity Analysis Tree Diagram

Energy Storage System Sensitivity Analyses

The first set of sensitivity analyses were performed to test the impact of changing certain characteristics of the storage system. The value that a storage system can provide is highly related to its configuration, such as battery duration. How durable a storage system is will determine how many replacements are necessary during the project lifetime, and directly impact the cost of the project. On the other hand, CPUC was interested in alternative storage technologies performing the same use case.

Battery Duration Configuration

Changing the duration of a battery system impacts both its capital cost and its ability to provide energy to the grid. A battery system with longer duration is more costly to build, but the increased duration may also allow it to provide more value. To test the difference, two modeling runs with battery duration of 3-hour and 4-hour were performed alongside the base case, which used a 2-hour battery. As illustrated in Figure 4-6, the cost-effectiveness of the 2 hour battery was better than the 3-hour and 4-hour battery. Under the assumptions of this use case, the cost increased by a greater multiplier than the benefit when duration was increased. One potential explanation of this is that the majority of the market services modeled does not require a 4-hour duration. Services like frequency regulation and spinning reserve require less than an hour of duration to qualify.

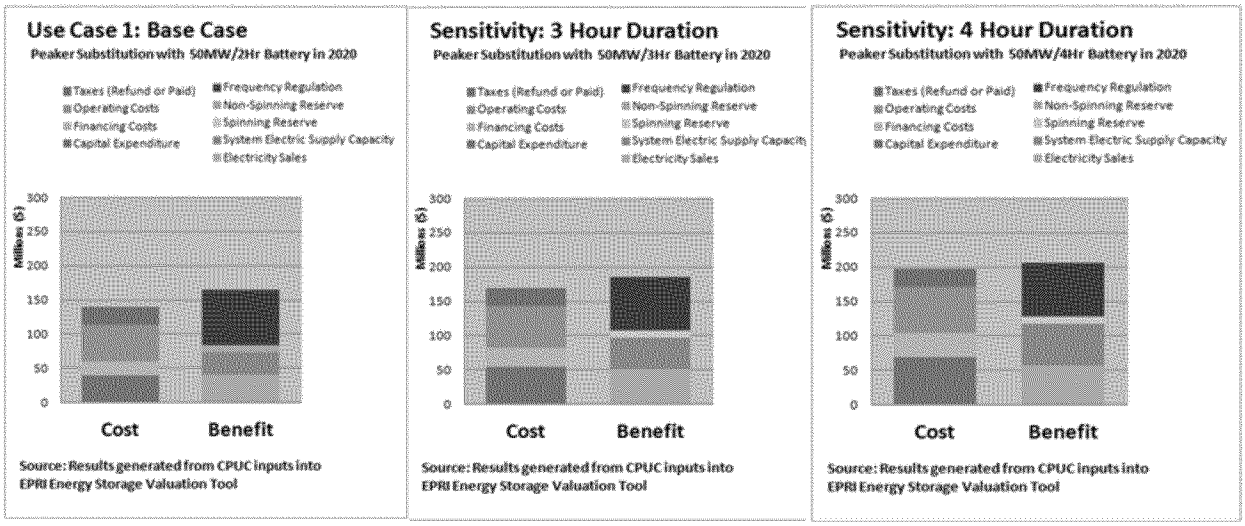

Figure 4-4
Sensitivity Analysis: Battery Duration

Table 4-5
Breakeven Capital Cost for Duration Sensitivity

	Base Case	Duration 3hr	Duration 4hr
Breakeven Capital Cost in 2013 dollars	$842 /kWh ($1684/kW)	$594 /kWh ($1781/kW)	$465 /kWh ($1860/kW)
Benefit to Cost Ratio	1.17	1.10	1.05

Battery Durability / Battery Replacement Frequency

The analysis assumes a 20-year project life for the base case. During this period, the storage system is dispatching every day. Services such as electric energy time-shift (arbitrage) and system capacity typically require deeper discharge on a daily or weekly basis, while frequency regulation service requires shallow dispatch almost hourly. This high cycle count usage pattern may lead to battery cycle life degradation in additional to time-dependent ("calendar life") degradation. This sensitivity analysis aims to understand the importance of battery durability by assuming different battery-replacement frequencies. The base case assumes that there will be one replacement for the entire project life (after 10 years). For this sensitivity analysis, two additional modeling runs were conducted, with the assumption of two (every 7 years) and three replacements (every 5 year) over the project life.

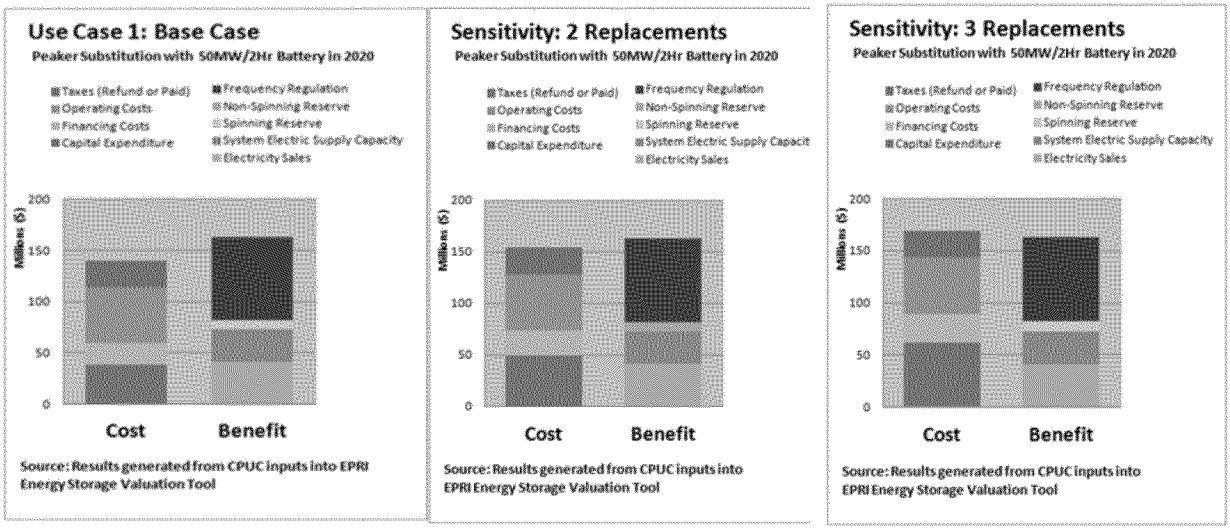

Figure 4-5
Sensitivity Analysis: Battery Replacement Frequency

No. of Replacements	Base Case (1X)	Base + 2X replace	Base + 3X replace
Breakeven Capital Cost in 2013 dollar	$842 /kWh ($1684/kW)	$619 /kWh ($1238/kW)	$377 /kWh ($754/kW)
Benefit to Cost Ratio	1.17	1.07	0.97

As illustrated in the graphs above, increasing the number of replacements does not alter the battery operation; the impact is solely on the cost side. In the base case, the cost to replace the battery system is 25 million dollars. Because the cost of replacing a battery system is significant compared to the total project cost, the model includes a battery replacement fund into the initial capital expenditure. The battery replacement fund earns interest over time and is reduced every time that a battery replacement occurs. Therefore, increasing the assumption for battery replacement frequency raises the upfront capital cost as well as financing cost. It is observed that, under the assumptions of this use case, the base case and the case with two battery replacements were cost-effective. However, when there are three replacements over the 20-year project life time, the benefit-to-cost ratio is less than 1, indicating that the case is no longer cost-effective.

Table 4-6
Alternative Technology Inputs for Use Case 1

Category	Input	2020			
		Battery*	Flow Battery	PHS	AG CAES
Technology Cost / Performance	Nameplate Capacity (MW)	50	50	300	100
	Nameplate Duration (hr)	2	4	8	8
	Capital Cost ($/kWh) -Start Yr Nominal	528	443	166	211
	Capital Cost ($/kW) - Start Yr Nominal	1056	1772	1325	1684
	Project Life (yr)	20	20	100	35
	Roundtrip Efficiency	83%	75%	82.50%	-
	Variable O&M ($/kWh)	0.00025	0.00025	0.001	0.003
	Fixed O&M ($/kW-yr)	15	15	7.5	5
	Major Replacement Frequency	1	0	-	-
	Major Replacement Cost ($/kWh)	250	-	-	-
	MACRS Depreciation Term (yr)	7	7	7	7
	Energy Charge Ratio (CAES)	-	-	-	0.7
	Full Capacity Heat Rate (CAES/CT)	-			3810
	Heat Rate Curve (CAES/CT)	-	-	-	see wkst
	Turbine Efficiency Curve (PHS)	-	-	see wkst	-
	Pump Efficiency (PHS)	-	-	see wkst	-

The CPUC working group was also interested in the impact of utilizing different storage technologies. For the purpose of this analysis, three additional modeling runs were performed to access the cost-effectiveness of alternative technologies performing the same use case. The alternative technologies selected were a flow battery, a pumped hydro storage (PHS) system, and a compressed air energy storage (CAES) system.

The flow battery system inputs used in this case do not have a replacement cost, which means it is assumed that no battery replacement would be necessary during its lifetime. It also has a roundtrip efficiency of 75%, instead of 83% as the battery system used for the base case.

The pumped hydro storage system was modeled as a 300-MW/8-hr system with 100-year project life. Because the size of the pumped hydro storage system is significantly larger than the base case system, the resulting benefit value and cost are both higher.

The compressed air storage system used in this case is a 100-MW/8-hr system with 35-year project life. Similar to the pumped hydro system, the above-ground CAES system in this case is sized larger than the base case battery, resulting in larger costs and benefits bars.

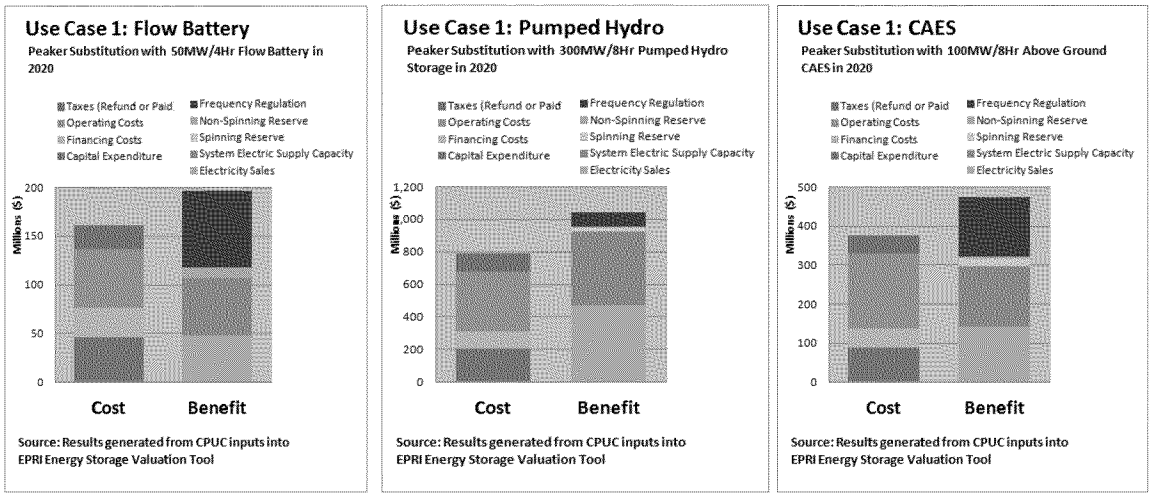

Figure 4-6
Sensitivity Analysis: Storage Technology

Overall, as shown in Table 4-7, the flow battery system has the highest breakeven capital cost among all the alternative technologies included here.

Table 4-7
Alternative Technology Breakeven Capital Cost

	Flow Battery	Pumped Hydro	Abv Ground CAES
Breakeven Capital Cost in 2013 dollars	$675/kWh ($2699/kW)	$223/kWh ($1783/kW)	$232/kWh ($1853/kW)
Benefit to Cost Ratio	1.23	1.32	1.27

Energy Market Conditions

Regulation Service Value

As shown in the base case, the revenue generated from regulation service makes up more than half of the total revenues. Therefore, it is particularly important to understand the impact of different assumptions made about regulation. Storage systems have an innate advantage to provide regulation service because of their fast response capability. Especially in CAISO, where there are separate markets for regulation up and regulation down services, a storage system that can serve both as load and generation can potentially bid twice its capacity into the regulation market. Under FERC order 755, ISOs were mandated to compensate resources based on their performance. A sensitivity analysis was performed with regulation prices doubled to gauge the impact of better compensation mechanism for storage performing regulation service. On the other hand, due to the limited size of the regulation market, a large amount of storage participation may reduce the profitability in the market quickly. To understand how storage will do without regulation, another modeling run was performed with the base case minus regulation service.

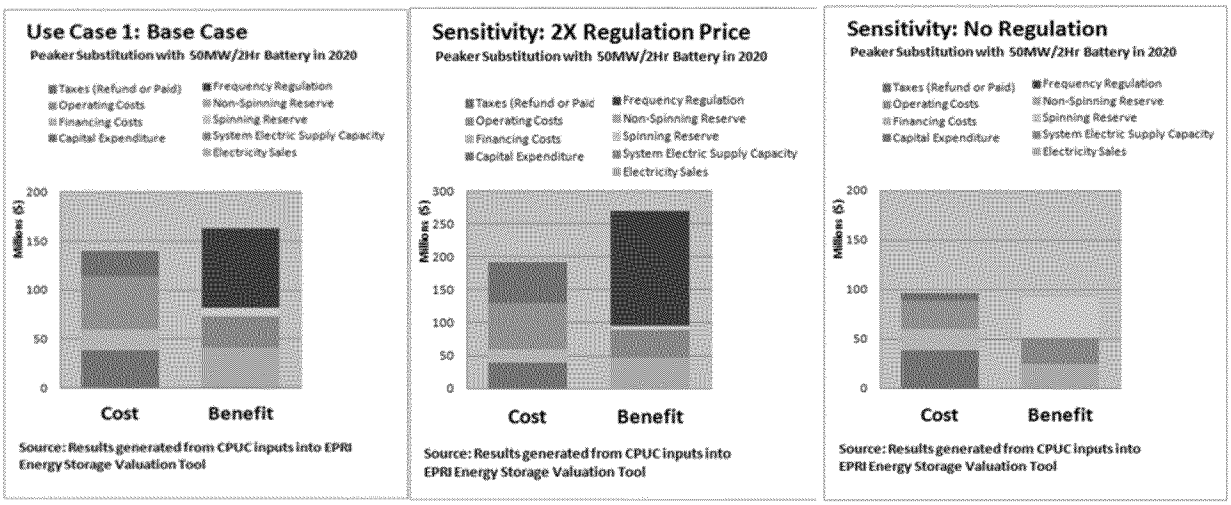

Figure 4-7
Sensitivity Analysis: Regulation Service Value

	Base Case	2X P4P	No Regulation
Breakeven Capital Cost in 2013 dollars	$842 /kWh ($1684/kW)	$1593 /kWh ($3186/kW)	$433 /kWh ($865/kW)
Benefit to Cost Ratio	1.17	1.38	0.98

Table 4-8
Regulation Service Value Sensitivity Analysis Breakeven Capital Cost

As illustrated in Figure 4-8, the 2X pay for performance pricing doubled regulation service revenue while reducing the revenue generated from spinning reserve. When frequency regulation service is removed from the equation, the storage system partially made up for the lost revenue by bidding more for spinning reserve but still was not able to break even.

Gas and Market Price Escalation Rates

In ESVT, market scenarios are defined by project start year prices, which includes energy and ancillary prices. The project start year for this use case is 2020. To generate 2020 prices, based on CPUC provided inputs, a set of 2011 price data was escalated at 3% to 2020 level.

There are a lot of uncertainties when it comes to predicting future market conditions. Among them are the gas prices and energy price escalation expectations, renewable penetration rate, and ancillary services prices escalation rates. This part of the sensitivity analysis identified four market scenarios in comparison with the base case scenario. The prices used for these scenarios were generated from the same 2011 prices data, but with different escalation rates. Table 4-8 provides an overview of the market scenarios.

Market Scenario 1: Gas prices are high during the project lifetime. High renewable penetration rate reduced energy market prices but increase the cost of ancillary services. The regulation market does not include pay-for-performance pricing for storage system. To represent this

scenario, energy price was escalated at 2% from 2011 to 2020, instead of the 3% in the base case. Ancillary service prices were escalated at 5%.

Market Scenario 2: Low gas prices and renewable penetration reduce energy market prices, ancillary prices stays the same as the base case. There is no regulation pay for performance pricing for storage. To represent this scenario, energy price was escalated at 2%, and ancillary service prices were escalated at 3%.

Market Scenario 3: High gas prices and renewable penetration reduce energy market prices but increase the cost of ancillary services. The market implements regulation pay for performance pricing for energy storage. In this scenario, energy prices was escalated at 2%, ancillary service prices were escalated at 5%, and regulation prices were doubled to represent the pay-for-performance pricing.

Market Scenario 4: Low gas prices and renewable penetration reduce energy market prices, ancillary prices remain at base case level. The market implements regulation pay for performance pricing for energy storage. In this scenario, energy prices were escalated at 2%, and ancillary service prices at 3%, regulation prices were doubled to represent pay-for-performance pricing.

Table 4-8
Market Scenario Overview

	Gas Price	Renewable Penetration	Energy Price	Ancillary Service Price	Regulation Pay For Performance
Market Scenario 1	High	High	Reduced	Increased	No
Market Scenario 2	Low	Low	Reduced	Base	No
Market Scenario 3	High	High	Reduced	Increased	Yes
Market Scenario 4	Low	Low	Reduced	Base	Yes

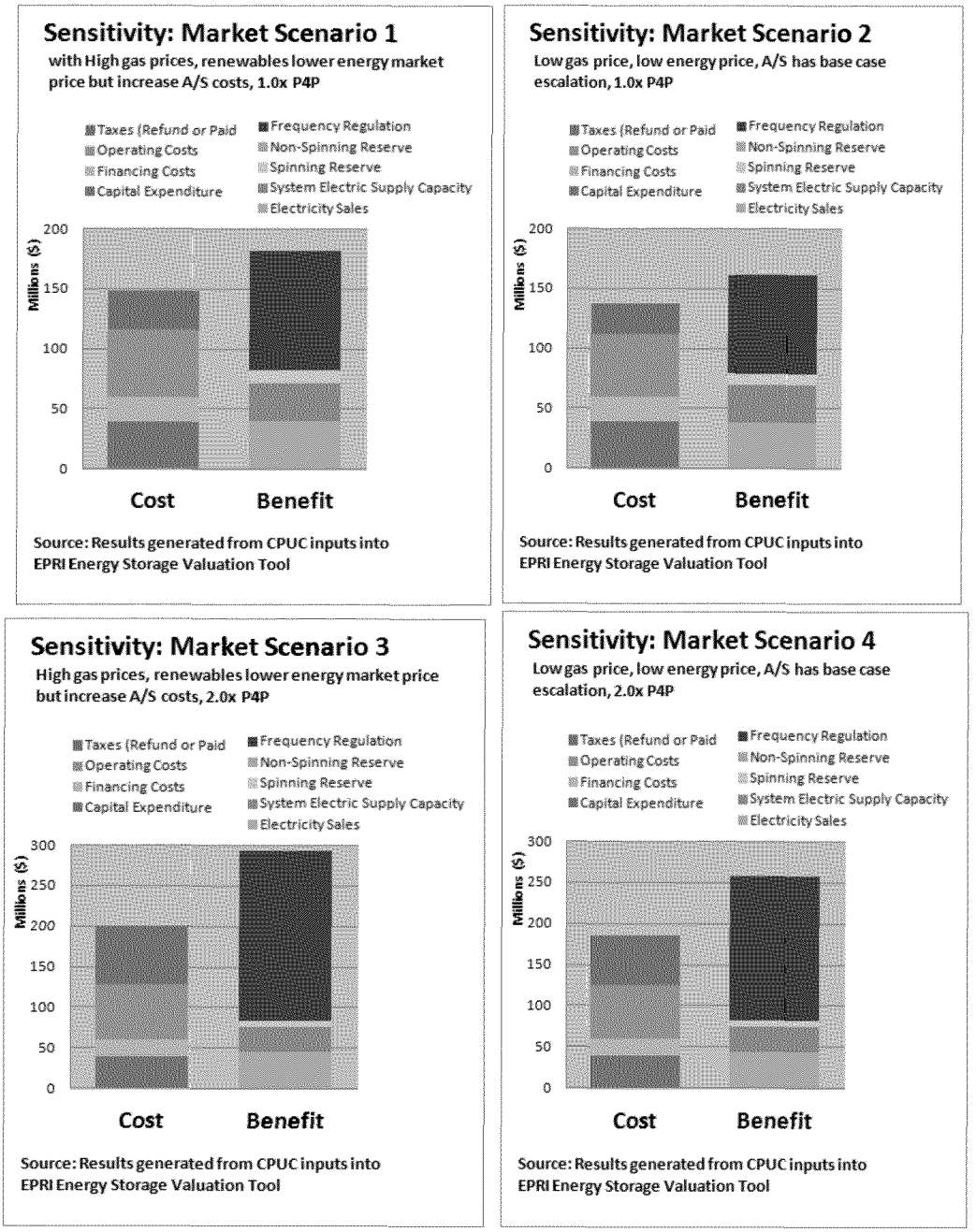

Figure 4-8
Market Scenario Sensitivity Results

Table 4-9
Market Scenario Analysis Breakeven Capital Cost

Market Scenario	Base	1	2	3	4
Breakeven Capital Cost in 2013 dollar	$842 /kWh ($1684/kW)	$1010 /kWh ($2020/kW)	$851 /kWh ($1701/kW)	$1941 /kWh ($3883/kW)	$1619 /kWh ($3238/kW)
Benefit to Cost Ratio	1.17	1.24	1.18	1.47	1.40

As shown in Table 4-9, with 2X pay-for-performance pricing for regulation service, market scenario 3 and market scenario 4 have higher breakeven capital cost than the other two scenarios. All of the market scenario cases had higher benefit-to-cost ratio than that of the base case. In market scenario 2, the energy price was reduced compared to that of the base case, but the benefit-to-cost ratio is slightly higher than that of the base case. This is because the CONE value in market scenario 2 is higher than that of the base case. Because a CT makes less money when energy prices are low, thus requiring a higher CONE in market scenario 2. The resulting increase in system electric supply capacity value in market scenario 2 offsets the drop in electricity sales revenue, leading to the slightly higher benefit-to-cost ratio than that of the base case.

Capacity Value Sensitivity Analysis

This analysis used the Cost of New Entry (CONE) value generated from ESVT 4.0 Beta, under the assumption that in resource balance year 2020, the system capacity value will be equal to the cost of new entry of the marginal unit (LM6000 Sprint). Different future scenarios may lead to different CONE assumptions in 2020. In another situation, when growth in renewable generation offsets load growth, it may be possible to use mothballed generators to serve as reserve capacity for occasional usage during peak times. In this situation, the system capacity value is not determined by the installation cost of a new plant but by the fixed operation and maintenance cost of the existing plants. More details related with CONE value calculation can be found in Appendix B. To simulate this situation, the system capacity value in this sensitivity run was generated by escalating the system capacity value from 2011 at an inflation rate (2%) to the 2020 value.

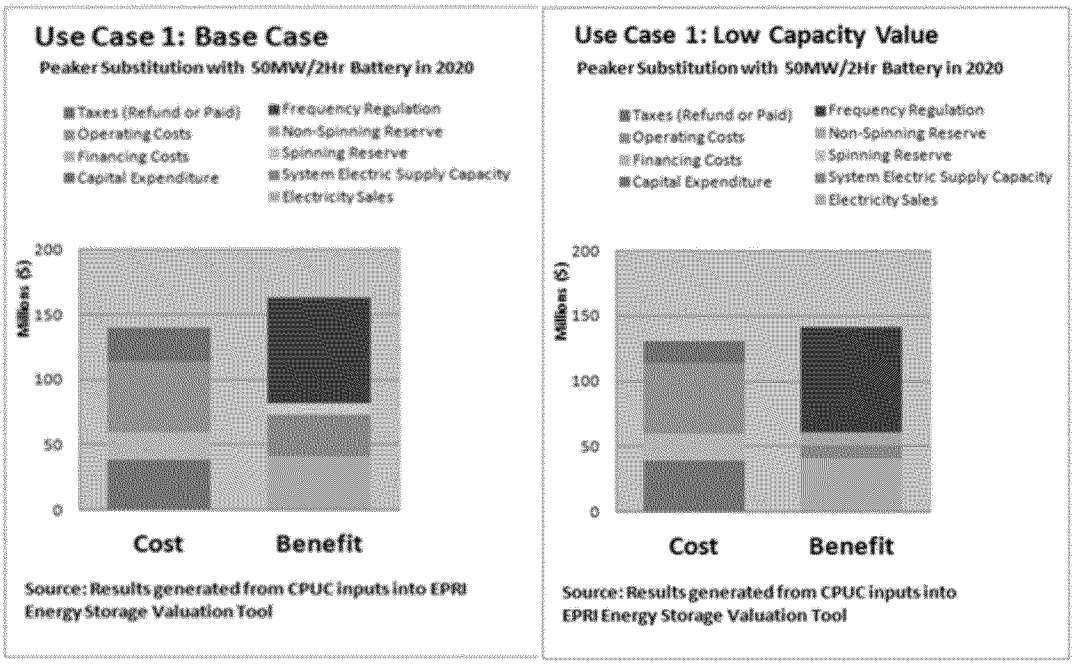

Figure 4-9
Sensitivity Analysis: Capacity Value (CONE)

Table 4-9
Capacity Value (CONE) Breakeven Capital Cost

	Base Case	Low CONE
Breakeven Capital Cost in 2013 dollars	$842 /kWh ($1684/kW)	$632 /kWh ($1264/kW)
Benefit to Cost Ratio	1.17	1.08
CONE	161	50

As illustrated in Table 4-8, in the case with low system capacity value, the system electric supply capacity benefit is lower than that of the base case. This reduction on the benefit side was partially offset by the reduction in taxes on the cost side, leading to a lower benefit-to-cost ratio than that of the base case.

CAISO Market Reference Year

The base case used 2011 as the CAISO market price reference year, escalating 2011 prices to project start year. Because the year 2011 was a high-hydro year, the ancillary service prices were generally higher than average. This sensitivity analysis includes two cases conducted with prices generated from 2010 base year price. The CONE value in resource balance year is also recalculated to reflect the change in base year prices.

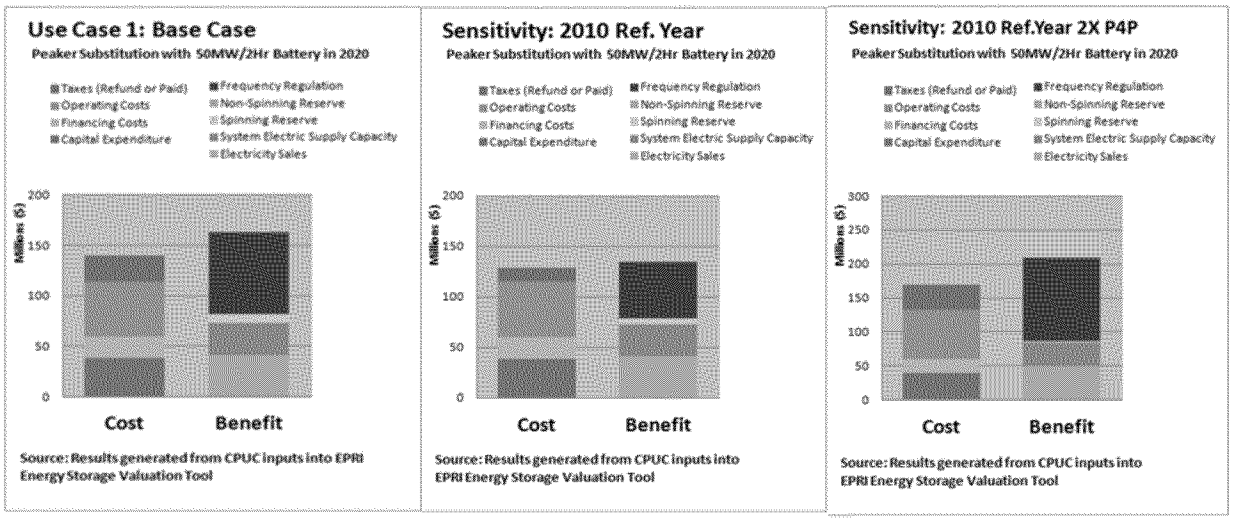

Figure 4-10
Sensitivity Analysis: Market Reference Year

Table 4-10
Project Reference Year Sensitivity Analysis Breakeven Capital Cost

	Base Case	2010 Ref.Yr	2010 Ref. 2X Reg
Breakeven Capital Cost in 2013 dollars	$842 /kWh ($1684/kW)	$565 /kWh ($1130/kW)	$1079 /kWh ($2159/kW)
Benefit to Cost Ratio	1.17	1.05	1.23

Project Reference Year Sensitivity Analysis Breakeven Capital Cost

As illustrated in Figure 4-11, with a price reference year that has lower prices, the value of ancillary services revenue decreased in the case without pay-for-performance pricing. Both cases have benefit-to-cost ratio higher than 1.

Project Start Year

The base case assumed a project start year of 2020 and reference price year as 2011. A sensitivity analysis was performed with the project start year as 2015. Changing the project start year influences the inputs in several ways. Firstly, the cost of the storage system is higher in 2015, $1206/kW instead of $1056/kW in 2020. The energy and ancillary service prices are also lower in 2015 than in the 2020 assumption because it is escalated for fewer years. Moreover, because 2015 is not the resource balance year, it is assumed that there are still excess generation capacity at that time, which means for the first five years of the project, until resource balance year in 2020, the capacity value that the storage system gets will be lower than the CONE in resource balance year, leading to a lower system capacity revenue. The case with 2015 as project start year has a lower cost-benefit ratio than the base case, illustrated in Figure 4-12. It also has a lower breakeven capital cost than the base case.

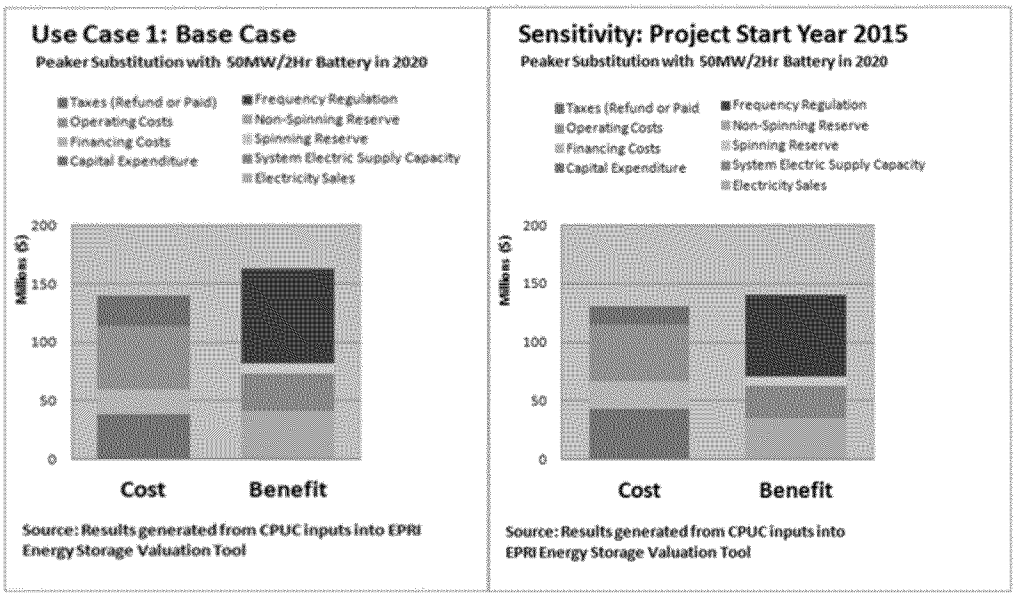

Figure 4-11
Sensitivity Analysis: Project Start Year

Table 4-11
Project Start Year Sensitivity Analysis Breakeven Capital Cost

	Base Case (2020 start)	Base Case (2015 start)
Breakeven Capital Cost in 2013 dollars	$842/kWh ($1684/kW)	$755/kWh ($1509/kW)
Benefit to Cost Ratio	1.17	1.07

Summary of Use Case Results

Under the input assumptions provided by the CPUC staff and stakeholders, the majority of the cases in this use case had a benefit-to-cost ratio that is higher than one, indicating cost-effectiveness. We also see that when the storage system has a high capital cost, or when the system requires three replacements during its lifetime, the increased cost leads to a B/C ratio of less than one. On the benefit side, the revenue contribution from frequency regulation service is very important. In the case without regulation service, the storage system was not able to break even.

5
USE CASE 2: ANCILLARY SERVICE ONLY MODELING, INPUTS, ANALYSIS, AND RESULTS

Details of Model Operation

Overview of the Use Case

In this use case, the smaller storage system mainly provides ancillary service. Specifically, it will only provide frequency regulation service by bidding into the regulation up and regulation down markets. The storage dispatch was optimized to maximize the market profit that it can generate from both the energy market and the regulation market.

Model Dispatch Logic

The storage system decides whether or not to bid regulation based on its charging cost, variable O&M cost, and the regulation market prices. In certain instances, the storage may be able to bid double capacity into the regulation market.

Grid Service Included in This Use Case

Regulation

Definition

Frequency regulation is the use of storage to follow the Balancing Authority's (BA) Automatic Generation Control (AGC) signal to balance short-duration (seconds to minutes) imbalances to maintain the grid's fundamental system frequency (60 Hz in the U.S.).

Market Bidding and Dispatch

Regulation service has lower priority than system electric supply capacity and distribution investment deferral. To provide this service, the storage system must have at least 15 minutes of capacity available. Its dispatch is on the same priority level and co-optimized with other ancillary services and electric energy time-shift to maximize market profit. The CPUC analysis is done for California electricity markets, which has a separate market for regulation up and regulation down. The default assumption is that we allow load to bid into those markets.

Therefore, the storage can bid both its charge and discharge capacity into the regulation up market or the regulation down market.

Also, due to calculation time limit, this analysis did not take into account intra-hour dispatch in this case. So the actual dispatch is calculated from regulation market bids by multiplying a mileage factor for regulation up and regulation down.

Benefit Calculation

Storage bids capacity into regulation markets and is paid based on hourly regulation market clearing prices for being available. It also gets electricity price for dispatching when it does, but

is also charged at the electricity prices for charging. The ability to bid regulation is based on the full difference between discharge and charge capacity.

Regulation Benefit = Regulation Market Revenue + Electricity Sales Revenue – Regulation Charging Cost – Variable O&M Cost

Summary of CPUC-Provided Inputs

Global Financial Assumptions

As illustrated above, ESVT takes many different inputs. To simplify the inputs and focus on the key inputs, a few financial assumptions are fixed throughout the use case. As shown in Table 5-1, global financial assumptions are used consistently in the base case and the sensitivity analysis to make comparison easier. IPP financial model was selected by the CPUC staff to ensure a discounted cash flow model, making it easier to compare this case with those of independent power producers (CT). The discount rate, inflation, and tax rates stay the same throughout this analysis.

Table 5-1
Global Financial Assumptions

Input	2020	2015
Financial Model	IPP	IPP
Discount Rate	11.47%	11.47%
Inflation Rate	2%	2%
Fed Taxes	35%	35%
State Taxes	8.84%	8.84%

Market Inputs

Table 5-2
Average Market Price Summary Table

Input Type	Reference Year Avg. Price	Project Start Year 2020 Avg. Price*
Energy ($/MWh)	30.62	39.96
Regulation Up ($/MW-hr)	9.20	24.02
Regulation Down ($/MW-hr)	6.93	18.08

*Inputs in this table are in 2020 dollars
2020 Regulation prices included 2x pay-for-performance price multiplier.

Storage Technology Inputs

Because this use case explores the market potential of a storage system that focus on frequency regulation service, a smaller system with shorter duration was chosen.

Table 5-3
Ancillary Service Use Case: Technology Input Table

Technology	Battery	
Configuration	Capacity (MW)	20
	Nameplate Duration (hr)	0.25
	Plant Life (yrs)	20
Performance	Lifetime Battery Replacements	1
	Roundtrip Efficiency (%)	83%
Cost	Capital Cost ($/kWh) in 2020	3112
	Variable O&M Cost ($/kWh)	0.0003
	Fixed O&M Cost ($/kW-yr)	15
	Battery Replacement Cost	250

*Inputs in this table are in 2020 dollars

Results of Base Case

In this use case, the 20-MW storage system with 15 minutes of duration mainly provides frequency regulation service. As a result, the majority of its revenue comes from frequency regulation, with the rest made up of electricity sales revenue.

There are a number of factors that contributed to the cost-effectiveness of this case. First, the frequency regulation prices used in this use case assumes 2X pay-for-performance pricing for a storage system providing frequency regulation service. The pay-for-performance pricing was chosen to take into account the expected change in CAISO regulation market following FERC order 755. The storage is getting paid more than a conventional resource because of its ability to follow the ACG signal more accurately. Moreover, in CAISO, the regulation market is separated into two parts, regulation up market and regulation down market. Regulation service can utilize both the load and generation portions of energy storage operation. In some circumstances, the storage system can bid double its capacity into the regulation market. For example, when the storage system is charging at full capacity, it can bid twice its capacity into the regulation up market.

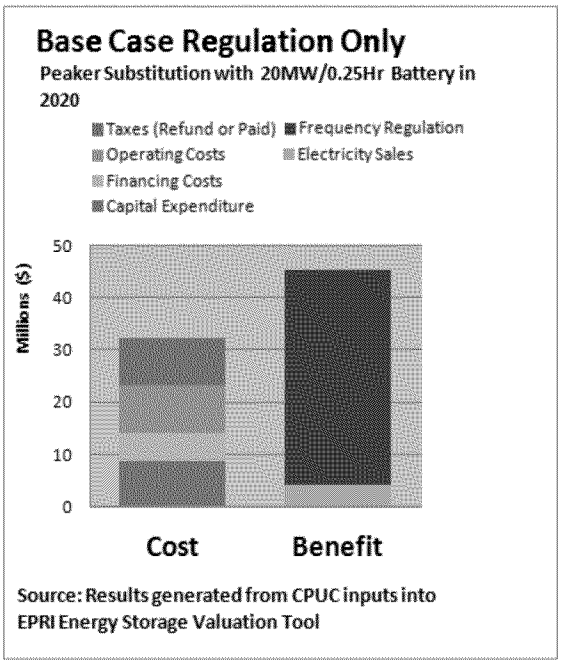

Figure 5-1
Base Case: Regulation Only

6
USE CASE 3: DISTRIBUTION ENERGY STORAGE MODELING, INPUTS, ANALYSIS, AND RESULTS

Details of Model Operation

Overview of the Use Case

This use case attempts to simulate the operation of a storage system located at a substation. The storage system will be providing system capacity and ancillary services while being reserved to shaving substation peak load so as to help defer the investment on the substation.

Model Dispatch Optimization Logic

For this use case, the top priority of the storage system dispatch was to keep the growing peak load on the substation under a certain threshold for as long as possible, so as to defer the distribution investment. This typically requires only a few hours a year of dispatching depending on the load shape and rate of load growth. Once the storage has met the dispatch commitment for investment deferral, it will prioritize the dispatch to meet system capacity needs. After distribution investment deferral and system capacity commitments are fulfilled, the remaining dispatch capability is co-optimized between energy and ancillary services, dispatching to maximize market profit. The optimization function takes into account the various factors that contribute to the market profit and optimize the dispatch and market bidding of the storage system accordingly.

The dispatch is prioritized in this fashion because deferring an investment on the distribution system requires the storage to always be available during the peak hours. The consequence of failing to shave the peak load is the highest. For system capacity, the storage system usually has to enter into a yearly agreement, with penalties occurring when it fails to fulfill its commitment. For energy and ancillary services, the storage system can bid into the market hours before the actual dispatch, and the penalty for non-conformance is relatively low.

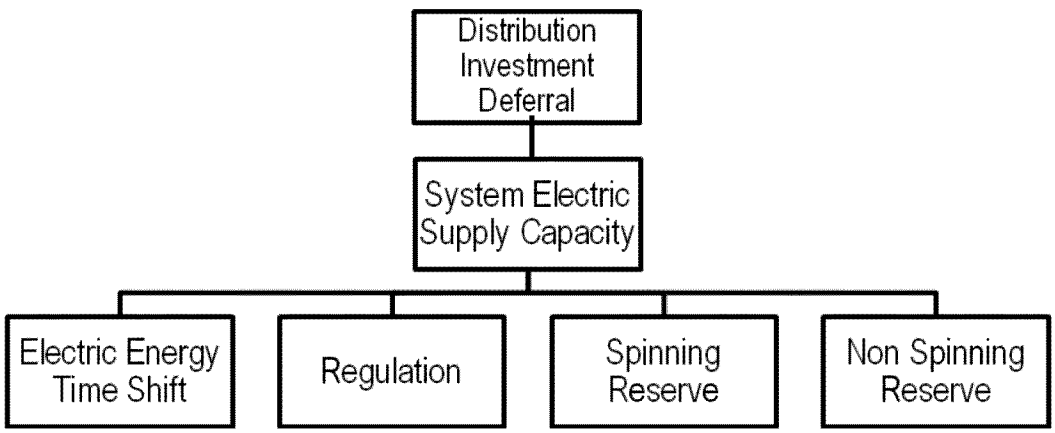

Figure 6-1
Distributed Storage Use Case: Dispatch Hierarchy

Grid Service Included in This Use Case

In this section, we will discuss how each service in this use case is modeled in more detail.

System Electric Supply Capacity

Definition

System electric supply capacity is the use of energy storage in place of a combustion turbine (CT) to provide the system with peak generation capacity during peak hours. Storage systems that can successfully fulfill the service requirements are compensated with the system capacity value, which is equal to the Cost of New Entry in resource balance year.

Under ESVT default assumptions, which can be changed by users, the storage system must have a minimum duration of 4 hours to qualify for this service. Capacity hour each months are defined as the top 20 load hours each month. Probability for storage to dispatch during capacity hour is 100%.

Dispatch Decision

The dispatch for system electric supply capacity has higher priority than other AS services but a lower priority than distribution investment deferral. The storage system is charged before capacity hours to ensure that it has enough energy at the beginning of capacity hour, and it discharges at full qualifying capacity during capacity hour.

Benefit Calculation

*System Electric Supply Capacity Benefit = Capacity Payment ($/kw) * Storage Qualifying Capacity *Capacity Derate*

1. Capacity payment is different every year. The user can enter two values for this capacity payment: current year capacity value and resource balance year CONE. If the current year is resource balance year, then system capacity value and resource balance year CONE are the same. If not, the user can modify the input "Years Until Resource Balance Year" to let the model know how many years are between the current year and resource balance year; then the system capacity price will be escalated from current year to resource balance year.
2. Qualifying capacity is a measure to make sure that the battery has the required duration to meet system capacity requirement. The default assumption for the duration requirement is 4 hours, which means a 50-MW/2-hr battery would be used as a 25-MW/4-hr battery for this service. The qualifying capacity in this case is 25MW.
3. Capacity Derate, in the actual dispatch, there might be circumstances where the peak is longer than the battery capacity or the storage is doing other higher-priority services and the storage system is not able to cover all the capacity hours. In those cases, the storage system will be derated based on actual dispatch/qualifying capacity to reflect the real performance and compensation.

Electric Energy Time Shift

Definition

Electric Energy Time Shift is the use of storage to buy energy during low-price hours and sell during high-price hours.

Dispatch Decision

Electric Energy Time Shift has lower priority than System Electric Supply Capacity and Distribution Investment Deferral. After the storage system dispatches to fulfill the requirement for these two services, the remaining capacity is optimized between electric time shift and AS services. In a 24-hour window, the dispatch is optimized to "buy low and sell high."

Benefit Calculation

Electric Energy Time-Shift (Arbitrage) benefit = (Energy sales) – (Energy Cost) / (Roundtrip efficiency) – (Variable O&M)

1. Electricity Sales = Hourly Discharge * Hourly Energy Prices. Discharge is the same every year but the energy price escalates every year based on inflation and gas price escalation rate.
2. Energy Cost = Hourly Discharge * Hourly Energy Prices. Charge is the same every year, but the energy price escalates every year based on inflation and gas price escalation rate.
3. Roundtrip Efficiency (%) = The roundtrip efficiency is defined as the total energy out divided by energy in, including losses in the power electronics, balance of plants, battery, and control equipment. Parasitic losses are assumed to be included in this metric for this analysis, but the user may separately define "housekeeping power" to decouple hourly parasitic losses from roundtrip efficiency.
4. Variable O&M = Hourly Discharge * User Defined Variable O&M Cost.

Regulation

Definition

Frequency regulation is the use of storage to follow the Balancing Authority's (BA) Automatic Generation Control (AGC) signal to balance short-duration (seconds to minutes) imbalances to maintain the grid's fundamental system frequency (60 Hz in the U.S.).

Market Bidding and Dispatch

Regulation service has lower priority than system electric supply capacity and distribution investment deferral. To provide this service, the storage system must have at least 15 minutes of capacity available. Its dispatch is on the same priority level and co-optimized with other ancillary services and electric energy time-shift to maximize market profit. The CPUC analysis is done for California electricity markets, which has a separate market for regulation up and regulation down. The default assumption is that we allow load to bid into those markets.

Therefore, the storage can bid both its charge and discharge capacity into the regulation up market or the regulation down market.

Also, due to calculation time limit, this analysis did not take into account intra-hour dispatch in this case. So the actual dispatch is calculated from regulation market bids by multiplying a mileage factor for regulation up and regulation down.

Benefit Calculation

Storage bids capacity into regulation markets and is paid based on hourly regulation market clearing prices. It also gets electricity price for dispatching when it does, but is also charged at the electricity prices for charging. The ability to bid regulation is based on the full difference between discharge and charge capacity.

Regulation Benefit = Regulation Market Revenue + Electricity Sales Revenue – Regulation Charging Cost – Variable O&M Cost

Synchronous Reserve

Definition

Synchronous reserve (spinning) is generation capacity that is already operating and synchronized to the system that can increase or decrease generation within 10 minutes. Synchronous reserves are procured by the ISO on an hour by hour basis in a competitive market. Energy storage may be capable of bidding in the synchronous reserve market to supply synchronous reserves.

Market Bidding and Dispatch

Synchronous reserve is on the same hierarchy level as other AS services. Its bidding and dispatch is optimized with other services on the same level with it.

Benefit Calculation

*Synchronous Reserve Benefit = Synchronous Reserve Bid * Synchronous Reserve Prices*

Non-Synchronous Reserve

Definition

Non-synchronous reserve is an ancillary services product that consists of off-line generation that can be ramped up to capacity and synchronized to the grid in less than 10 minutes when responding to a dispatch signal. Storage is eligible to provide this service by charging and discharging in response to the ISO signals

Market Bidding and Dispatch

System must reserve at least one hour of duration and the storage capacity (kW) bid when it agrees to provide this reserve. System may not be discharging at full capacity or otherwise obligated to possibly discharge during hours when it is providing this reserve.

Benefit Calculation

The storage system bids capacity into non-synchronous reserve markets and is paid based on hourly market clearing prices for being available. The storage system attempts to maintain a full charge so that it can offer its full discharge capacity in all hours. If a system is discharged (based on a small probability of non-synchronous reserves being called), it also receives the energy

price during the hour of discharge, which is represented by electricity sales in the NPV benefit table.

*Non-Synchronous Reserve Benefit = Non-Synchronous Reserve Bid * Non-Synchronous Reserve Price*

Distribution Investment Deferral

Definition

Distribution investment deferral is the use of storage to shave transformer peak load to delay a bulky investment on the substation for a few years. Transformer peak is defined as the highest load hour in base, or reference year load on the substation. The investment is deferred for as long as the storage is able to keep annual peak under the base year load peak or a defined threshold percent of base year load peak. It is possible to start deferring the investment a few years after the storage system is installed by making the "Load Target" a number above 100%.

Storage Dispatch

To provide this service, the storage system is discharged to bring the peak load under the load target. Load target is defined as a percentage of the base year peak load. Based on perfect foresight, the storage system charges to full capacity before the anticipated peak load. Distribution investment deferral has the higher priority over system and ancillary services because once the storage system fails to keep the load under the load target, the investment must be made. The longer the storage system can keep the load under the load target, the more money will be saved.

Benefit Calculation

The benefit value is calculated as NPV of investment deferred by the number of deferral years. The investment value to occur when the deferral year ends is defined by the user.

Summary of CPUC-Provided Inputs

ESVT requires various types of inputs ranging from system and market inputs to specific storage technical inputs. The inputs shown in this section were provided by CPUC staff and multiple stakeholders. The input collection process is described in more detail in section 3 of this report. In short, EPRI provided CPUC staff with an ESVT input template based on the services in the use case, and CPUC staff and stakeholders provided inputs based on the input template. Detailed input spreadsheets for this analysis were made public in the March 25 workshop at CPUC. This section seeks to highlight some of the inputs provided by the CPUC staff to help the user better understand the modeling process.

Global Financial Assumptions

To simplify the inputs and focus on the key inputs, a few financial assumptions are fixed throughout the use case. As shown in Table 6-1, global financial assumptions are used consistently in the base case and the sensitivity analysis to make comparison easier. IPP financial model was selected by the CPUC staff to ensure a discounted cash flow model, making it easier to compare this case with those of independent power producers. The discount rate, inflation, and tax rates stay the same throughout this analysis.

Table 6-1
Global Financial Assumptions

Input	2020	2015
Financial Model	IPP	IPP
Discount Rate	11.47%	11.47%
Inflation Rate	2%	2%
Fed Taxes	35%	35%
State Taxes	8.84%	8.84%

Market Inputs

The market prices in this use case were similar to that used in use case 1. However, the project start year in the base case is 2015. A case with project beginning year 2020 was performed as a sensitivity run.

Table 6-2
Average Market Prices

Input Type	Reference Year Avg. Price	Project Start Year 2020 Avg. Price*	Project Start Year 2015 Avg. Price
Energy ($/MWh)	30.62	39.96	34.47
Regulation Up ($/MW-hr)	9.20	12.01	10.36
Regulation Down ($/MW-hr)	6.93	9.04	7.80
Synchronous Reserve ($/MW-hr)	7.22	9.43	8.13
Non-Synchronous Reserve ($/MW-hr)	0.98	1.28	1.11

Table 6-3
Market Inputs

Input Name	Inputs
Market Price/Load Reference Year	CAISO 2011
Project Start Year	2015
Escalation Rate from Ref. Year to Start Year	3%
Escalation Rate After Start Year	4%
Allow Load (Storage Charge) to Bid Regulation?	Yes
Regulation Pay for Performance Factor	1.0x (no adjustment to base case)
Hourly Energy Deviation for Regulation Up	11.34%
Hourly Energy Deviation for Regulation Down	13.43%
Allow Load (Charge) to Bid Spinning Reserve	Yes
System Capacity Value at Project Start Year 2015	75
Cost of New Entry (CONE) adjusted for transmission loss	169.05
Resource Balance Year	2020
System Capacity Storage Min Duration (hr)	4
Capacity Hours Reserved Per Month	20
Probability to Dispatch During Capacity Hours	100%

Storage Technology Inputs

For this use case, the base case used a 1MW/4-Hour battery system with $500/kWh capital cost.

Table 6-4
Technology Inputs

Technology	Battery	
Configuration	Capacity (MW)	1
	Nameplate Duration (hr)	4
	Plant Life (yrs)	20
Performance	Lifetime Battery Replacements	1
	Roundtrip Efficiency (%)	83%
Cost	Capital Cost ($/kWh) in 2020	500
	Variable O&M Cost ($/kWh)	0.0003
	Fixed O&M Cost ($/kW-yr)	15
	Battery Replacement Cost	250

*Inputs in this table are in 2015 dollars

Results of Base Case

In the base case, the storage system deferred the 5.5 million dollar investment on the substation for five years by dispatching to keep substation peak load under the load target (defined by CPUC). During the time when the storage system is not used for distribution investment deferral service, the storage system generated revenue from the energy and ancillary service markets and by providing system capacity. The intensive usage led to a average capacity factor of 28.2% over project life time.

As illustrated in Figure 6-2, the base case of the distributed storage use case has a positive cost-benefit ratio. Frequency regulation and distribution investment deferral services provided more than half of the benefit together.

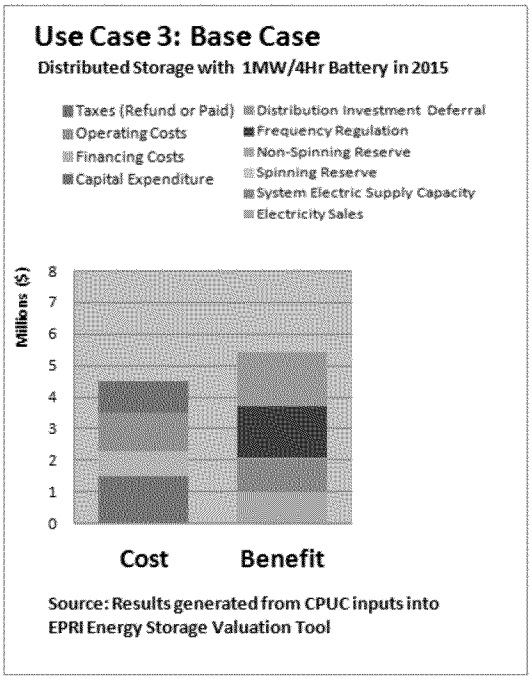

Figure 6-2
Distributed Storage Use Case: Base Case

Overview of Scenarios and Sensitivities

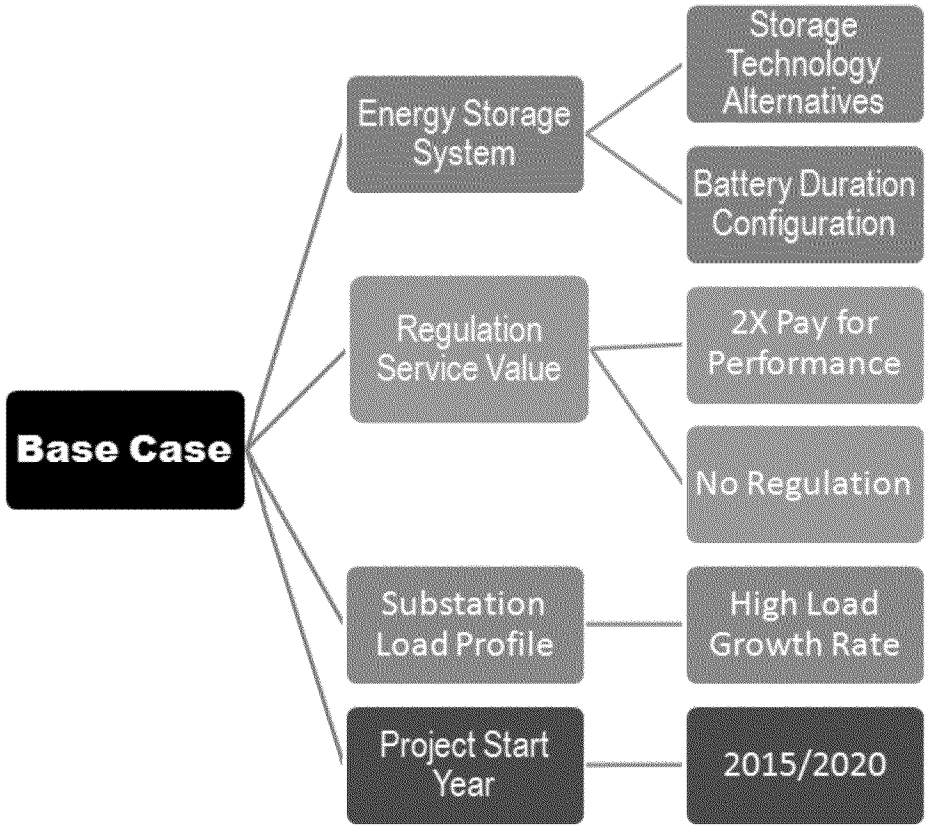

Figure 6-3
Distributed Storage Use Case Sensitivity Analysis Tree

In order to better understand this use case, CPUC requested a number of sensitivity runs. These sensitivity runs focused on four categories of factors that may influence the cost-effectiveness of the use case. Distribution investment deferral is one of the key services in this use case. The value of the distribution investment deferral service depends on the number of years that an investment can be deferred and on the size of the deferred investment. Furthermore, the number of years that an investment can be deferred is directly related to the load shape, the load growth rate, and the size of the storage system. Therefore, the sensitivity runs included cases where a different battery duration and a different load growth rate were compared to the base case.

Frequency regulation also contributed significantly to the cost-effectiveness of this use case. To better understand the influence of this service on the use case, two sensitivity runs related to regulation were performed. In the first one, the prices of regulation were doubled to simulate the condition where storage systems are paid for better performance in the regulation market. In the second case, regulation service was taken out of the equation.

Energy Storage System Sensitivity

Battery Duration of 2 Hours

In the base case, a battery system with a 4-hour duration was used. To determine the impact of changing battery duration on the cost-effectiveness of the case, another case with a 2-hour battery system was performed.

Table 6-5
Battery Duration Sensitivity

	Base Case (4 Hour)	Base Case (2 Hour)
Breakeven Capital Cost in 2013 dollars	$866/kWh ($3464/kW)	$1509/kWh ($3018/kW)
Benefit to Cost Ratio	1.20	1.35

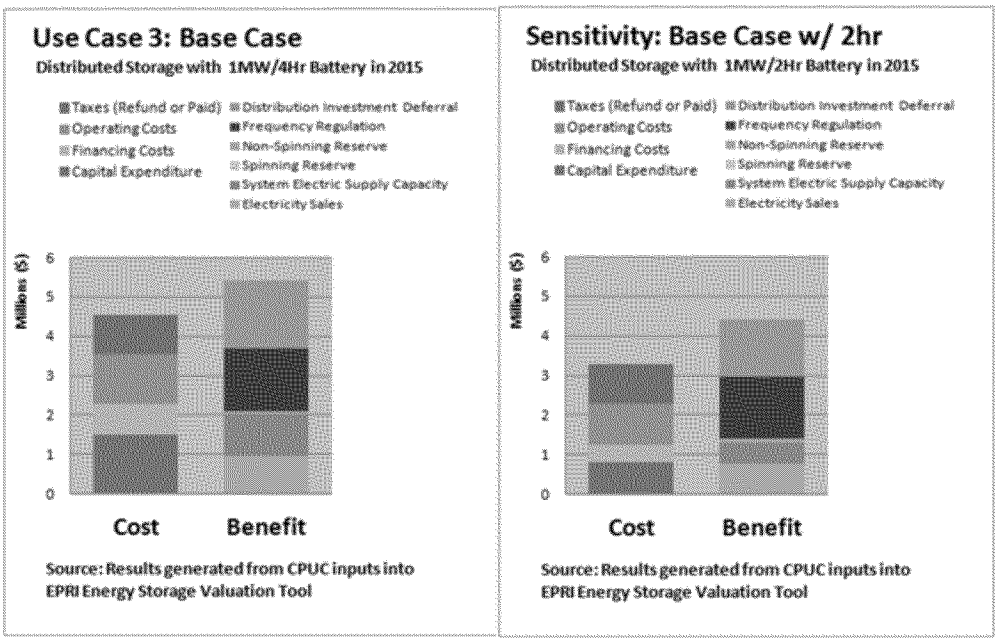

Figure 6-4
Sensitivity Analysis: Battery Duration

As shown in Figure 6-4, the case performed with a 2-hour battery has both lower cost and lower benefits than the base case. Under the assumptions of this use case, a 2-hour battery is more cost-effective than a 4-hour battery.

Alternative Technology—Flow Battery

In this use case, the base case was performed with a 1-MW/4-hour battery system. In order to understand the impact of switching to another technology, CPUC requested another run in which a flow battery was used to perform the base case. For detailed inputs of the flow battery used in this sensitivity run, refer to Table A-1 in Appendix A. Based on the inputs provided by CPUC,

compared to the battery system used in the base case, the flow battery has a shorter life, 17 years instead of 20 years, and lower efficiency, 70% instead of 83%. It is also assumed that no battery replacement would be necessary during its lifetime.

Table 6-6
Alternative Technology Breakeven Capital Cost

	Base Case	Base Case w/ Flow Battery – 4h
Breakeven Capital Cost in 2013 dollars	$866/kWh ($3464/kW)	$1009 /kWh ($4037/kW)
Benefit to Cost Ratio	1.20	1.32

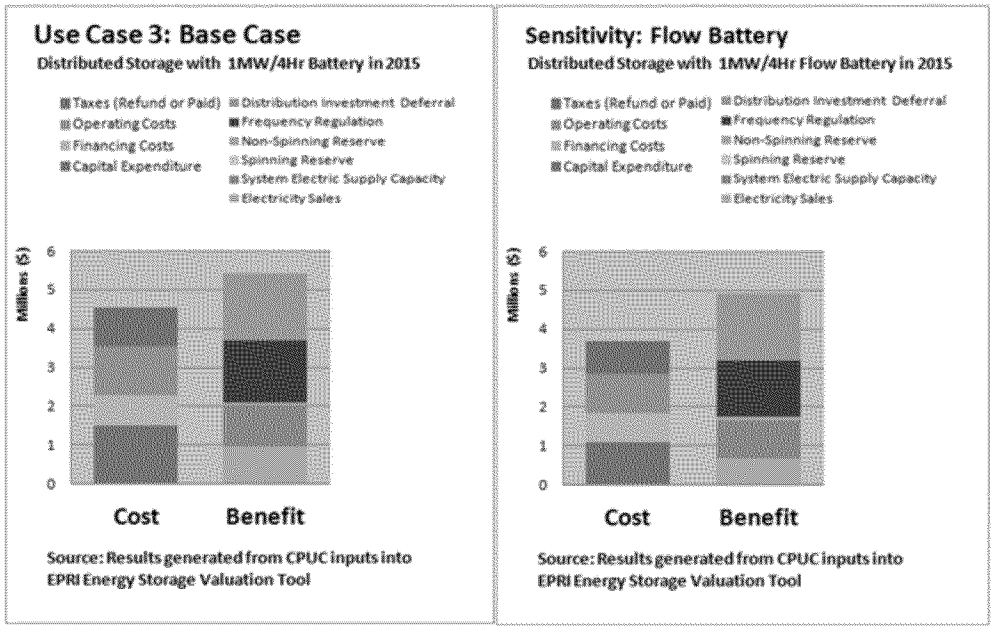

Figure 6-5
Sensitivity Analysis: Alternative Technology (Flow Battery)

As shown in Figure 6-5, the case with the flow battery has lower cost than the base case, mainly because it does not require any replacement throughout its lifetime. However, the benefit revenue generated by the flow battery is also lower because of its lower efficiency. Overall, the case with flow battery has a higher benefit-to-cost ratio than the base case.

Sensitivity on Value of Regulation Service

As shown in the base case, frequency regulation makes up more than a quarter of the total benefits. This part of the sensitivity analysis looks at the two conditions related with frequency regulation. The first one simulates the market condition where storage that provides regulation is getting compensated for its fast response capability, doubling its revenue. The second case takes out frequency regulation from the equation completely to see its impact on the base case.

As shown in Table 6-7 and Figure 6-6, all three cases remained cost effective with changing assumptions about frequency regulation. With double the frequency regulation price, the benefit-to-cost ratio increased from 1.20 to 1.35. When frequency regulation is taken out of the equation, the storage system is providing more spinning reserve service, which partially made up for the revenue loss. Overall, the cost-effectiveness in the case with higher regulation prices increased compared to that of the base case, while the cost-effectiveness in the case without regulation dropped compared to that of the base case.

Table 6-7
Sensitivity Analysis: Regulation Value

	Base Case	2X P4P	No Regulation
Breakeven Capital Cost in 2013 dollars	$866 /kWh ($3464/kW)	$1326 /kWh ($5306/kW)	$686 /kWh ($2745/kW)
Benefit to Cost Ratio	1.20	1.35	1.12

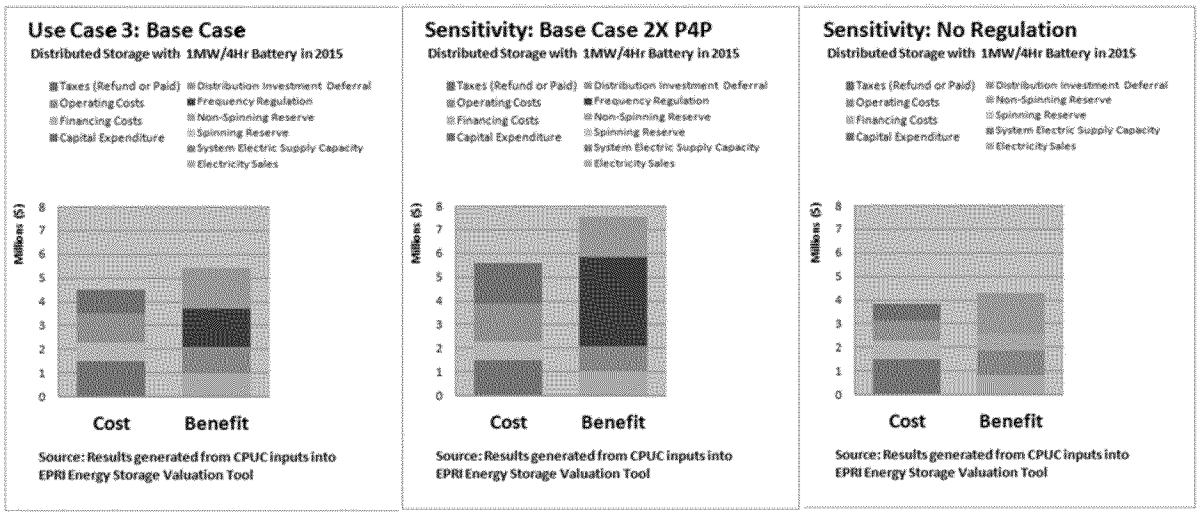

Figure 6-6
Sensitivity Analysis: Regulation Value

Substation Load Profile

As discussed earlier, distribution investment deferral made up almost a third of the benefits in the base case. Therefore, it is important to understand factors that may significantly impact the investment deferral value. One such factor is the rate of load growth on the substation.

The value of the distribution investment deferral service is directly related to the number of years that a storage system can defer the investment on a substation. As long as the storage system can keep the peak load under a certain threshold, new investment to expand substation capacity will not be necessary. However, when load outgrows the storage capacity, an investment on the substation can no longer be deferred. In this part of the sensitivity analysis, another case with a higher rate of load growth was conducted in comparison with the base case.

As shown in Table 6-8, under the assumptions in this use case, a 2 percent point increase in the load growth rate lowered the breakeven capital cost from $866/kWh to $634/kWh.

Table 6-8
Breakeven Capital Cost: Growth Rate Sensitivity

Load Growth Rate	Base Case (2%)	High Case (4%)
Breakeven Capital Cost in 2013 dollars	$866/kWh ($3464/kW)	$634/kWh ($2537/kW)
Benefit to Cost Ratio	1.20	1.09

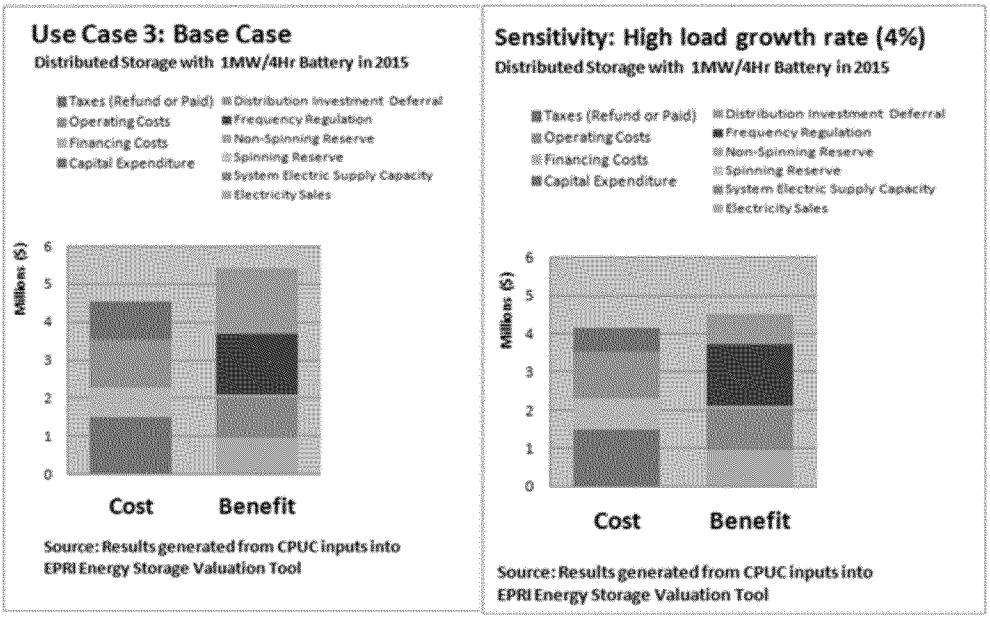

Figure 6-7
Sensitivity Analysis: Load Growth Rate

Project Start Year

In the base case, the project start year was 2015. To analyze the impact of a different project start year, an additional case was performed with a project start year as 2020. As the project start year changed, a number of inputs were adjusted accordingly. The value of the investment to be deferred has been updated, as was the system capacity value and CONE. Because 2020 is assumed to be resource balance year in this analysis, the system capacity value and CONE are the same in 2020. Moreover, due to escalation, ancillary service prices and energy prices are higher in 2020. The cost of the storage system is also expected to decrease over time.

As shown in Table 6-9, all of the above factors contributed to a higher breakeven capital cost and benefit-to-cost ratio in the case with 2020 as the project start year.

Table 6-9
Project Start Year Sensitivity Analysis Breakeven Capital Cost

Project Start Year	Base Case (2015)	High Case (2020)
Breakeven Capital Cost in 2013 dollars	$866/kWh ($3464/kW)	$940/kWh ($3761/kW)
Benefit to Cost Ratio	1.20	1.30

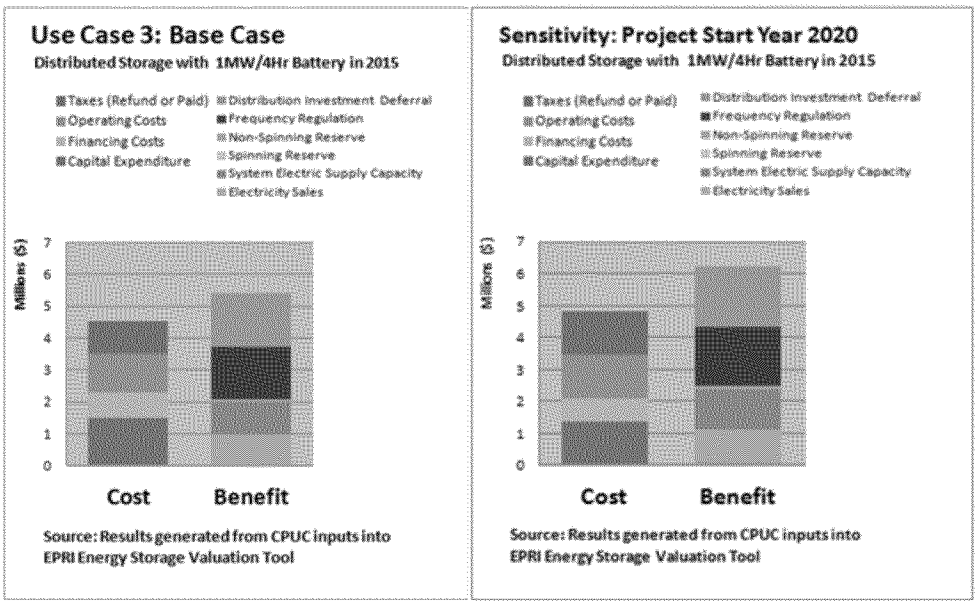

Figure 6-8
Sensitivity Analysis: Project Start Year 2015 vs 2020

Summary of Use Case Results

Under the assumptions provided by CPUC, the base case had a breakeven capital cost of $866/kWh. Distribution investment deferral and frequency regulation services provided over half of the benefits in this use case. The sensitivity analysis saw an increase in cost-effectiveness when the duration of the storage system was reduced to 2 hours, and a decrease in cost-effectiveness when the rate of load growth was doubled. The cost-effectiveness of the case also increased when the assumption for project start year was changed to 2020 and when a CPUC-defined flow battery system was used.

7
SUMMARY OF CONCLUSIONS AND RECOMMENDED FUTURE RESEARCH

Disclaimer

The analyses described in this report are provided as a demonstration of the EPRI storage valuation methodology and the Energy Storage Valuation Tool (ESVT) to inform the stakeholders of the CPUC Storage proceeding of the potential value of energy storage, from a technical perspective and under a limited number of high-priority scenarios. The analyses are not exhaustive with respect to the opportunities for energy storage in California, and the results of the analyses are only valid under the sets of inputs provided by the CPUC technical staff, as informed by the core group of stakeholders, including participants from CESA, PG&E, SCE, and SDG&E.

Results Summary

Figure 7-1 and Figure 7-2 display summaries of the benefit-to-cost (B/C) ratios and breakeven capital costs observed in these analyses.

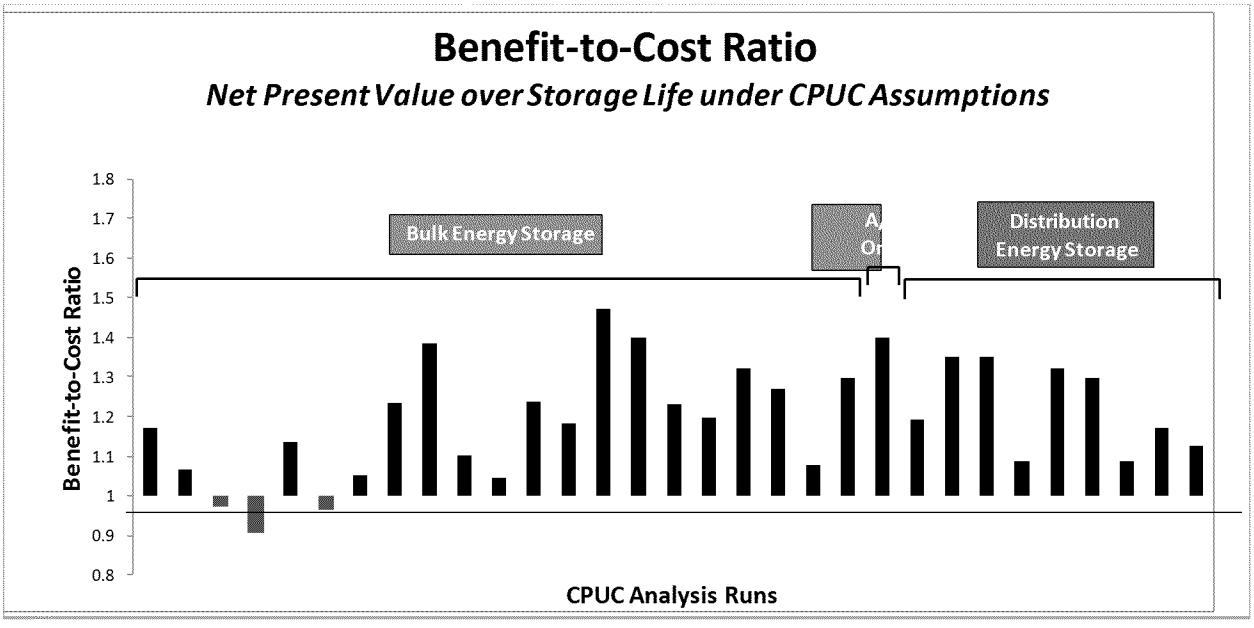

Figure 7-1
Summary of Benefit-to-Cost Ratios

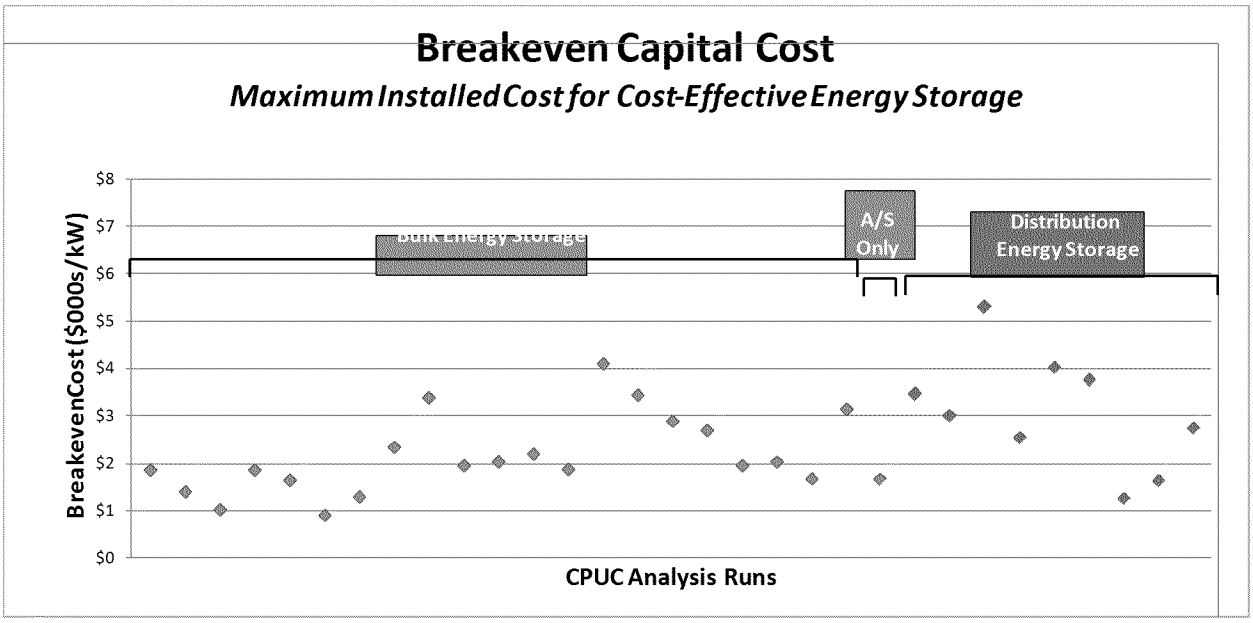

Figure 7-2
Energy Storage Breakeven Capital Costs

The majority of cases investigated returned a B/C ratio greater than 1, under the input cost assumptions provided for the different technologies. This indicates that the net present value (NPV) of direct, quantifiable benefits of the energy storage system modeled over its lifetime exceeds the direct, quantifiable costs in the simulation. Breakeven capital costs are more difficult to make general conclusions across cases, because different storage systems have different inherent cost structures and capabilities. However, the majority of cases returned breakeven capital cost results of $1000 to 4000/kW installed. The breakeven capital cost may be interpreted as the maximum threshold upfront cost that results in a benefit-to-cost ratio of greater than or equal to 1.

It should again be noted that benefits quantified in these analyses may cut across multiple stakeholders, and the analyses do not explicitly consider the monetizable potential for the owner of energy storage to cost-effectively recover an investment. In other words, some benefits accrue to entities other than the owner, and the owners of energy storage may not presently be able to easily monetize those benefits. Additionally, it does not consider indirect impacts of storage to the total production costs to the electric system or to society, nor does it consider the potential environmental impacts associated with the operation of the energy storage.

Comparison of Use Case Cost-Effectiveness

Three general use cases were investigated in this effort: bulk energy storage, regulation service-only, and distribution energy storage at a utility substation. Several additional possible use cases exist and have been identified by CPUC proceeding stakeholders.

It should be noted that the bulk storage use case, particularly the bulk battery use case, comprised the majority of all cases investigated. Most of the sensitivity-analysis runs are variations of the bulk battery base case. As a result, it is challenging to draw broad conclusions about the relative

cost-effectiveness of storage in the different use cases. However, below are a few high level observations.

Under the cost assumptions provided, distribution energy storage returns better cost-effectiveness numbers, controlling for project start year and market scenario. The distribution storage systems assumed were marginally more costly than the bulk energy storage systems, but significant additional value was calculated from the deferral of a distribution asset upgrade.

The ancillary services (regulation service-only) use case with a short-duration battery storage system returned the highest cost-effectiveness results, particularly under the assumption of a 2x pay-for-performance multiplier of the prices provided. The system demand for this service is significantly lower than those grid services relating to energy or capacity, so further analysis is recommended to draw robust conclusions about the potential for cost-effectiveness of this use case under storage-deployment scenarios.

Conclusions Relating to Input Sensitivities

Several input sensitivities were analyzed in this project. These are summarized in the tree in Figure 7-3 below.

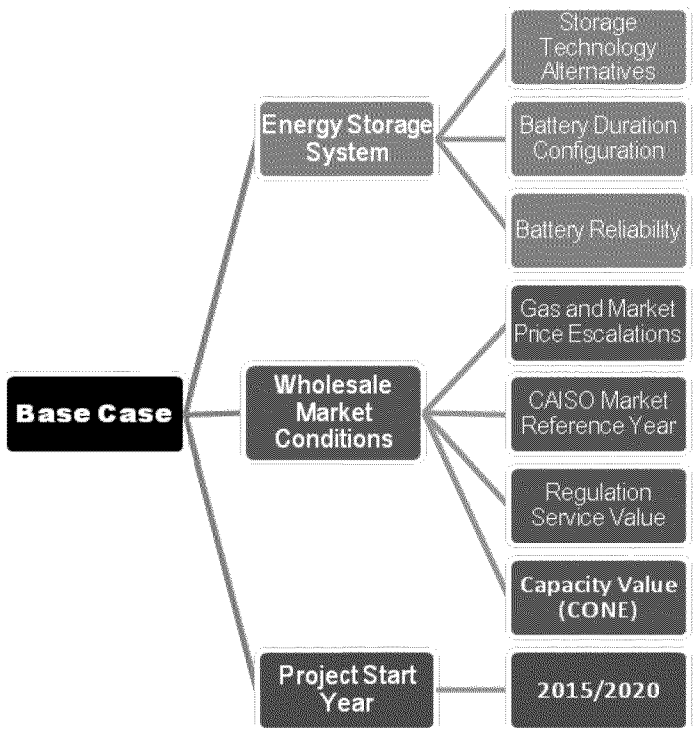

Figure 7-3
Input Sensitivities Investigated

The sensitivities fit into three broad categories, including energy storage system, wholesale market conditions, and project start year.

Sensitivity to Energy Storage System Inputs

Storage Technology

The majority of cases utilized "battery" technology, generally resembling characteristics of lithium-ion technology. However, a small number of cases looked at the results of flow battery, pumped hydro storage (PHS), and compressed air energy storage (CAES). Flow battery provided less cost-effective results in 2015 but more cost-effective in 2020, due to an assumed cost reduction. Pumped hydro and CAES systems provided more cost-effective results than the base case battery in bulk energy storage cases.

Battery Duration Configuration

Simulation of two-hour battery duration returned better cost-effectiveness results than the four-hour battery, under the assumptions provided. This was primarily a result of ancillary service value scaling by capacity/power ($/MW) when minimum duration thresholds have been satisfied. The base battery defined by the CPUC inputs had a large cost contribution scaling by amount of energy storage ($/kWh) than the other technologies of flow battery, pumped hydro, and CAES, so this conclusion may not be transferable to other technologies where this sensitivity was not investigated.

Battery Reliability / Frequency of Battery Replacement

The cost-effectiveness of the base case battery storage system was strongly influenced by the long-term reliability of the underlying battery technology. The results were significantly more cost-effective in the case with a battery replacement every 10 years versus a battery replacement every 5 years. This highlights the importance of increasing certainty around the expected field lifetime for emerging energy storage technologies.

Sensitivity to Wholesale Market Inputs

Gas and Market Price Escalation

The assumed escalation rate for fuel, energy, and ancillary services had an impact on cost-effectiveness. As expected, higher energy and ancillary service prices increase the cost-effectiveness of the modeled energy storage. However, this is partially offset by a somewhat lower expected value for capacity, because the benchmark combustion turbine would also garner some of the benefits of higher prices, which would lower the required capacity payment for CT breakeven.

CAISO Market Reference Year

For nearly all cases, the reference year of 2011 was used as the basis for load, energy, and ancillary service hourly shape and magnitude. When 2010 was used as a reference year, the cost-effectiveness of storage dropped significantly. 2011 was a "high hydro" year, which caused hydroelectric plants in the Northwest to generate higher sustained levels of power, which caused CAISO energy prices to be lower and ancillary services prices to be higher, which typically benefited the storage systems simulated, because they were earning significant ancillary service revenue. When the reference year was changed to 2010, the result was a drop in storage breakeven capital cost by approximately one-third. This material change underscores the importance of developing a range of potential future scenarios, which adequately capture the range of expectations when evaluating storage cost-effectiveness.

Regulation Service Value

Multiple scenarios were investigated to test the importance of value from regulation service. These included a 2x multiplier (implying a pay-for-performance factor for fast storage) and a case with no regulation value (to test the importance of this thinly demanded service on the cost-effectiveness). The regulation value had a significant impact on the cost-effectiveness overall; however, it was also observed that as the value of regulation decreases, value from providing spinning reserve partially fills the gap in the storage scenarios modeled.

Capacity Value

Along with regulation service and distribution investment deferral (where applicable), capacity value provided a large piece of the value in the ESVT simulations. Most of the values in this analysis were based on the Cost of New Entry (CONE) for an LM6000 with SPRINT, the assumed marginal combustion turbine to be built for additional capacity needs. However, if the future marginal unit is required for improved flexibility of the system, the marginal generator may already exist with an option of retiring the generator or mothballing it as a capacity resource. In this case, the capacity payment may only need to keep an existing generator on-line, allowing it to recover ongoing fixed costs, rather than needing to provide incentive for a new build. In the low capacity value case, the storage is significantly less cost-effective. The value of future capacity payments strongly affects storage cost-effectiveness in the modeled scenarios. It should also be noted that capacity payments for energy storage and other limited-duration resources are not well-established and a subject of continuing research.

Distribution Deferral Load Growth Sensitivity

As load growth rate on a distribution asset grows, the length of the asset deferral decreases. In the cases modeled, the distribution storage system generated significant value from a distribution investment deferral. As a result, the potential for providing distribution upgrade investment deferral service is highly site-specific and sensitive to the expected load growth. Load shape is also important, because the storage needs to have sufficient

Sensitivity to Project Start Year (2015/2020)

In general, calculated storage cost-effectiveness cases with a project start year of 2020 were more cost-effective than cases with project start year of 2015. This is the result of two primary assumptions: 1) additional capacity need begins in 2020, so earlier-year capacity values are lower; 2) storage system costs will be lower in future years. Most runs were performed with a 2020 project start year.

Research Recommendations

Following the analyses in this report, the following research recommendations are provided:

1. Expand analysis to cover greater breadth of expanded use cases. Due to time and resource constraints, the analysis was curtailed to cover only a small portion of the storage landscape, in terms of uses, technologies, scenarios, and sites.
2. For use cases reliant on regulation service for cost-effectiveness, model storage operation as a component of the larger CAISO or WECC system. Storage deployments could have substantial impact on regulation service price, and therefore profitability.

3. For inputs where there is significant uncertainty, and where those inputs are shown to be highly influential to the output cost-effectiveness, carefully expend analytical resources to narrow the uncertainty for those inputs. Some key inputs include: future market scenario development, capacity value, and understanding of future energy storage costs and durability/reliability.

Important Caveats

- Only a limited, prioritized series of analysis runs were completed. Results do not represent exhaustive treatment of storage opportunities in California.
- Results are only valid under the CPUC input assumptions provided.
- Analysis is limited to direct, quantifiable costs and benefits under the input assumptions and grid services modeled in the simulation.
- Analysis does not specifically consider how levels of storage deployment affect cost-effectiveness or impact society.

This project does not consider technical feasibility of energy storage projects, nor does it validate the cost and performance assumptions used in the analyses.

8
REFERENCES

1. http://www.leginfo.ca.gov/pub/09-10/bill/asm/ab_2501-2550/ab_2514_bill_20100929_chaptered.pdf
2. *Electric Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits*. EPRI, Palo Alto, CA: 2010. 1020676.
3. CPUC Energy Storage Proceeding R. 10-12-007: Energy Storage Phase 2 Interim Staff Report. January 4, 2013. http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M042/K157/42157799.PDF
4. http://www.cpuc.ca.gov/PUC/energy/electric/storage.htm
5. DER Avoided Cost Calculator https://www.pge.com/regulation/DemandResponseOIR/Other-Docs/E3/2010/DemandResponseOIR_Other-Doc_E3_20101105-01Atch02.doc.

A
USE CASE RESULTS

The table below summarizes energy storage technology inputs in the various runs in this report. It indicates each of the technologies as well as the assumed project start year. For complete inputs used to generate the results in this report, please refer to the CPUC Storage OIR website.

Table A-1
Energy Storage Technology Inputs

Category	Input	2020					2015	
		Battery*	Flow Battery	PHS	AG CAES	CT**	Battery	Flow Battery
Technology Cost / Performance	Nameplate Capacity (MW)	50	50	300	100	50	50	50
	Nameplate Duration (hr)	2	4	8	8	-	2	4
	Capital Cost ($/kWh) -Start Yr Nominal	528	443	166	211	-	603	775
	Capital Cost ($/kW) - Start Yr Nominal	1056	1772	1325	1684	1619	1206	3100
	Project Life (yr)	20	20	100	35	20	20	17
	Roundtrip Efficiency	83%	75%	82.50%	-	-	83%	70%
	Variable O&M ($/kWh)	0.00025	0.00025	0.001	0.003	0.004	0.00025	0.00025
	Fixed O&M ($/kW-yr)	15	15	7.5	5	17.4	15	15
	Major Replacement Frequency	1	0	-	-	-	1	0
	Major Replacement Cost ($/kWh)	250	-	-	-	-	250	-
	MACRS Depreciation Term (yr)	7	7	7	7	15	7	7
	Energy Charge Ratio (CAES)	-	-	-	0.7	-	-	-
	Full Capacity Heat Rate (CAES/CT)	-			3810	9387	-	-
	Heat Rate Curve (CAES/CT)	-	-	-	see wkst	see wkst	-	-
	Turbine Efficiency Curve (PHS)	-	-	see wkst	-	-	-	-
	Pump Efficiency (PHS)	-	-	see wkst	-	-	-	-

* Battery based loosely on Li-ion technology
**CT based on LM6000 w/ SPRINT technology

Table A-2
ESVT Run Reference and Results Summary

Run #	Detail	B/C Ratio	Breakeven Capital Cost ($/kWh) (2013$)	Breakeven Capital Cost ($/kW) (2013$)
run1	Use Case 1 (Bulk Energy Storage): Base Case	1.17	842	1684
run1 2010	Use Case 1 Sensitivity: 2010 Ref Year	1.05	565	1130
run1 2010P4P	Use Case 1 Sensitivity: 2010 Ref Year with P4P regulation prices	1.23	1079	2159
run1 LMS100	Use Case 1: CONE derived with LMS100	1.17	824	1649
run1 lowCONE	Use Case 1 Sensitivity: low CONE	1.08	632	1264
run1a	Use Case 1 Sensitivity: 2 Replacements	1.07	619	1238
run1b	Use Case 1 Sensitivity: No regulation services	0.98	433	865
run1c	Use Case 1: higher CapEX assumption	0.91	842	1684
run1d	Use Case 1: higher variable O&M assumption	1.14	740	1480
run1e	Use Case 1 Sensitivity: 3 Replacements	0.97	377	754
run2	Use Case 1 Sensitivity: 2X Regulation Price	1.38	1593	3186
run3	Use Case 1 Sensitivity: 3 Hour Duration	1.10	594	1781
run4	Use Case 1 Sensitivity: 4 Hour Duration	1.05	465	1860
run10	Use Case 1 Sensitivity: Market Scenario 1	1.24	1010	2020
run11	Use Case 1 Sensitivity: Market Scenario 2	1.18	851	1701
run12	Use Case 1 Sensitivity: Market Scenario 3	1.47	1941	3883
run13	Use Case 1 Sensitivity: Market Scenario 4	1.40	1619	3238
run16	Use Case 1 Sensitivity: Flow Battery	1.23	675	2699
run16a	Use Case 1 Sensitivity: Flow Battery (high variable O&M)	1.20	628	2511
run17	Use Case 1 Sensitivity: Pumped Hydro	1.32	223	1783
run18	Use Case 1 Sensitivity: CAES	1.27	232	1853
run19	Use Case 2 (Ancillary Service Only): Base Case	1.40	6712	1678
run20	Use Case 1 Sensitivity: Project Start Year 2015	1.08	755	1509
run21	Use Case 1 Sensitivity: Project Start Year 2015 with P4P regulation prices	1.30	1471	2941
run22	Use Case 3 (Distributed Storage): Base Case	1.19	866	3464
run22noreg	Use Case 3 Sensitivity: No regulation	1.12	686	2745
run22b	Use Case 3 Sensitivity: 2 Hour Duration	1.35	1509	3018
run23	Use Case 3 Sensitivity: 2X P4P regulation prices	1.35	1326	5306
run24	Use Case 3 Sensitivity: High Load Growth Rate	1.09	634	2537
run26	Use Case 3 Sensitivity: Flow Battery	1.32	1009	4037
run35	Use Case 3 Sensitivity: Project Start Year 2020	1.30	940	3761

Table A-2 provides an overview of all runs performed in this project. The first column provides references for all detailed results in the remainder of this appendix. The table also provides summary results in terms of benefit-to-cost ratio and breakeven energy storage capital cost. All breakeven capital cost numbers are displayed in inflation-adjusted 2013 dollars.

Description of Detailed Results

The detailed results provided in the subsequent tables were requested by the CPUC and core stakeholder group. These include detailed net present value cost and benefit information, breakeven capital cost in project start year nominal and 2013 inflation-adjusted forms, benefit-to-cost ratio, breakeven residual capacity value, capacity factor and full project life financial ProForma results.

Breakeven capital cost is the upfront energy storage installed cost at which the NPV of the storage investment equals zero. This is the cost point at which the benefit-to-cost ratio is equal to one.

Residual Capacity Value ($/kW-yr) is the levelized annual capacity payment that would be required to make the NPV equal to zero and the benefit-to-cost ratio equal to one.

$$\text{Storage System Annual Discharged Energy (MWh)} = \text{(illegible)}$$

Run 1: Base Case for Use Case One

Table A-3
Run 1

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	38,747,614	0
Financing Costs (Debt)	21,045,017	0
Operating Costs	53,559,217	0
Taxes (Refund or Paid)	26,536,652	0
Electricity Sales	0	41,065,527
System Electric Supply Capacity	0	32,828,088
Non-synchronous Reserve (Non-spin)	0	9,068
Synchronous Reserve (Spin)	0	9,354,815
Frequency Regulation	0	81,097,223
Total	**139,888,500**	**164,354,721**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	1,934	1,684
$/kWh**	967	842
Benefit-to-Cost Ratio		1.17
Breakeven Residual Capacity Value		$0
Capacity Factor		21.10%

Table A-3 (continued)
Run 1

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Electricity Sales	4,088,768	4,252,318	4,422,411	4,599,307	4,783,280	4,974,611	5,173,595	5,380,539	5,595,761	5,819,591	6,052,375	6,294,470	6,546,249	6,808,098	7,080,422	7,363,639	7,658,185	7,964,512	8,283,093	8,614,417
Benefit Revenues	12,610,320	13,042,647	13,490,826	13,955,460	14,437,181	14,936,640	15,454,517	15,991,517	16,548,374	17,125,849	17,724,734	18,345,851	18,990,056	19,658,235	20,351,314	21,070,251	21,816,043	22,589,726	23,392,378	24,225,117
Operating Revenue	16,699,088	17,294,965	17,913,236	18,554,768	19,220,461	19,911,251	20,628,112	21,372,057	22,144,135	22,945,440	23,777,109	24,640,321	25,536,304	26,466,334	27,431,737	28,433,890	29,474,228	30,554,239	31,675,471	32,839,533
Total Revenue	16,699,088	17,294,965	17,913,236	18,554,768	19,220,461	19,911,251	20,628,112	21,372,057	22,144,135	22,945,440	23,777,109	24,640,321	25,536,304	26,466,334	27,431,737	28,433,890	29,474,228	30,554,239	31,675,471	32,839,533
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(28,189)	(28,753)	(29,328)	(29,915)	(30,513)	(31,123)	(31,746)	(32,381)	(33,028)	(33,689)	(34,363)	(35,050)	(35,751)	(36,466)	(37,195)	(37,939)	(38,698)	(39,472)	(40,261)	(41,067)
Charging Costs	(4,206,416)	(4,374,673)	(4,549,660)	(4,731,646)	(4,920,912)	(5,117,749)	(5,322,458)	(5,535,357)	(5,756,771)	(5,987,042)	(6,226,524)	(6,475,585)	(6,734,608)	(7,003,992)	(7,284,152)	(7,575,518)	(7,878,539)	(8,193,680)	(8,521,427)	(8,862,285)
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)
Total Operating Costs	(5,565,406)	(5,749,226)	(5,940,088)	(6,138,267)	(6,344,049)	(6,557,732)	(6,779,626)	(7,010,052)	(7,249,344)	(7,487,850)	(7,755,932)	(8,023,965)	(8,302,340)	(8,591,463)	(8,891,756)	(9,203,658)	(9,527,626)	(9,864,133)	(10,213,673)	(10,576,760)
Operating Profit	11,133,682	11,545,739	11,973,148	12,416,501	12,876,411	13,353,519	13,848,486	14,362,005	14,894,791	15,447,590	16,021,177	16,616,356	17,233,964	17,874,871	18,539,980	19,230,232	19,946,602	20,690,106	21,461,797	22,262,774
Interest Expense	(2,394,603)	(2,330,756)	(2,262,963)	(2,190,981)	(2,114,550)	(2,033,396)	(1,947,226)	(1,855,732)	(1,758,582)	(1,655,429)	(1,545,902)	(1,429,605)	(1,306,121)	(1,175,006)	(1,035,788)	(887,967)	(731,010)	(564,353)	(387,396)	(199,504)
Loan Repayment Expense (Principal)	(1,033,122)	(1,096,969)	(1,164,761)	(1,236,743)	(1,313,174)	(1,394,328)	(1,480,498)	(1,571,993)	(1,669,142)	(1,772,295)	(1,881,822)	(1,998,119)	(2,121,603)	(2,252,718)	(2,391,986)	(2,539,758)	(2,696,715)	(2,863,372)	(3,040,328)	(3,228,220)
Debt Service Reserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,335,419
Interest earned on DSRF	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164
Interest earned on Battery Replacement Fund	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(2,643,292)	(2,621,283)	(2,598,594)	(2,575,204)	(2,551,091)	(2,526,233)	(2,500,606)	(2,474,188)	(2,446,954)	(2,418,878)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(1,020,141)
State Tax Refund (Paid)	(174,890)	257,182	(115,326)	(396,326)	(612,033)	(664,048)	(717,219)	(981,676)	(1,247,941)	(1,308,409)	(1,285,994)	(1,348,888)	(1,414,401)	(1,482,647)	(1,553,750)	(1,627,836)	(1,705,038)	(1,785,496)	(1,869,356)	(1,956,772)
Federal Tax Refund (Paid)	(631,226)	928,240	(416,244)	(1,430,448)	(2,208,997)	(2,396,732)	(2,588,642)	(3,543,139)	(4,504,163)	(4,722,409)	(4,641,506)	(4,868,509)	(5,104,962)	(5,351,284)	(5,607,912)	(5,875,308)	(6,153,952)	(6,444,348)	(6,747,023)	(7,062,532)
Tax Credit - Federal ITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(805,115)	1,185,421	(531,571)	(1,826,774)	(2,821,031)	(3,060,780)	(3,305,861)	(4,524,814)	(5,752,104)	(6,030,818)	(5,927,500)	(6,217,398)	(6,519,363)	(6,833,931)	(7,161,662)	(7,503,144)	(7,858,989)	(8,229,843)	(8,616,380)	(9,019,304)
Equity Investment (Invested Before Project)	(43,191,965)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	7,684,274	10,109,878	8,842,984	8,014,523	7,504,290	7,766,506	8,042,019	7,363,002	6,695,733	6,997,894	6,738,117	7,043,398	7,359,041	7,685,380	8,022,758	8,371,529	8,732,053	9,104,702	9,489,858	12,223,329

Run 1 2010: Run 1 with Price Escalated from 2010 Price

Table A-4
Run 1 2010

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	38,747,614	0
Financing Costs (Debt)	21,045,017	0
Operating Costs	55,525,159	0
Taxes (Refund or Paid)	14,350,311	0
Electricity Sales	0	41,096,460
System Electric Supply Capacity	0	33,504,923
Non-synchronous Reserve (Non-spin)	0	15,110
Synchronous Reserve (Spin)	0	6,174,641
Frequency Regulation	0	55,621,463
Total	129,668,101	136,412,597

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	1,298	1,130
$/kWh**	649	565
Benefit-to-Cost Ratio		1.05
Breakeven Residual Capacity Value		$115
Capacity Factor		17.90%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Electricity Sales	4,091,847	4,255,521	4,425,742	4,602,772	4,786,883	4,978,358	5,177,492	5,384,592	5,599,976	5,823,975	6,056,934	6,299,211	6,551,180	6,813,227	7,085,756	7,369,186	7,663,953	7,970,512	8,289,332	8,620,905
Benefit Revenues	9,974,473	10,297,020	10,630,939	10,976,656	11,334,612	11,705,263	12,089,086	12,486,574	12,898,240	13,324,617	13,766,258	14,223,737	14,697,652	15,188,624	15,697,295	16,224,336	16,770,441	17,336,333	17,922,762	18,530,509
Operating Revenue	14,066,321	14,552,541	15,056,681	15,579,428	16,121,495	16,683,621	17,266,579	17,871,166	18,498,216	19,148,592	19,823,191	20,522,948	21,248,832	22,001,850	22,783,051	23,593,522	24,434,394	25,306,845	26,212,095	27,151,414
Total Revenue	14,066,321	14,552,541	15,056,681	15,579,428	16,121,495	16,683,621	17,266,579	17,871,166	18,498,216	19,148,592	19,823,191	20,522,948	21,248,832	22,001,850	22,783,051	23,593,522	24,434,394	25,306,845	26,212,095	27,151,414
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(23,532)	(24,003)	(24,483)	(24,973)	(25,472)	(25,982)	(26,501)	(27,031)	(27,572)	(28,123)	(28,686)	(29,260)	(29,845)	(30,442)	(31,050)	(31,671)	(32,305)	(32,951)	(33,610)	(34,282)
Charging Costs	(4,406,226)	(4,582,475)	(4,765,774)	(4,956,405)	(5,154,661)	(5,360,848)	(5,575,282)	(5,798,293)	(6,030,225)	(6,271,433)	(6,522,291)	(6,783,182)	(7,054,510)	(7,336,690)	(7,630,158)	(7,935,364)	(8,252,779)	(8,582,890)	(8,926,205)	(9,283,254)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)
Total Operating Costs	(5,760,558)	(5,952,278)	(6,151,357)	(6,358,084)	(6,572,757)	(6,795,690)	(7,027,205)	(7,267,638)	(7,517,341)	(7,776,676)	(8,046,022)	(8,325,773)	(8,616,336)	(8,918,137)	(9,231,617)	(9,557,237)	(9,895,473)	(10,246,822)	(10,611,800)	(10,990,944)
Operating Profit	8,305,762	8,600,263	8,905,324	9,221,345	9,548,737	9,887,932	10,239,374	10,603,528	10,980,875	11,371,915	11,777,169	12,197,176	12,632,496	13,083,714	13,551,433	14,036,285	14,538,922	15,060,023	15,600,294	16,160,470
Interest Expense	(2,394,603)	(2,330,756)	(2,262,963)	(2,190,981)	(2,114,550)	(2,033,306)	(1,947,226)	(1,855,732)	(1,758,582)	(1,655,429)	(1,545,902)	(1,429,605)	(1,306,121)	(1,175,006)	(1,035,788)	(887,967)	(731,010)	(564,353)	(387,396)	(199,504)
Loan Repayment Expense	(1,093,122)	(1,096,969)	(1,164,761)	(1,236,743)	(1,313,174)	(1,394,328)	(1,480,498)	(1,571,993)	(1,669,142)	(1,772,295)	(1,881,822)	(1,998,119)	(2,121,603)	(2,252,718)	(2,391,936)	(2,539,758)	(2,696,715)	(2,863,372)	(3,040,328)	(3,228,220)
DebtServiceReserve	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,335,419
Interest earned on DSRF	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164
Interestearnedon Battery	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(2,643,292)	(2,621,283)	(2,598,594)	(2,575,204)	(2,551,091)	(2,526,233)	(2,500,606)	(2,474,188)	(2,446,954)	(2,418,878)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(1,020,141)
State Tax Refund (Paid)	75,098	517,562	155,869	(113,874)	(317,867)	(357,690)	(398,174)	(649,426)	(901,951)	(948,119)	(910,823)	(958,233)	(1,007,681)	(1,059,109)	(1,112,762)	(1,168,691)	(1,226,999)	(1,287,797)	(1,351,200)	(1,417,329)
Federal Tax Refund (Paid)	271,050	1,868,023	562,576	(411,002)	(1,147,270)	(1,291,002)	(1,437,118)	(2,343,959)	(3,255,389)	(3,422,024)	(3,287,413)	(3,458,526)	(3,636,818)	(3,822,617)	(4,016,267)	(4,218,127)	(4,428,577)	(4,648,013)	(4,876,852)	(5,115,531)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	346,149	2,385,585	718,445	(524,875)	(1,465,137)	(1,648,692)	(1,835,292)	(2,993,385)	(4,157,340)	(4,370,144)	(4,198,236)	(4,416,758)	(4,644,449)	(4,881,726)	(5,129,029)	(5,386,818)	(5,655,576)	(5,935,810)	(6,228,052)	(6,532,859)
(InvestedBeforeProject)	(43,191,965)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	6,008,619	8,364,565	7,025,175	6,121,265	5,532,510	5,713,007	5,903,476	5,135,954	4,376,581	4,582,894	4,223,373	4,424,857	4,632,488	4,846,428	5,066,845	5,293,907	5,527,786	5,768,653	6,016,683	8,607,470

Run 1 2010 P4P: Run 1 with Price Escalated from 2010 Price and 2X Regulation Price

Table A-5
Run 1 2010 P4P

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	38,747,614	0
Financing Costs (Debt)	21,045,017	0
Operating Costs	72,108,834	0
Taxes (Refund or Paid)	36,965,855	0
Electricity Sales	0	50,464,140
System Electric Supply Capacity	0	33,106,461
Non-synchronous Reserve (Non-spin)	0	259
Synchronous Reserve (Spin)	0	3,352,613
Frequency Regulation	0	121,576,513
Total	168,867,320	208,499,987

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	2,480	2,159
$/kWh**	1,240	1,079
Benefit-to-Cost Ratio		1.23
Breakeven Residual Capacity Value		$0
Capacity Factor		23.30%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Electricity Sales	5,024,558	5,225,541	5,434,562	5,651,945	5,878,023	6,113,144	6,357,669	6,611,976	6,876,455	7,151,513	7,437,574	7,735,077	8,044,480	8,366,259	8,700,909	9,048,946	9,410,904	9,787,340	10,178,833	10,585,987
Benefit Revenues	16,213,311	16,786,354	17,380,808	17,997,500	18,637,290	19,301,068	19,989,764	20,704,340	21,445,800	22,215,183	23,013,573	23,842,093	24,701,915	25,594,252	26,520,367	27,481,574	28,479,238	29,514,775	30,589,662	31,705,430
Operating Revenue	21,237,870	22,011,894	22,815,370	23,649,445	24,515,312	25,414,212	26,347,433	27,316,316	28,322,255	29,366,696	30,451,146	31,577,170	32,746,395	33,960,511	35,221,277	36,530,520	37,890,141	39,302,115	40,768,495	42,291,417
Total Revenue	21,237,870	22,011,894	22,815,370	23,649,445	24,515,312	25,414,212	26,347,433	27,316,316	28,322,255	29,366,696	30,451,146	31,577,170	32,746,395	33,960,511	35,221,277	36,530,520	37,890,141	39,302,115	40,768,495	42,291,417
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(30,666)	(31,279)	(31,905)	(32,543)	(33,194)	(33,858)	(34,535)	(35,226)	(35,930)	(36,649)	(37,382)	(38,129)	(38,892)	(39,670)	(40,463)	(41,273)	(42,098)	(42,940)	(43,799)	(44,675)
Charging Costs	(6,051,181)	(6,293,228)	(6,544,958)	(6,806,756)	(7,079,026)	(7,362,187)	(7,656,675)	(7,962,942)	(8,281,459)	(8,612,718)	(8,957,226)	(9,315,515)	(9,688,136)	(10,075,662)	(10,478,688)	(10,897,836)	(11,333,749)	(11,787,099)	(12,258,583)	(12,748,926)
Housekeeping Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)
Total Operating Costs	(7,412,647)	(7,670,308)	(7,937,963)	(8,216,005)	(8,504,844)	(8,804,906)	(9,116,632)	(9,440,482)	(9,776,934)	(10,126,486)	(10,489,654)	(10,866,976)	(11,259,010)	(11,666,336)	(12,089,560)	(12,529,309)	(12,986,236)	(13,461,020)	(13,954,366)	(14,467,009)
Operating Profit	13,825,222	14,341,586	14,877,408	15,433,440	16,010,468	16,609,306	17,230,802	17,875,835	18,545,321	19,240,210	19,961,492	20,710,195	21,487,385	22,294,174	23,131,716	24,001,211	24,903,905	25,841,095	26,814,129	27,824,408
Interest Expense	(2,394,603)	(2,330,756)	(2,262,963)	(2,190,981)	(2,114,550)	(2,033,396)	(1,947,226)	(1,855,732)	(1,758,582)	(1,655,429)	(1,545,902)	(1,429,605)	(1,306,121)	(1,175,006)	(1,035,788)	(887,967)	(731,010)	(564,353)	(387,396)	(199,504)
Loan Repayment Expense (Principal)	(1,033,122)	(1,096,969)	(1,164,761)	(1,236,743)	(1,313,174)	(1,394,328)	(1,480,498)	(1,571,093)	(1,669,142)	(1,772,295)	(1,881,822)	(1,998,119)	(2,121,603)	(2,252,718)	(2,391,936)	(2,539,758)	(2,696,715)	(2,863,372)	(3,040,328)	(3,228,220)
Debt Service Reserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,335,419
Interest earned on DSRF	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164
Interest earned on Battery Replacement Fund	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(2,643,292)	(2,621,283)	(2,598,594)	(2,575,204)	(2,551,091)	(2,526,233)	(2,500,606)	(2,474,188)	(2,446,954)	(2,418,878)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(1,020,141)
State Tax Refund (Paid)	(412,822)	10,029	(372,063)	(663,023)	(889,084)	(951,860)	(1,016,216)	(1,292,298)	(1,570,648)	(1,643,677)	(1,634,318)	(1,710,783)	(1,790,403)	(1,873,314)	(1,959,659)	(2,049,590)	(2,143,263)	(2,240,843)	(2,342,503)	(2,448,421)
Federal Tax Refund (Paid)	(1,489,988)	36,197	(1,342,877)	(2,393,033)	(3,208,950)	(3,435,524)	(3,667,803)	(4,664,261)	(5,668,901)	(5,932,483)	(5,898,703)	(6,174,690)	(6,462,059)	(6,761,307)	(7,072,952)	(7,397,536)	(7,735,629)	(8,087,822)	(8,454,738)	(8,837,027)
Tax Credit - Federal TC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(1,902,810)	46,226	(1,714,940)	(3,056,056)	(4,098,034)	(4,387,383)	(4,684,019)	(5,956,559)	(7,239,549)	(7,576,159)	(7,533,021)	(7,885,473)	(8,252,462)	(8,634,620)	(9,032,611)	(9,447,127)	(9,878,892)	(10,328,666)	(10,797,241)	(11,285,447)
Equity Investment (Invested Before Project)	(43,191,965)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	9,279,120	11,766,529	10,563,874	9,802,180	9,361,344	9,695,690	10,046,176	9,445,087	8,858,818	9,245,173	9,072,912	9,469,162	9,879,364	10,303,994	10,743,546	11,198,524	11,669,453	12,156,870	12,661,329	15,518,820

Run 1 LMS100: CONE derived from LMS100

Table A-6
Run 1 LMS100 Derived CONE

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	38,747,614	0
Financing Costs (Debt)	21,045,017	0
Operating Costs	53,559,217	0
Taxes (Refund or Paid)	26,038,162	0
Electricity Sales	0	41,065,527
System Electric Supply Capacity	0	31,604,681
Non-synchronous Reserve (Non-spin)	0	9,068
Synchronous Reserve (Spin)	0	9,354,815
Frequency Regulation	0	81,097,223
Total	**139,390,011**	**163,131,314**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	1894	1649
$/kWh**	947	824
Benefit-to-Cost Ratio		1.17
Breakeven Residual Capacity Value		$0
Capacity Factor		21.50%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Electricity Sales	4,088,768	4,252,318	4,422,411	4,599,307	4,783,280	4,974,611	5,173,595	5,380,539	5,595,761	5,819,591	6,052,375	6,294,470	6,546,249	6,808,098	7,080,422	7,363,639	7,658,185	7,964,512	8,283,093	8,614,417
Benefit Revenues	12,540,580	12,971,512	13,418,268	13,881,451	14,361,692	14,859,641	15,375,978	15,911,408	16,466,662	17,042,503	17,639,721	18,259,138	18,901,608	19,568,019	20,259,293	20,976,390	21,720,304	22,492,073	23,292,771	24,123,518
Operating Revenue	16,629,347	17,223,830	17,840,679	18,480,759	19,144,971	19,834,252	20,549,573	21,291,947	22,062,423	22,862,094	23,692,095	24,553,607	25,447,856	26,376,117	27,339,716	28,340,029	29,378,489	30,456,585	31,575,864	32,737,935
Total Revenue	16,629,347	17,223,830	17,840,679	18,480,759	19,144,971	19,834,252	20,549,573	21,291,947	22,062,423	22,862,094	23,692,095	24,553,607	25,447,856	26,376,117	27,339,716	28,340,029	29,378,489	30,456,585	31,575,864	32,737,935
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(28,189)	(28,753)	(29,328)	(29,915)	(30,513)	(31,123)	(31,746)	(32,381)	(33,028)	(33,689)	(34,363)	(35,050)	(35,751)	(36,466)	(37,195)	(37,939)	(38,698)	(39,472)	(40,261)	(41,067)
Charging Costs	(4,206,416)	(4,374,673)	(4,549,660)	(4,731,646)	(4,920,912)	(5,117,749)	(5,322,458)	(5,535,357)	(5,756,771)	(5,987,042)	(6,226,524)	(6,475,585)	(6,734,608)	(7,003,992)	(7,284,152)	(7,575,518)	(7,878,539)	(8,193,680)	(8,521,427)	(8,862,285)
Housekeeping Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)
Total Operating Costs	(5,565,406)	(5,749,226)	(5,940,088)	(6,138,267)	(6,344,049)	(6,557,732)	(6,779,626)	(7,010,052)	(7,249,344)	(7,497,850)	(7,755,932)	(8,023,965)	(8,302,340)	(8,591,463)	(8,891,756)	(9,203,658)	(9,527,626)	(9,864,133)	(10,213,673)	(10,576,760)
Operating Profit	11,063,942	11,474,604	11,900,590	12,342,492	12,800,922	13,276,519	13,769,947	14,281,895	14,813,079	15,364,244	15,936,163	16,529,642	17,145,516	17,784,654	18,447,959	19,136,371	19,850,863	20,592,452	21,362,191	22,161,175
Interest Expense	(2,394,603)	(2,330,756)	(2,262,963)	(2,190,981)	(2,114,550)	(2,033,396)	(1,947,226)	(1,855,732)	(1,758,582)	(1,655,429)	(1,545,902)	(1,429,605)	(1,306,121)	(1,175,006)	(1,035,788)	(887,967)	(731,010)	(564,353)	(387,396)	(199,604)
Loan Repayment Expense (Principal)	(1,033,122)	(1,096,969)	(1,164,761)	(1,236,743)	(1,313,174)	(1,394,328)	(1,480,498)	(1,571,993)	(1,669,142)	(1,772,295)	(1,881,822)	(1,998,119)	(2,121,603)	(2,252,718)	(2,391,936)	(2,539,758)	(2,696,715)	(2,863,372)	(3,040,328)	(3,228,220)
Debt Service Reserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,335,419
Interest earned on DSRF	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164
Interest earned on Battery Replacement	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(2,643,292)	(2,621,283)	(2,598,594)	(2,575,204)	(2,551,091)	(2,526,233)	(2,500,606)	(2,474,188)	(2,446,954)	(2,418,878)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(1,020,141)
State Tax Refund (Paid)	(168,725)	263,470	(108,912)	(389,783)	(605,360)	(657,241)	(710,276)	(974,594)	(1,240,718)	(1,301,041)	(1,278,478)	(1,341,223)	(1,406,582)	(1,474,672)	(1,545,615)	(1,619,538)	(1,696,574)	(1,776,863)	(1,860,551)	(1,947,791)
Federal Tax Refund	(608,374)	950,936	(393,094)	(1,406,835)	(2,184,912)	(2,372,165)	(2,563,583)	(3,517,579)	(4,478,092)	(4,695,817)	(4,614,382)	(4,840,843)	(5,076,742)	(5,322,499)	(5,578,552)	(5,845,361)	(6,123,405)	(6,413,190)	(6,715,243)	(7,030,116)
Tax Credit-Federal ITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(777,699)	1,214,406	(502,006)	(1,796,618)	(2,790,272)	(3,029,406)	(3,273,859)	(4,492,173)	(5,718,810)	(5,996,858)	(5,892,860)	(6,182,065)	(6,483,324)	(6,797,171)	(7,124,167)	(7,464,899)	(7,819,980)	(8,190,054)	(8,575,794)	(8,977,907)
(Invested Before Project)	(43,191,965)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash	7,642,950	10,067,727	8,799,990	7,970,670	7,459,559	7,720,881	7,995,482	7,315,534	6,647,315	6,948,508	6,687,744	6,992,017	7,306,632	7,631,923	7,968,232	8,315,912	8,675,324	9,046,839	9,430,837	12,163,128

Run 1 Low CONE

Table A-7
Run 1 Low CONE

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	38,747,614	0
Financing Costs (Debt)	21,045,017	0
Operating Costs	53,559,217	0
Taxes (Refund or Paid)	17,314,598	0
Electricity Sales	0	41,065,527
System Electric Supply Capacity	0	10,195,058
Non-synchronous Reserve (Non-spin)	0	9,068
Synchronous Reserve (Spin)	0	9,354,815
Frequency Regulation	0	81,097,223
Total	**130,666,446**	**141,721,691**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	1452	1264
$/kWh**	726	632
Benefit-to-Cost Ratio		1.08
Breakeven Residual Capacity Value		$0
Capacity Factor		21.50%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Electricity Sales	4,088,768	4,252,318	4,422,411	4,599,307	4,783,280	4,974,611	5,173,595	5,380,539	5,595,761	5,819,591	6,052,375	6,294,470	6,546,249	6,808,098	7,080,422	7,363,639	7,658,185	7,964,512	8,283,093	8,614,417
Benefit Revenues	10,163,404	10,552,313	10,951,237	11,365,141	11,795,055	12,241,672	12,705,650	13,187,673	13,688,452	14,208,729	14,749,271	15,310,873	15,894,384	16,500,651	17,130,578	17,785,100	18,465,183	19,171,855	19,906,149	20,669,164
Operating Revenue	14,258,172	14,805,231	15,373,708	15,964,448	16,578,335	17,216,283	17,878,245	18,568,212	19,284,213	20,028,320	20,801,646	21,605,343	########	23,308,749	24,211,000	25,148,739	26,123,374	27,136,367	28,189,242	29,283,580
Total Revenue	14,258,172	14,805,231	15,373,708	15,964,448	16,578,335	17,216,283	17,878,245	18,568,212	19,284,213	20,028,320	20,801,646	21,605,343	########	23,308,749	24,211,000	25,148,739	26,123,374	27,136,367	28,189,242	29,283,580
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(28,189)	(28,753)	(29,328)	(29,915)	(30,513)	(31,123)	(31,746)	(32,381)	(33,028)	(33,689)	(34,363)	(35,050)	(35,751)	(36,466)	(37,195)	(37,939)	(38,698)	(39,472)	(40,261)	(41,067)
Charging Costs	(4,206,416)	(4,374,673)	(4,549,660)	(4,731,646)	(4,920,912)	(5,117,749)	(5,322,458)	(5,535,357)	(5,756,771)	(5,987,042)	(6,226,524)	(6,475,585)	(6,734,608)	(7,003,992)	(7,284,152)	(7,575,518)	(7,878,539)	(8,193,680)	(8,521,427)	(8,862,285)
Housekeeping Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)
Total Operating Costs	(5,565,405)	(5,749,226)	(5,940,088)	(6,138,267)	(6,344,049)	(6,557,732)	(6,779,626)	(7,010,052)	(7,249,344)	(7,497,850)	(7,755,932)	(8,023,365)	(8,302,340)	(8,591,463)	(8,891,756)	(9,203,658)	(9,527,626)	(9,864,133)	(10,213,673)	(10,576,760)
Operating Profit	8,692,766	9,056,005	9,433,620	9,826,182	10,234,286	10,658,550	11,098,619	11,558,160	12,034,869	12,530,470	13,045,714	13,581,384	14,138,293	14,717,286	15,319,244	15,945,081	16,595,748	17,272,234	17,975,569	18,706,821
Interest Expense	(2,394,603)	(2,330,756)	(2,262,363)	(2,190,381)	(2,114,550)	(2,033,336)	(1,947,226)	(1,855,732)	(1,758,582)	(1,655,429)	(1,545,302)	(1,429,605)	(1,306,121)	(1,175,006)	(1,035,788)	(887,367)	(731,010)	(564,353)	(387,396)	(199,504)
Loan Repayment Expense (Principal)	(1,033,122)	(1,096,969)	(1,164,761)	(1,236,743)	(1,313,174)	(1,394,328)	(1,480,436)	(1,571,993)	(1,669,142)	(1,772,295)	(1,881,822)	(1,998,119)	(2,121,603)	(2,252,716)	(2,391,936)	(2,539,758)	(2,696,715)	(2,863,372)	(3,040,328)	(3,228,220)
Debt Service Reserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,335,419
Interest earned on DSRF	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164
Interest earned on Battery Replacement Fund	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(2,643,292)	(2,621,283)	(2,598,594)	(2,575,204)	(2,551,091)	(2,526,233)	(2,500,606)	(2,474,188)	(2,446,954)	(2,418,878)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(1,020,141)
State Tax Refund (Paid)	40,887	477,274	109,168	(167,341)	(378,463)	(425,813)	(474,219)	(733,816)	(395,124)	(1,050,536)	(1,022,963)	(1,080,597)	(1,140,743)	(1,203,511)	(1,269,037)	(1,337,428)	(1,408,822)	(1,483,356)	(1,561,174)	(1,642,426)
Federal Tax Refund (Paid)	147,573	1,722,614	394,018	(603,581)	(1,366,001)	(1,536,876)	(1,711,588)	(2,648,544)	(3,591,677)	(3,791,673)	(3,692,155)	(3,900,171)	(4,117,257)	(4,343,825)	(4,580,304)	(4,827,148)	(5,084,826)	(5,353,842)	(5,634,707)	(5,927,963)
Tax Credit-Federal ITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	188,460	2,199,888	503,186	(771,322)	(1,744,470)	(1,962,688)	(2,185,807)	(3,382,360)	(4,586,800)	(4,842,208)	(4,715,118)	(4,980,768)	(5,258,001)	(5,547,341)	(5,849,341)	(6,164,576)	(6,493,650)	(6,837,198)	(7,195,881)	(7,570,395)
Equity Investment (Invested Before Project)	(43,131,365)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash	6,237,934	8,634,611	7,338,212	6,473,656	5,338,725	6,169,629	6,413,205	5,701,612	5,001,115	5,269,383	4,975,037	5,245,056	5,524,732	5,814,385	6,114,343	6,424,345	6,746,538	7,079,477	7,424,128	10,116,285

Run 1a

Table A-8
Run 1a

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	49,714,903	0
Financing Costs (Debt)	24,219,274	0
Operating Costs	53,559,217	0
Taxes (Refund or Paid)	26,643,831	0
Electricity Sales	0	41,065,527
System Electric Supply Capacity	0	32,828,088
Non-synchronous Reserve (Non-spin)	0	9,068
Synchronous Reserve (Spin)	0	9,354,815
Frequency Regulation	0	81,097,223
Total	**154,137,225**	**164,354,721**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	1,422	1,238
$/kWh**	711	619
Benefit-to-Cost Ratio		1.07
Breakeven Residual Capacity Value		$85
Capacity Factor		21.50%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Electricity Sales	4,089,768	4,252,358	4,422,411	4,599,307	4,783,280	4,974,611	5,173,595	5,380,539	5,595,761	5,819,591	6,052,375	6,294,470	6,546,249	6,808,098	7,080,422	7,363,639	7,658,185	7,964,512	8,283,092	8,614,417
Benefit Revenue	12,749,801	13,184,918	13,635,941	14,103,479	14,588,159	15,090,638	15,611,595	16,151,737	16,711,799	17,292,542	17,894,760	18,519,270	19,166,951	19,838,669	20,535,356	21,257,974	22,007,521	22,785,033	23,591,591	24,428,314
Operating Revenue	16,838,569	17,437,276	18,058,352	18,702,786	19,371,439	20,065,249	20,785,191	21,532,276	22,307,559	23,112,133	23,947,135	24,813,740	25,713,200	26,646,767	27,615,779	28,621,612	29,665,705	30,749,546	31,874,684	33,042,731
Total Revenue	16,838,569	17,437,276	18,058,352	18,702,786	19,371,439	20,065,249	20,785,191	21,532,276	22,307,559	23,112,133	23,947,135	24,813,740	25,713,200	26,646,767	27,615,779	28,621,612	29,665,705	30,749,546	31,874,684	33,042,731
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(29,184)	(29,753)	(29,328)	(29,915)	(30,513)	(31,123)	(31,746)	(32,381)	(33,028)	(33,689)	(34,363)	(35,050)	(35,751)	(36,466)	(37,195)	(37,939)	(38,698)	(39,472)	(40,261)	(41,067)
Charging Costs	(4,206,416)	(4,274,672)	(4,549,440)	(4,721,646)	(4,920,912)	(5,117,749)	(5,322,459)	(5,535,357)	(5,756,771)	(5,987,042)	(6,226,524)	(6,475,585)	(6,734,608)	(7,003,992)	(7,284,152)	(7,575,518)	(7,878,539)	(8,193,680)	(8,521,427)	(8,862,285)
Housekeeping Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)
Total Operating Costs	(5,565,400)	(5,649,225)	(5,940,068)	(6,128,267)	(6,344,049)	(6,557,732)	(6,779,626)	(7,010,052)	(7,249,344)	(7,497,850)	(7,755,933)	(8,023,965)	(8,302,340)	(8,591,463)	(8,891,356)	(9,203,658)	(9,527,626)	(9,864,133)	(10,213,673)	(10,576,760)
Operating Profit	11,273,169	11,788,050	12,118,284	12,574,519	13,027,390	13,507,517	14,005,565	14,522,225	15,059,215	15,614,283	16,191,203	16,789,775	17,410,859	18,055,304	18,724,422	19,417,955	20,138,079	20,885,413	21,661,010	22,465,971
Interest Expense	(2,672,381)	(2,990,463)	(2,903,482)	(2,811,125)	(2,713,061)	(2,608,927)	(2,499,378)	(2,384,036)	(2,264,529)	(2,140,969)	(1,983,460)	(1,834,247)	(1,675,811)	(1,507,585)	(1,328,962)	(1,139,300)	(937,918)	(724,089)	(497,047)	(255,972)
Loan Repayment Expense (Principal)	(1,325,541)	(1,497,459)	(1,494,440)	(1,586,797)	(1,684,861)	(1,788,985)	(1,899,548)	(2,016,926)	(2,141,503)	(2,273,932)	(2,414,462)	(2,563,675)	(2,722,110)	(2,890,337)	(3,068,960)	(3,258,621)	(3,460,004)	(3,673,832)	(3,900,875)	(4,141,949)
Debt Service Reserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,335,419
Interest earned on Interest earned on	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164
Battery Replacement	1,410,989	1,454,589	1,499,526	1,545,871	1,593,629	1,642,892	1,693,647	780,356	804,469	829,327	854,952	881,371	908,606	936,682	(0)	(0)	(0)	(0)	(0)	(0)
Net Finance Costs	(2,914,768)	(2,871,148)	(2,826,222)	(2,779,886)	(2,732,119)	(2,682,879)	(2,632,110)	(3,545,401)	(3,521,208)	(3,496,430)	(3,470,004)	(3,444,356)	(3,417,152)	(3,389,076)	(4,325,757)	(4,325,757)	(4,325,757)	(4,325,757)	(4,325,757)	(1,990,239)
State Tax Refund	(109,075)	239,247	(127,176)	(422,261)	(642,234)	(690,702)	(756,524)	(940,477)	(1,209,180)	(1,272,234)	(1,337,922)	(1,406,362)	(1,477,670)	(1,552,000)	(1,544,103)	(1,622,212)	(1,703,674)	(1,788,640)	(1,877,274)	(1,969,743)
Federal Tax Refund	(432,411)	863,510	(495,105)	(1,524,057)	(2,318,000)	(2,521,893)	(2,730,502)	(3,394,441)	(4,364,265)	(4,591,843)	(4,828,929)	(5,075,943)	(5,333,349)	(5,601,593)	(5,573,093)	(5,855,012)	(6,149,028)	(6,455,697)	(6,775,599)	(7,109,347)
Tax Credit-Federal ITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(871,482)	1,102,758	(622,281)	(1,946,318)	(2,960,234)	(3,220,509)	(3,487,026)	(4,334,918)	(5,572,445)	(5,864,077)	(6,166,850)	(6,482,319)	(6,811,027)	(7,153,593)	(7,117,195)	(7,477,225)	(7,852,702)	(8,244,337)	(8,652,873)	(9,079,090)
Equity Investment (Inverted Before	(55,417,202)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	$7,486,913.13	$9,919,599.09	$8,659,761.45	$7,628,315.03	$7,335,037.01	$7,604,132.12	$7,886,428.62	$6,641,905.46	$5,963,481.29	$6,253,775.72	$6,553,548.74	$6,863,086.20	$7,182,680.49	$7,512,630.42	$7,261,069.80	$7,614,972.97	$7,959,620.14	$8,315,318.38	$8,682,389.27	$11,396,542.79

Run 1b: Base Case Without Regulation

Table A-9
Run 1b

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	38,747,614	0
Financing Costs (Debt)	21,045,017	0
Operating Costs	28,255,643	0
Taxes (Refund or Paid)	8,514,249	0
Electricity Sales	0	24,578,345
System Electric Supply Capacity	0	28,137,171
Non-synchronous Reserve (Non-spin)	0	17,360
Synchronous Reserve (Spin)	0	42,087,173
Total	96,562,524	94,820,050

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	994	865
$/kWh**	497	433
Benefit-to-Cost Ratio		0.98
Breakeven Residual Capacity Value		$176
Capacity Factor		12.00%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	2,447,190	2,545,077	2,646,881	2,752,756	2,862,866	2,977,381	3,096,476	3,220,335	3,349,148	3,483,114	3,622,439	3,767,336	3,918,030	4,074,751	4,237,741	4,407,251	4,583,541	4,766,882	4,957,558	5,155,860
BenefitRevenues	7,400,394	7,632,212	7,872,018	8,120,107	8,376,784	8,642,365	8,917,180	9,201,570	9,495,889	9,800,506	10,115,804	10,442,179	10,780,044	11,129,827	11,491,973	11,866,944	12,255,219	12,657,298	13,073,697	13,504,954
Operating Revenue	9,847,584	10,177,289	10,518,899	10,872,863	11,239,650	11,619,746	12,013,656	12,421,904	12,845,037	13,283,620	13,738,243	14,209,515	14,698,074	15,204,578	15,729,714	16,274,194	16,838,760	17,424,180	18,031,255	18,660,814
Total Revenue	9,847,584	10,177,289	10,518,899	10,872,863	11,239,650	11,619,746	12,013,656	12,421,904	12,845,037	13,283,620	13,738,243	14,209,515	14,698,074	15,204,578	15,729,714	16,274,194	16,838,760	17,424,180	18,031,255	18,660,814
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(15,815)	(16,131)	(16,453)	(16,782)	(17,118)	(17,460)	(17,810)	(18,166)	(18,529)	(18,900)	(19,278)	(19,663)	(20,057)	(20,458)	(20,867)	(21,284)	(21,710)	(22,144)	(22,587)	(23,039)
Charging Costs	(1,697,825)	(1,765,738)	(1,836,367)	(1,909,822)	(1,986,215)	(2,065,663)	(2,148,290)	(2,234,222)	(2,323,590)	(2,416,534)	(2,513,195)	(2,613,723)	(2,718,272)	(2,827,003)	(2,940,083)	(3,057,687)	(3,179,994)	(3,307,194)	(3,439,482)	(3,577,061)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)
Total Operating Costs	(3,044,439)	(3,127,669)	(3,213,921)	(3,303,310)	(3,395,957)	(3,491,985)	(3,591,522)	(3,694,702)	(3,801,664)	(3,912,553)	(4,027,519)	(4,146,717)	(4,270,310)	(4,398,466)	(4,531,359)	(4,669,172)	(4,812,093)	(4,960,319)	(5,114,053)	(5,273,508)
Operating Profit	6,803,144	7,049,620	7,304,978	7,569,552	7,843,693	8,127,761	8,422,134	8,727,203	9,043,373	9,371,067	9,710,724	10,062,798	10,427,763	10,806,112	11,198,355	11,605,022	12,026,667	12,463,861	12,917,201	13,387,306
Interest Expense	(2,394,603)	(2,330,756)	(2,262,963)	(2,190,981)	(2,114,550)	(2,033,396)	(1,947,226)	(1,855,732)	(1,758,582)	(1,655,429)	(1,545,902)	(1,429,605)	(1,306,121)	(1,175,006)	(1,035,788)	(887,967)	(731,010)	(564,353)	(387,396)	(199,504)
Loan Repayment Expense (Principal)	(1,033,122)	(1,096,969)	(1,164,761)	(1,236,743)	(1,313,174)	(1,394,328)	(1,480,498)	(1,571,993)	(1,669,142)	(1,772,295)	(1,881,822)	(1,998,119)	(2,121,603)	(2,252,718)	(2,391,936)	(2,539,758)	(2,696,715)	(2,863,372)	(3,040,328)	(3,228,220)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,335,419
Interest earned on DSRF	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164
Interestearnedon Battery Replacement Fund	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(2,643,292)	(2,621,283)	(2,598,594)	(2,575,204)	(2,551,091)	(2,526,233)	(2,500,606)	(2,474,188)	(2,446,954)	(2,418,878)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(1,020,141)
State Tax Refund (Paid)	207,930	654,639	297,340	32,145	(167,141)	(202,091)	(237,530)	(483,559)	(730,676)	(771,244)	(728,150)	(769,554)	(812,732)	(857,769)	(904,750)	(953,767)	(1,004,915)	(1,058,296)	(1,114,014)	(1,172,181)
Federal Tax Refund (Paid)	750,476	2,362,771	1,073,182	116,019	(603,258)	(729,402)	(857,310)	(1,745,299)	(2,637,210)	(2,783,634)	(2,628,093)	(2,777,531)	(2,933,376)	(3,095,925)	(3,265,493)	(3,442,409)	(3,627,017)	(3,819,682)	(4,020,784)	(4,230,725)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	958,405	3,017,410	1,370,522	148,164	(770,399)	(931,493)	(1,094,839)	(2,228,858)	(3,367,885)	(3,554,878)	(3,356,242)	(3,547,085)	(3,746,108)	(3,953,694)	(4,170,243)	(4,396,176)	(4,631,933)	(4,877,978)	(5,134,799)	(5,402,906)
Equity Investment (InvestedBeforeProject)	(43,191,965)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	5,118,258	7,445,747	6,076,906	5,142,512	4,522,203	4,670,035	4,826,689	4,024,156	3,228,534	3,397,311	2,998,921	3,160,153	3,326,095	3,496,858	3,672,552	3,853,287	4,039,174	4,230,324	4,426,843	6,964,260

Run 1c: Base Case with High CapEx Assumption

Table A-10
Run 1c

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	76,444,368	0
Financing Costs (Debt)	45,678,609	0
Operating Costs	59,694,132	0
Taxes (Refund or Paid)	0	1,672,052
Electricity Sales	0	41,065,527
System Electric Supply Capacity	0	32,828,088
Non-synchronous Reserve (Non-spin)	0	9,068
Synchronous Reserve (Spin)	0	9,354,815
Frequency Regulation	0	81,097,223
Total	**181,817,109**	**166,026,773**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	1,934	1,684
$/kWh**	967	842
Benefit-to-Cost Ratio		0.91
Breakeven Residual Capacity Value		$278
Capacity Factor		21.50%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Electricity Sales	4,088,768	4,252,318	4,422,411	4,599,307	4,783,280	4,974,611	5,173,595	5,380,539	5,595,761	5,819,591	6,052,375	6,294,470	6,546,249	6,808,098	7,080,422	7,363,639	7,658,185	7,964,512	8,283,093	8,614,417
Benefit Revenues	12,749,801	13,184,918	13,635,941	14,103,479	14,588,159	15,090,638	15,611,595	16,151,737	16,711,798	17,292,542	17,894,760	18,519,278	19,166,951	19,838,669	20,535,356	21,257,974	22,007,521	22,785,033	23,591,591	24,428,314
Operating Revenue	16,838,569	17,437,236	18,058,352	18,702,786	19,371,439	20,065,249	20,785,191	21,532,276	22,307,559	23,112,133	23,947,135	24,813,748	25,713,200	26,646,767	27,615,779	28,621,613	29,665,705	30,749,546	31,874,684	33,042,731
Total Revenue	16,838,569	17,437,236	18,058,352	18,702,786	19,371,439	20,065,249	20,785,191	21,532,276	22,307,559	23,112,133	23,947,135	24,813,748	25,713,200	26,646,767	27,615,779	28,621,613	29,665,705	30,749,546	31,874,684	33,042,731
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(28,189)	(28,753)	(29,328)	(29,915)	(30,513)	(31,123)	(31,746)	(32,381)	(33,028)	(33,689)	(34,363)	(35,050)	(35,751)	(36,466)	(37,195)	(37,939)	(38,698)	(39,472)	(40,261)	(41,067)
Charging Costs	(4,206,416)	(4,374,673)	(4,549,660)	(4,731,646)	(4,920,912)	(5,117,749)	(5,322,458)	(5,535,357)	(5,756,771)	(5,987,042)	(6,226,524)	(6,475,585)	(6,734,608)	(7,003,992)	(7,284,152)	(7,575,518)	(7,878,539)	(8,193,680)	(8,521,427)	(8,862,285)
Housekeeping Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)	(1,375,000)
Total Operating Costs	(6,359,606)	(6,543,426)	(6,734,288)	(6,932,467)	(7,138,249)	(7,351,932)	(7,573,826)	(7,804,252)	(8,043,544)	(8,292,050)	(8,550,132)	(8,818,165)	(9,096,540)	(9,385,663)	(9,685,956)	(9,997,858)	(10,321,826)	(10,658,333)	(11,007,873)	(11,370,960)
Operating Profit	10,478,963	10,893,810	11,324,064	11,770,319	12,233,190	12,713,317	13,211,365	13,728,025	14,264,015	14,820,083	15,397,003	15,995,583	16,616,659	17,261,104	17,929,822	18,623,755	19,343,879	20,091,213	20,866,810	21,671,771
Interest Expense	(4,724,262)	(4,508,300)	(4,464,553)	(4,322,541)	(4,171,752)	(4,011,645)	(3,841,643)	(3,661,135)	(3,469,471)	(3,265,963)	(3,049,877)	(2,820,438)	(2,576,820)	(2,318,146)	(2,043,485)	(1,751,851)	(1,442,194)	(1,113,400)	(764,286)	(393,597)
Loan Repayment Expense (Principal)	(2,038,224)	(2,164,187)	(2,297,933)	(2,439,946)	(2,590,734)	(2,750,842)	(2,920,844)	(3,101,352)	(3,293,015)	(3,496,524)	(3,712,609)	(3,942,048)	(4,185,667)	(4,444,341)	(4,719,001)	(5,010,635)	(5,320,293)	(5,649,087)	(5,998,200)	(6,368,889)
Debt Service Reserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,528,928
Interest earned on DSRF	170,844	170,844	170,844	170,844	170,844	170,844	170,844	170,844	170,844	170,844	170,844	170,844	170,844	170,844	170,844	170,844	170,844	170,844	170,844	170,844
Interest earned on Battery Replacement Fund	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(5,879,375)	(5,857,366)	(5,834,677)	(5,811,286)	(5,787,173)	(5,762,315)	(5,736,689)	(5,710,271)	(5,683,037)	(5,654,961)	(6,591,642)	(6,591,642)	(6,591,642)	(6,591,642)	(6,591,642)	(6,591,642)	(6,591,642)	(6,591,642)	(6,591,642)	(1,062,715)
State Tax Refund (Paid)	992,262	2,069,609	1,244,246	637,675	187,916	128,017	67,801	(490,099)	(1,049,661)	(1,119,289)	(1,106,588)	(1,179,785)	(1,256,224)	(1,336,060)	(1,419,455)	(1,506,579)	(1,597,612)	(1,692,741)	(1,792,166)	(1,896,093)
Federal Tax Refund (Paid)	3,581,349	7,469,791	4,490,827	2,301,546	678,242	462,049	244,713	(1,768,902)	(3,788,516)	(4,039,825)	(3,993,983)	(4,258,171)	(4,534,061)	(4,822,210)	(5,123,204)	(5,437,659)	(5,766,221)	(6,109,570)	(6,468,421)	(6,843,524)
Tax Credit - Federal ITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	4,573,611	9,539,400	5,735,072	2,939,222	866,158	590,066	312,514	(2,259,001)	(4,838,177)	(5,159,114)	(5,100,572)	(5,437,956)	(5,790,285)	(6,158,270)	(6,542,659)	(6,944,238)	(7,363,833)	(7,802,312)	(8,260,587)	(8,739,617)
Equity Investment (Invested Before Project)	(85,212,537)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	9,173,199	14,575,844	11,224,460	8,898,254	7,312,174	7,541,067	7,787,189	5,758,752	3,742,801	4,006,008	3,704,789	3,965,984	4,234,732	4,511,192	4,795,521	5,087,875	5,388,404	5,697,258	6,014,581	11,869,440

Run 1d: Base Case with Higher Variable O&M Assumption

Table A-11
Run 1d

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	38,747,614	0
Financing Costs (Debt)	21,045,017	0
Operating Costs	45,245,282	0
Taxes (Refund or Paid)	22,074,406	0
Electricity Sales	0	23,883,178
System Electric Supply Capacity	0	32,961,342
Non-synchronous Reserve (Non-spin)	0	0
Synchronous Reserve (Spin)	0	10,652,354
Frequency Regulation	0	77,592,541
Total	**127,112,319**	**145,089,415**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	1,700	1,480
$/kWh**	850	740
Benefit-to-Cost Ratio		1.14
Breakeven Residual Capacity Value		$28
Capacity Factor		11.10%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	2,377,974	2,473,093	2,572,017	2,674,898	2,781,893	2,893,169	3,008,896	3,129,252	3,254,422	3,384,599	3,519,983	3,660,782	3,807,213	3,959,502	4,117,882	4,282,597	4,453,901	4,632,057	4,817,339	5,010,033
BenefitRevenues	12,544,201	12,970,811	13,412,981	13,871,305	14,346,399	14,838,901	15,349,475	15,878,814	16,427,633	16,996,678	17,586,723	18,198,574	18,833,067	19,491,070	20,173,488	20,881,257	21,615,354	22,376,791	23,166,623	23,985,943
Operating Revenue	14,922,175	15,443,904	15,984,998	16,546,203	17,128,292	17,732,070	18,358,371	19,008,065	19,682,055	20,381,276	21,106,706	21,859,356	22,640,280	23,450,572	24,291,369	25,163,854	26,069,255	27,008,848	27,983,962	28,995,975
Total Revenue	14,922,175	15,443,904	15,984,998	16,546,203	17,128,292	17,732,070	18,358,371	19,008,065	19,682,055	20,381,276	21,106,706	21,859,356	22,640,280	23,450,572	24,291,369	25,163,854	26,069,255	27,008,848	27,983,962	28,995,975
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(1,453,351)	(1,482,419)	(1,512,067)	(1,542,308)	(1,573,154)	(1,604,617)	(1,636,710)	(1,669,444)	(1,702,833)	(1,736,890)	(1,771,627)	(1,807,060)	(1,843,201)	(1,880,065)	(1,917,666)	(1,956,020)	(1,995,140)	(2,035,043)	(2,075,744)	(2,117,259)
Charging Costs	(2,134,007)	(2,219,367)	(2,308,142)	(2,400,468)	(2,496,486)	(2,596,346)	(2,700,200)	(2,808,208)	(2,920,536)	(3,037,357)	(3,158,852)	(3,285,206)	(3,416,614)	(3,553,279)	(3,695,410)	(3,843,226)	(3,996,955)	(4,156,833)	(4,323,107)	(4,496,031)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)
Total Operating Costs	(4,918,159)	(5,047,586)	(5,181,309)	(5,319,482)	(5,462,265)	(5,609,824)	(5,762,331)	(5,919,966)	(6,082,913)	(6,251,366)	(6,425,525)	(6,605,596)	(6,791,797)	(6,984,349)	(7,183,485)	(7,389,447)	(7,602,485)	(7,822,857)	(8,050,835)	(8,286,698)
Operating Profit	10,004,017	10,396,318	10,803,689	11,226,721	11,666,027	12,122,246	12,596,040	13,088,100	13,599,141	14,129,910	14,681,181	15,253,760	15,848,484	16,466,224	17,107,884	17,774,407	18,466,770	19,185,991	19,933,127	20,709,277
Interest Expense	(2,394,603)	(2,330,756)	(2,262,963)	(2,190,981)	(2,114,550)	(2,033,396)	(1,947,226)	(1,855,732)	(1,758,582)	(1,655,429)	(1,545,902)	(1,429,605)	(1,306,121)	(1,175,006)	(1,035,788)	(887,967)	(731,010)	(564,353)	(387,396)	(199,504)
Loan Repayment Expense (Principal)	(1,033,122)	(1,096,969)	(1,164,761)	(1,236,743)	(1,313,174)	(1,394,328)	(1,480,498)	(1,571,993)	(1,669,142)	(1,772,295)	(1,881,822)	(1,998,119)	(2,121,603)	(2,252,718)	(2,391,936)	(2,539,758)	(2,696,715)	(2,863,372)	(3,040,328)	(3,228,220)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,335,419
Interest earned on DSRF	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164
Interestearnedon Battery Replacement Fund	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(2,643,292)	(2,621,283)	(2,598,594)	(2,575,204)	(2,551,091)	(2,526,233)	(2,500,606)	(2,474,188)	(2,446,954)	(2,418,878)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(1,020,141)
State Tax Refund (Paid)	(75,027)	358,791	(11,946)	(291,149)	(505,035)	(555,203)	(606,503)	(869,062)	(1,133,405)	(1,191,926)	(1,167,538)	(1,228,435)	(1,291,924)	(1,358,123)	(1,427,153)	(1,499,141)	(1,574,221)	(1,652,532)	(1,734,222)	(1,819,443)
Federal Tax Refund (Paid)	(270,795)	1,294,974	(43,117)	(1,050,837)	(1,822,812)	(2,003,882)	(2,189,036)	(3,136,686)	(4,090,773)	(4,301,990)	(4,213,967)	(4,433,760)	(4,662,911)	(4,901,841)	(5,150,988)	(5,410,812)	(5,681,797)	(5,964,445)	(6,259,286)	(6,566,873)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(345,822)	1,653,765	(55,063)	(1,341,986)	(2,327,848)	(2,559,086)	(2,795,539)	(4,005,749)	(5,224,179)	(5,493,916)	(5,381,505)	(5,662,194)	(5,954,835)	(6,259,964)	(6,578,140)	(6,909,953)	(7,256,017)	(7,616,977)	(7,993,507)	(8,386,316)
Equity Investment (InvestedBeforeProject)	(43,191,965)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	7,014,903	9,428,799	8,150,032	7,309,531	6,787,089	7,036,927	7,299,895	6,608,162	5,928,008	6,217,116	5,944,116	6,236,006	6,538,089	6,850,700	7,174,184	7,508,894	7,855,193	8,213,454	8,584,060	11,302,820

Run 1e: Base Case with Three Battery Replacements

Table A-12
Run 1e

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	61,366,771	0
Financing Costs (Debt)	28,261,110	0
Operating Costs	53,559,217	0
Taxes (Refund or Paid)	26,484,930	0
Electricity Sales	0	41,065,527
System Electric Supply Capacity	0	32,828,088
Non-synchronous Reserve (Non-spin)	0	9,068
Synchronous Reserve (Spin)	0	9,354,815
Frequency Regulation	0	81,097,223
Total	**169,672,027**	**164,354,721**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	866	754
$/kWh**	433	377
Benefit-to-Cost Ratio		0.97
Breakeven Residual Capacity Value		$200
Capacity Factor		21.50%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Electricity Sales	4,088,768	4,252,318	4,422,411	4,599,307	4,783,280	4,974,611	5,173,595	5,380,539	5,595,761	5,819,591	6,052,375	6,294,470	6,546,249	6,808,098	7,080,422	7,363,639	7,658,185	7,964,512	8,283,093	8,614,417
Benefit Revenues	12,749,801	13,184,918	13,635,941	14,103,479	14,588,159	15,090,638	15,611,595	16,151,737	16,711,798	17,292,542	17,894,760	18,519,278	19,166,951	19,838,669	20,535,356	21,257,974	22,007,521	22,785,033	23,591,591	24,428,314
Operating Revenue	16,838,569	17,437,236	18,058,352	18,702,786	19,371,439	20,065,249	20,785,191	21,532,276	22,307,559	23,112,133	23,947,135	24,813,748	25,713,200	26,646,767	27,615,779	28,621,613	29,665,705	30,749,546	31,874,684	33,042,731
Total Revenue	16,838,569	17,437,236	18,058,352	18,702,786	19,371,439	20,065,249	20,785,191	21,532,276	22,307,559	23,112,133	23,947,135	24,813,748	25,713,200	26,646,767	27,615,779	28,621,613	29,665,705	30,749,546	31,874,684	33,042,731
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(28,189)	(28,753)	(29,328)	(29,915)	(30,513)	(31,123)	(31,746)	(32,381)	(33,028)	(33,689)	(34,363)	(35,050)	(35,751)	(36,466)	(37,195)	(37,939)	(38,698)	(39,472)	(40,261)	(41,067)
Charging Costs	(4,206,416)	(4,374,673)	(4,549,660)	(4,731,646)	(4,920,912)	(5,117,749)	(5,322,458)	(5,535,357)	(5,756,771)	(5,987,042)	(6,226,524)	(6,475,585)	(6,734,608)	(7,003,992)	(7,284,152)	(7,575,518)	(7,878,539)	(8,193,680)	(8,521,427)	(8,862,285)
Housekeeping Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)
Total Operating Costs	(5,565,406)	(5,749,226)	(5,940,088)	(6,138,267)	(6,344,049)	(6,557,732)	(6,779,626)	(7,010,052)	(7,249,344)	(7,497,850)	(7,755,932)	(8,023,965)	(8,302,340)	(8,591,463)	(8,891,756)	(9,203,658)	(9,527,626)	(9,864,133)	(10,213,673)	(10,576,760)
Operating Profit	11,273,163	11,688,010	12,118,264	12,564,519	13,027,390	13,507,517	14,005,565	14,522,225	15,058,215	15,614,283	16,191,203	16,789,783	17,410,859	18,055,304	18,724,022	19,417,955	20,138,079	20,885,413	21,661,010	22,465,971
Interest Expense	(3,792,466)	(3,691,348)	(3,583,981)	(3,469,979)	(3,348,931)	(3,220,403)	(3,083,932)	(2,939,026)	(2,785,166)	(2,621,797)	(2,448,331)	(2,264,146)	(2,068,578)	(1,860,923)	(1,640,436)	(1,406,323)	(1,157,741)	(893,797)	(613,541)	(315,966)
Loan Repayment Expense (Principal)	(1,636,213)	(1,737,331)	(1,844,698)	(1,958,700)	(2,079,748)	(2,208,276)	(2,344,747)	(2,489,653)	(2,643,513)	(2,806,883)	(2,980,348)	(3,164,533)	(3,360,102)	(3,567,756)	(3,788,243)	(4,022,357)	(4,270,938)	(4,534,882)	(4,815,138)	(5,112,713)
Debt Service Reserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,335,419
Interest earned on DSRF	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164
Interest earned on Battery Replacement Fund	2,153,325	2,219,863	2,288,457	2,359,170	2,432,069	1,541,594	1,589,230	1,638,337	1,688,962	1,741,150	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0
Net Finance Costs	(3,203,189)	(3,136,652)	(3,068,058)	(2,997,344)	(2,924,446)	(3,814,920)	(3,767,285)	(3,718,178)	(3,667,553)	(3,615,364)	(4,527,188)	(4,501,561)	(4,475,143)	(4,447,909)	(4,419,833)	(5,356,515)	(5,356,515)	(5,356,515)	(5,356,515)	(3,021,096)
State Tax Refund (Paid)	(191,038)	233,556	(146,760)	(435,914)	(660,140)	(635,694)	(695,530)	(966,992)	(1,240,621)	(1,308,833)	(1,294,562)	(1,366,024)	(1,440,550)	(1,518,283)	(1,599,371)	(1,598,608)	(1,684,241)	(1,773,638)	(1,866,976)	(1,964,440)
Federal Tax Refund (Paid)	(689,510)	842,966	(529,698)	(1,573,334)	(2,382,629)	(2,294,396)	(2,510,360)	(3,490,140)	(4,477,744)	(4,723,939)	(4,672,431)	(4,930,256)	(5,199,344)	(5,479,904)	(5,772,572)	(5,769,816)	(6,078,892)	(6,401,550)	(6,738,430)	(7,090,206)
Tax Credit - Federal TC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(880,548)	1,076,522	(676,459)	(2,009,248)	(3,042,769)	(2,930,091)	(3,205,890)	(4,457,131)	(5,718,365)	(6,032,772)	(5,966,992)	(6,296,279)	(6,639,894)	(6,998,187)	(7,371,943)	(7,368,424)	(7,763,133)	(8,175,188)	(8,605,406)	(9,054,645)
Equity Investment (Invested Before Project)	(68,405,539)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	7,189,426	9,627,880	8,373,748	7,557,926	7,060,175	6,762,506	7,032,390	6,346,915	5,672,297	5,966,147	5,697,023	5,991,842	6,295,822	6,609,208	6,932,247	6,693,016	7,018,432	7,353,710	7,699,090	10,390,230

Run 2: Base Case with P4P Regulation Price

Table A-13
Run 2

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	38,747,614	0
Financing Costs (Debt)	21,045,017	0
Operating Costs	69,152,374	0
Taxes (Refund or Paid)	59,749,352	0
Electricity Sales	0	47,573,868
System Electric Supply Capacity	0	32,278,379
Non-synchronous Reserve (Non-spin)	0	18,732
Synchronous Reserve (Spin)	0	6,599,610
Frequency Regulation	0	174,988,847
Total	**188,694,357**	**261,459,437**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	3,660	3,186
$/kWh**	1,830	1,593
Benefit-to-Cost Ratio		1.39
Breakeven Residual Capacity Value		$0
Capacity Factor		26.80%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Electricity Sales	4,736,783	4,926,254	5,123,304	5,328,237	5,541,366	5,763,021	5,993,542	6,233,283	6,482,615	6,741,919	7,011,596	7,292,060	7,583,742	7,887,092	8,202,575	8,530,678	8,871,906	9,226,782	9,595,853	9,979,687
Benefit Revenues	21,762,402	22,559,254	23,386,507	24,245,348	25,137,011	26,062,776	27,023,978	28,022,003	29,058,289	30,134,335	31,251,697	32,411,993	33,616,905	34,868,183	36,167,644	37,517,178	38,918,750	40,374,403	41,886,260	43,456,528
Operating Revenue	26,499,185	27,485,508	28,509,812	29,573,585	30,678,377	31,825,797	33,017,520	34,255,286	35,540,903	36,876,254	38,263,292	39,704,053	41,200,648	42,755,275	44,370,220	46,047,857	47,790,656	49,601,185	51,482,113	53,436,215
Total Revenue	26,499,185	27,485,508	28,509,812	29,573,585	30,678,377	31,825,797	33,017,520	34,255,286	35,540,903	36,876,254	38,263,292	39,704,053	41,200,648	42,755,275	44,370,220	46,047,857	47,790,656	49,601,185	51,482,113	53,436,215
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(35,269)	(35,975)	(36,694)	(37,428)	(38,177)	(38,940)	(39,719)	(40,513)	(41,324)	(42,150)	(42,993)	(43,853)	(44,730)	(45,624)	(46,537)	(47,468)	(48,417)	(49,385)	(50,373)	(51,381)
Charging Costs	(5,752,706)	(5,982,908)	(6,222,224)	(6,471,113)	(6,729,957)	(6,999,156)	(7,279,122)	(7,570,287)	(7,873,086)	(8,188,022)	(8,515,543)	(8,856,165)	(9,210,411)	(9,578,828)	(9,961,981)	(10,360,460)	(10,774,879)	(11,205,874)	(11,654,109)	(12,120,273)
Housekeeping Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)
Total Operating Costs	(7,118,865)	(7,364,682)	(7,620,018)	(7,885,247)	(8,160,758)	(8,446,956)	(8,744,263)	(9,053,114)	(9,373,966)	(9,707,292)	(10,053,582)	(10,413,348)	(10,787,123)	(11,175,457)	(11,578,927)	(11,998,129)	(12,433,685)	(12,886,240)	(13,356,466)	(13,845,062)
Operating Profit	19,380,320	20,120,826	20,889,794	21,688,338	22,517,619	23,378,841	24,273,257	25,202,171	26,166,937	27,168,962	28,209,711	29,290,704	30,413,525	31,579,818	32,791,293	34,049,728	35,356,971	36,714,945	38,125,646	39,591,153
Interest Expense	(2,394,603)	(2,230,756)	(2,262,963)	(2,190,981)	(2,114,550)	(2,033,396)	(1,947,226)	(1,855,732)	(1,758,582)	(1,655,429)	(1,545,902)	(1,429,605)	(1,306,121)	(1,175,006)	(1,035,788)	(887,967)	(731,010)	(564,333)	(387,396)	(199,504)
Loan Repayment Expense (Principal)	(1,083,122)	(1,096,969)	(1,164,761)	(1,236,743)	(1,312,174)	(1,394,328)	(1,480,498)	(1,571,993)	(1,668,142)	(1,772,295)	(1,881,822)	(1,998,119)	(2,121,603)	(2,252,718)	(2,391,936)	(2,539,758)	(2,696,715)	(2,863,372)	(3,040,328)	(3,228,220)
Debt Service Reserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,335,419
Interest earned on DSRF	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164
Interest earned on Battery Replacement Fund	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(2,643,292)	(2,621,283)	(2,598,594)	(2,575,204)	(2,551,091)	(2,526,233)	(2,500,606)	(2,474,188)	(2,446,954)	(2,418,878)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(1,020,141)
State Tax Refund (Paid)	(902,892)	(500,856)	(903,558)	(1,215,956)	(1,464,316)	(1,550,286)	(1,638,769)	(1,929,946)	(2,244,399)	(2,344,578)	(2,363,460)	(2,469,301)	(2,579,474)	(2,694,165)	(2,813,566)	(2,937,879)	(3,067,314)	(3,202,092)	(2,342,441)	(3,488,601)
Federal Tax Refund (Paid)	(3,262,308)	(1,807,727)	(3,261,189)	(4,388,721)	(5,285,121)	(5,595,412)	(5,914,769)	(7,001,802)	(8,100,654)	(8,462,230)	(8,530,380)	(8,912,387)	(9,310,033)	(9,723,984)	(10,154,936)	(10,603,616)	(11,070,784)	(11,557,233)	(12,063,791)	(12,591,324)
Tax Credit-Federal ITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(4,166,290)	(2,308,583)	(4,164,747)	(5,604,677)	(6,749,437)	(7,145,698)	(7,553,538)	(8,941,749)	(10,345,053)	(10,806,808)	(10,893,840)	(11,381,688)	(11,889,507)	(12,418,149)	(12,968,502)	(13,541,495)	(14,138,098)	(14,759,324)	(15,406,231)	(16,079,926)
Equity Investment (Invested Before Project)	(43,191,965)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	12,570,737	15,190,960	14,126,453	13,508,458	13,217,091	13,706,910	14,219,113	13,786,234	13,374,930	13,943,276	13,960,311	14,553,457	15,168,458	15,806,109	16,467,231	17,152,673	17,863,313	18,600,061	19,363,855	22,491,087

Run 3: Base Case Storage Duration of Three Hours

Table A-14
Run 3

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	53,474,852	0
Financing Costs (Debt)	28,531,146	0
Operating Costs	61,278,521	0
Taxes (Refund or Paid)	26,874,023	0
Electricity Sales	0	50,671,736
System Electric Supply Capacity	0	48,370,231
Non-synchronous Reserve (Non-spin)	0	7,122
Synchronous Reserve (Spin)	0	10,520,472
Frequency Regulation	0	78,389,408
Total	**170,158,542**	**187,958,970**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	2,046	1,781
$/kWh**	682	594
Benefit-to-Cost Ratio		1.10
Breakeven Residual Capacity Value		$71
Capacity Factor		25.20%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	5,045,228	5,247,037	5,456,919	5,675,195	5,902,203	6,138,291	6,383,823	6,639,176	6,904,743	7,180,933	7,468,170	7,766,897	8,077,573	8,400,676	8,736,703	9,086,171	9,449,618	9,827,602	10,220,706	10,629,535
BenefitRevenues	14,367,994	14,832,404	15,313,184	15,810,944	16,326,320	16,859,969	17,412,577	17,984,853	18,577,535	19,191,390	19,827,215	20,485,836	21,168,112	21,874,937	22,607,236	23,365,974	24,152,149	24,966,803	25,811,014	26,685,905
Operating Revenue	19,413,223	20,079,441	20,770,102	21,486,140	22,228,523	22,998,261	23,796,400	24,624,028	25,482,278	26,372,323	27,295,385	28,252,733	29,245,685	30,275,612	31,343,939	32,452,144	33,601,767	34,794,405	36,031,720	37,315,439
Total Revenue	19,413,223	20,079,441	20,770,102	21,486,140	22,228,523	22,998,261	23,796,400	24,624,028	25,482,278	26,372,323	27,295,385	28,252,733	29,245,685	30,275,612	31,343,939	32,452,144	33,601,767	34,794,405	36,031,720	37,315,439
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(33,131)	(33,794)	(34,470)	(35,159)	(35,862)	(36,580)	(37,311)	(38,057)	(38,819)	(39,595)	(40,387)	(41,195)	(42,018)	(42,859)	(43,716)	(44,590)	(45,482)	(46,392)	(47,320)	(48,266)
Charging Costs	(4,822,628)	(5,015,533)	(5,216,154)	(5,424,801)	(5,641,793)	(5,867,464)	(6,102,163)	(6,346,249)	(6,600,099)	(6,864,103)	(7,138,667)	(7,424,214)	(7,721,183)	(8,030,030)	(8,351,231)	(8,685,280)	(9,032,692)	(9,393,999)	(9,769,759)	(10,160,550)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)	(773,306)
Total Operating Costs	(6,379,065)	(6,587,632)	(6,804,230)	(7,029,171)	(7,262,785)	(7,505,410)	(7,757,401)	(8,019,127)	(8,290,968)	(8,573,323)	(8,866,606)	(9,171,245)	(9,487,688)	(9,816,399)	(10,157,862)	(10,512,578)	(10,881,069)	(11,263,878)	(11,661,569)	(12,074,730)
Operating Profit	13,034,158	13,491,809	13,965,873	14,456,968	14,965,739	15,492,851	16,038,998	16,604,902	17,191,310	17,799,000	18,428,779	19,081,488	19,757,997	20,459,213	21,186,077	21,939,567	22,720,698	23,530,528	24,370,151	25,240,709
Interest Expense	(3,304,746)	(3,216,632)	(3,123,073)	(3,023,731)	(2,918,251)	(2,806,251)	(2,687,330)	(2,561,060)	(2,426,986)	(2,284,627)	(2,133,470)	(1,972,971)	(1,802,553)	(1,621,604)	(1,429,472)	(1,225,466)	(1,008,853)	(778,852)	(534,638)	(275,332)
Loan Repayment Expense (Principal)	(1,425,792)	(1,513,906)	(1,607,465)	(1,706,806)	(1,812,287)	(1,924,286)	(2,043,207)	(2,169,477)	(2,303,551)	(2,445,910)	(2,597,068)	(2,757,567)	(2,927,984)	(3,108,934)	(3,301,066)	(3,505,072)	(3,721,685)	(3,951,685)	(4,195,899)	(4,455,206)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,109,491
Interest earned on DSRF	96,083	96,083	96,083	96,083	96,083	96,083	96,083	96,083	96,083	96,083	96,083	96,083	96,083	96,083	96,083	96,083	96,083	96,083	96,083	96,083
Interestearnedon Battery Replacement Fund	1,068,401	1,101,415	1,135,449	1,170,534	1,206,703	1,243,990	1,282,430	1,322,057	1,362,908	1,405,022	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Net Finance Costs	(3,566,053)	(3,533,039)	(3,499,006)	(3,463,920)	(3,427,751)	(3,390,464)	(3,352,024)	(3,312,397)	(3,271,546)	(3,229,432)	(4,634,454)	(4,634,454)	(4,634,454)	(4,634,454)	(4,634,454)	(4,634,454)	(4,634,454)	(4,634,454)	(4,634,454)	(1,524,963)
State Tax Refund (Paid)	(74,959)	507,762	19,556	(346,468)	(625,204)	(685,619)	(747,187)	(1,089,670)	(1,434,141)	(1,504,168)	(1,448,999)	(1,520,887)	(1,595,755)	(1,673,738)	(1,754,978)	(1,839,620)	(1,927,821)	(2,019,742)	(2,115,553)	(2,215,433)
Federal Tax Refund (Paid)	(270,549)	1,832,654	70,584	(1,250,499)	(2,256,533)	(2,474,587)	(2,696,806)	(3,932,918)	(5,176,211)	(5,428,958)	(5,229,838)	(5,489,300)	(5,759,520)	(6,040,984)	(6,334,199)	(6,639,697)	(6,958,038)	(7,289,806)	(7,635,615)	(7,996,110)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(345,508)	2,340,417	90,141	(1,596,967)	(2,881,736)	(3,160,206)	(3,443,993)	(5,022,588)	(6,610,352)	(6,933,127)	(6,678,837)	(7,010,186)	(7,355,275)	(7,714,722)	(8,089,176)	(8,479,318)	(8,885,859)	(9,309,548)	(9,751,168)	(10,211,543)
Equity Investment (InvestedBeforeProject)	(59,608,418)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	9,122,597	12,299,186	10,557,008	9,396,081	8,656,251	8,942,181	9,242,981	8,269,916	7,309,412	7,636,441	7,115,488	7,436,847	7,768,268	8,110,036	8,462,446	8,825,795	9,200,385	9,586,526	9,984,529	13,504,203

Run 4: Base Case Storage Duration of Four Hours

Table A-15
Run 4

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	68,332,097	0
Financing Costs (Debt)	36,102,229	0
Operating Costs	66,598,677	0
Taxes (Refund or Paid)	26,712,253	0
Electricity Sales	0	56,908,784
System Electric Supply Capacity	0	63,016,028
Non-synchronous Reserve (Non-spin)	0	7,835
Synchronous Reserve (Spin)	0	10,051,067
Frequency Regulation	0	78,172,952
Total	**197,745,257**	**208,156,666**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	2,136	1,860
$/kWh**	534	465
Benefit-to-Cost Ratio		1.05
Breakeven Residual Capacity Value		$120
Capacity Factor		27.60%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	5,666,232	5,892,881	6,128,596	6,373,740	6,628,690	6,893,837	7,169,591	7,456,374	7,754,629	8,064,814	8,387,407	8,722,903	9,071,819	9,434,692	9,812,080	10,204,563	10,612,746	11,037,255	11,478,746	11,937,896
BenefitRevenues	15,969,557	16,464,632	16,976,636	17,506,188	18,053,933	18,620,537	19,206,694	19,813,124	20,440,574	21,089,821	21,761,670	22,456,959	23,176,555	23,921,362	24,692,315	25,490,389	26,316,594	27,171,978	28,057,633	28,974,688
Operating Revenue	21,635,789	22,357,513	23,105,232	23,879,928	24,682,622	25,514,374	26,376,284	27,269,498	28,195,203	29,154,635	30,149,077	31,179,862	32,248,375	33,356,054	34,504,395	35,694,952	36,929,340	38,209,234	39,536,378	40,912,584
Total Revenue	21,635,789	22,357,513	23,105,232	23,879,928	24,682,622	25,514,374	26,376,284	27,269,498	28,195,203	29,154,635	30,149,077	31,179,862	32,248,375	33,356,054	34,504,395	35,694,952	36,929,340	38,209,234	39,536,378	40,912,584
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(36,294)	(37,020)	(37,761)	(38,516)	(39,286)	(40,072)	(40,873)	(41,691)	(42,525)	(43,375)	(44,243)	(45,127)	(46,030)	(46,951)	(47,890)	(48,847)	(49,824)	(50,821)	(51,837)	(52,874)
Charging Costs	(5,199,411)	(5,407,387)	(5,623,683)	(5,848,630)	(6,082,575)	(6,325,878)	(6,578,913)	(6,842,070)	(7,115,753)	(7,400,383)	(7,696,398)	(8,004,254)	(8,324,424)	(8,657,401)	(9,003,697)	(9,363,845)	(9,738,399)	(10,127,935)	(10,533,052)	(10,954,374)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)	(968,550)
Total Operating Costs	(6,954,255)	(7,177,957)	(7,410,293)	(7,651,602)	(7,902,235)	(8,162,561)	(8,432,958)	(8,713,825)	(9,005,572)	(9,308,627)	(9,623,436)	(9,950,462)	(10,290,185)	(10,643,107)	(11,009,746)	(11,390,644)	(11,786,362)	(12,197,487)	(12,624,624)	(13,068,407)
Operating Profit	14,681,534	15,179,556	15,694,939	16,228,327	16,780,387	17,351,813	17,943,326	18,555,673	19,189,631	19,846,008	20,525,641	21,229,400	21,958,189	22,712,947	23,494,650	24,304,309	25,142,977	26,011,747	26,911,754	27,844,177
Interest Expense	(4,222,924)	(4,110,328)	(3,990,775)	(3,863,833)	(3,729,046)	(3,585,929)	(3,433,968)	(3,272,615)	(3,101,291)	(2,919,379)	(2,726,225)	(2,521,134)	(2,303,368)	(2,072,144)	(1,826,631)	(1,565,945)	(1,289,148)	(995,246)	(683,180)	(351,829)
Loan Repayment Expense (Principal)	(1,821,928)	(1,934,523)	(2,054,077)	(2,181,019)	(2,315,806)	(2,458,922)	(2,610,884)	(2,772,236)	(2,943,561)	(3,125,473)	(3,318,627)	(3,523,718)	(3,741,484)	(3,972,708)	(4,218,221)	(4,478,907)	(4,755,703)	(5,049,606)	(5,361,672)	(5,693,023)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,894,577
Interest earned on DSRF	120,342	120,342	120,342	120,342	120,342	120,342	120,342	120,342	120,342	120,342	120,342	120,342	120,342	120,342	120,342	120,342	120,342	120,342	120,342	120,342
Interestearnedon Battery Replacement Fund	1,424,535	1,468,553	1,513,931	1,560,712	1,608,938	1,658,654	1,709,906	1,762,743	1,817,211	1,873,363	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(4,499,974)	(4,455,956)	(4,410,578)	(4,363,797)	(4,315,571)	(4,265,855)	(4,214,603)	(4,161,767)	(4,107,298)	(4,051,146)	(5,924,509)	(5,924,509)	(5,924,509)	(5,924,509)	(5,924,509)	(5,924,509)	(5,924,509)	(5,924,509)	(5,924,509)	(2,029,933)
State Tax Refund (Paid)	51,171	787,230	182,237	(269,452)	(611,530)	(679,869)	(749,344)	(1,170,338)	(1,593,489)	(1,672,558)	(1,584,107)	(1,664,449)	(1,748,124)	(1,835,285)	(1,926,091)	(2,020,710)	(2,119,317)	(2,222,097)	(2,329,244)	(2,440,962)
Federal Tax Refund (Paid)	184,690	2,841,332	657,745	(972,528)	(2,207,179)	(2,453,833)	(2,704,589)	(4,224,071)	(5,751,342)	(6,036,722)	(5,717,478)	(6,007,456)	(6,309,464)	(6,624,051)	(6,951,795)	(7,293,299)	(7,649,199)	(8,020,161)	(8,406,885)	(8,810,105)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	235,861	3,628,563	839,982	(1,241,980)	(2,818,709)	(3,133,702)	(3,453,933)	(5,394,409)	(7,344,831)	(7,709,280)	(7,301,585)	(7,671,905)	(8,057,588)	(8,459,336)	(8,877,886)	(9,314,009)	(9,768,516)	(10,242,258)	(10,736,129)	(11,251,067)
Equity Investment (InvestedBeforeProject)	(76,169,789)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	10,417,421	14,352,162	12,124,343	10,622,549	9,646,106	9,952,256	10,274,790	8,999,497	7,737,503	8,085,582	7,299,547	7,632,986	7,976,092	8,329,102	8,692,255	9,065,791	9,449,952	9,844,979	10,251,115	14,563,178

Run 10: Base Case with High Gas Price and Low Energy Price

Table A-16
Run 10

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	38,747,614	0
Financing Costs (Debt)	21,045,017	0
Operating Costs	55,956,476	0
Taxes (Refund or Paid)	34,089,887	0
Electricity Sales	0	40,084,258
System Electric Supply Capacity	0	35,290,175
Non-synchronous Reserve (Non-spin)	0	14,946
Synchronous Reserve (Spin)	0	11,248,687
Frequency Regulation	0	98,651,280
Total	**149,838,994**	**185,289,346**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	2,320	2,020
$/kWh**	1,160	1,010
Benefit-to-Cost Ratio		1.24
Breakeven Residual Capacity Value		$0
Capacity Factor		23.60%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	3,991,066	4,150,708	4,316,737	4,489,406	4,668,982	4,855,742	5,049,971	5,251,970	5,462,049	5,680,531	5,907,752	6,144,062	6,389,825	6,645,418	6,911,234	7,187,684	7,475,191	7,774,199	8,085,167	8,408,573
BenefitRevenues	14,967,544	15,485,743	16,023,060	16,580,227	17,158,006	17,757,187	18,378,593	19,023,078	19,691,528	20,384,867	21,104,054	21,850,083	22,623,991	23,426,854	24,259,789	25,123,959	26,020,571	26,950,880	27,916,192	28,917,862
Operating Revenue	18,958,610	19,636,452	20,339,797	21,069,633	21,826,988	22,612,929	23,428,564	24,275,048	25,153,577	26,065,398	27,011,806	27,994,145	29,013,816	30,072,271	31,171,023	32,311,642	33,495,762	34,725,079	36,001,359	37,326,435
Total Revenue	18,958,610	19,636,452	20,339,797	21,069,633	21,826,988	22,612,929	23,428,564	24,275,048	25,153,577	26,065,398	27,011,806	27,994,145	29,013,816	30,072,271	31,171,023	32,311,642	33,495,762	34,725,079	36,001,359	37,326,435
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(30,990)	(31,609)	(32,241)	(32,886)	(33,544)	(34,215)	(34,899)	(35,597)	(36,309)	(37,035)	(37,776)	(38,532)	(39,302)	(40,088)	(40,890)	(41,708)	(42,542)	(43,393)	(44,261)	(45,146)
Charging Costs	(4,442,658)	(4,620,365)	(4,805,179)	(4,997,387)	(5,197,282)	(5,405,173)	(5,621,380)	(5,846,235)	(6,080,085)	(6,323,288)	(6,576,220)	(6,839,269)	(7,112,839)	(7,397,353)	(7,693,247)	(8,000,977)	(8,321,016)	(8,653,857)	(9,000,011)	(9,360,011)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)
Total Operating Costs	(5,804,448)	(5,997,774)	(6,198,521)	(6,406,979)	(6,623,450)	(6,848,249)	(7,081,701)	(7,324,147)	(7,575,939)	(7,837,443)	(8,109,042)	(8,391,131)	(8,684,123)	(8,988,446)	(9,304,546)	(9,632,886)	(9,973,947)	(10,328,230)	(10,696,256)	(11,078,566)
Operating Profit	13,154,162	13,638,677	14,141,276	14,662,654	15,203,538	15,764,680	16,346,863	16,950,901	17,577,639	18,227,955	18,902,764	19,603,015	20,329,693	21,083,825	21,866,477	22,678,756	23,521,815	24,396,849	25,305,102	26,247,870
Interest Expense	(2,394,603)	(2,330,756)	(2,262,963)	(2,190,981)	(2,114,550)	(2,033,396)	(1,947,226)	(1,855,732)	(1,758,582)	(1,655,429)	(1,545,902)	(1,429,605)	(1,306,121)	(1,175,006)	(1,035,788)	(887,967)	(731,010)	(564,353)	(387,396)	(199,504)
Loan Repayment Expense (Principal)	(1,033,122)	(1,096,969)	(1,164,761)	(1,236,743)	(1,313,174)	(1,394,328)	(1,480,498)	(1,571,993)	(1,669,142)	(1,772,295)	(1,881,822)	(1,998,119)	(2,121,603)	(2,252,718)	(2,391,936)	(2,539,758)	(2,696,715)	(2,863,372)	(3,040,328)	(3,228,220)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,335,419
Interest earned on DSRF	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164
Interestearnedon Battery Replacement Fund	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(2,643,292)	(2,621,283)	(2,598,594)	(2,575,204)	(2,551,091)	(2,526,233)	(2,500,606)	(2,474,188)	(2,446,954)	(2,418,878)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(1,020,141)
State Tax Refund (Paid)	(353,500)	72,166	(306,980)	(594,886)	(817,751)	(877,195)	(938,076)	(1,210,534)	(1,485,105)	(1,554,193)	(1,540,726)	(1,612,900)	(1,688,063)	(1,766,319)	(1,847,812)	(1,932,685)	(2,021,086)	(2,113,172)	(2,209,105)	(2,309,055)
Federal Tax Refund (Paid)	(1,275,880)	260,467	(1,108,007)	(2,147,106)	(2,951,491)	(3,166,037)	(3,385,774)	(4,369,152)	(5,360,153)	(5,609,512)	(5,560,905)	(5,821,433)	(6,092,686)	(6,375,133)	(6,669,264)	(6,975,594)	(7,294,659)	(7,627,021)	(7,973,268)	(8,334,016)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(1,629,380)	332,633	(1,414,996)	(2,741,992)	(3,769,242)	(4,043,232)	(4,323,849)	(5,579,686)	(6,845,257)	(7,163,706)	(7,101,631)	(7,434,342)	(7,780,749)	(8,141,452)	(8,517,077)	(8,908,279)	(9,315,746)	(9,740,193)	(10,182,373)	(10,643,071)
Equity Investment (InvestedBeforeProject)	(43,191,965)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	8,881,490	11,350,027	10,127,686	9,345,459	8,883,205	9,195,215	9,522,407	8,897,026	8,285,427	8,645,371	8,445,573	8,813,113	9,193,385	9,586,814	9,993,841	10,414,917	10,850,509	11,301,096	11,767,170	14,584,658

Run 11: Base Case with Low Gas Price and Low Energy Price

Table A-17
Run 11

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	38,747,614	0
Financing Costs (Debt)	21,045,017	0
Operating Costs	51,900,667	0
Taxes (Refund or Paid)	26,940,544	0
Electricity Sales	0	38,520,667
System Electric Supply Capacity	0	34,046,298
Non-synchronous Reserve (Non-spin)	0	706
Synchronous Reserve (Spin)	0	9,310,725
Frequency Regulation	0	81,809,020
Total	**138,633,843**	**163,687,416**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	1,954	1,701
$/kWh**	977	851
Benefit-to-Cost Ratio		1.18
Breakeven Residual Capacity Value		$0
Capacity Factor		22.20%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	3,835,384	3,988,799	4,148,351	4,314,285	4,486,856	4,666,331	4,852,984	5,047,103	5,248,987	5,458,947	5,677,305	5,904,397	6,140,573	6,386,196	6,641,644	6,907,309	7,183,602	7,470,946	7,769,784	8,080,575
BenefitRevenues	12,954,218	13,394,752	13,851,355	14,324,639	14,815,239	15,323,815	15,851,053	16,397,666	16,964,396	17,552,011	18,161,311	18,793,128	19,448,325	20,127,799	20,832,483	21,563,346	22,321,394	23,107,675	23,923,276	24,769,326
Operating Revenue	16,789,601	17,383,551	17,999,706	18,638,924	19,302,095	19,990,145	20,704,037	21,444,770	22,213,383	23,010,958	23,838,616	24,697,525	25,588,898	26,513,995	27,474,127	28,470,655	29,504,996	30,578,621	31,693,059	32,849,901
Total Revenue	16,789,601	17,383,551	17,999,706	18,638,924	19,302,095	19,990,145	20,704,037	21,444,770	22,213,383	23,010,958	23,838,616	24,697,525	25,588,898	26,513,995	27,474,127	28,470,655	29,504,996	30,578,621	31,693,059	32,849,901
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(29,137)	(29,720)	(30,314)	(30,921)	(31,539)	(32,170)	(32,813)	(33,469)	(34,139)	(34,822)	(35,518)	(36,228)	(36,953)	(37,692)	(38,446)	(39,215)	(39,999)	(40,799)	(41,615)	(42,447)
Charging Costs	(4,040,452)	(4,202,070)	(4,370,153)	(4,544,959)	(4,726,757)	(4,915,827)	(5,112,461)	(5,316,959)	(5,529,637)	(5,750,823)	(5,980,856)	(6,220,090)	(6,468,894)	(6,727,649)	(6,996,755)	(7,276,626)	(7,567,691)	(7,870,398)	(8,185,214)	(8,512,623)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)
Total Operating Costs	(5,400,389)	(5,577,590)	(5,761,567)	(5,952,585)	(6,150,920)	(6,356,858)	(6,570,696)	(6,792,743)	(7,023,321)	(7,262,764)	(7,511,420)	(7,769,649)	(8,037,828)	(8,316,346)	(8,605,610)	(8,906,042)	(9,218,079)	(9,542,178)	(9,878,814)	(10,228,478)
Operating Profit	11,389,212	11,805,961	12,238,139	12,686,339	13,151,175	13,633,287	14,133,341	14,652,027	15,190,062	15,748,194	16,327,196	16,927,876	17,551,070	18,197,649	18,868,517	19,564,614	20,286,917	21,036,443	21,814,245	22,621,423
Interest Expense	(2,394,603)	(2,330,756)	(2,262,963)	(2,190,981)	(2,114,550)	(2,033,396)	(1,947,226)	(1,855,732)	(1,758,582)	(1,655,429)	(1,545,902)	(1,429,605)	(1,306,121)	(1,175,006)	(1,035,788)	(887,967)	(731,010)	(564,353)	(387,396)	(199,504)
Loan Repayment Expense (Principal)	(1,033,122)	(1,096,969)	(1,164,761)	(1,236,743)	(1,313,174)	(1,394,328)	(1,480,498)	(1,571,993)	(1,669,142)	(1,772,295)	(1,881,822)	(1,998,119)	(2,121,603)	(2,252,718)	(2,391,936)	(2,539,758)	(2,696,715)	(2,863,372)	(3,040,328)	(3,228,220)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,335,419
Interest earned on DSRF	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164
Interestearnedon Battery Replacement Fund	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(2,643,292)	(2,621,283)	(2,598,594)	(2,575,204)	(2,551,091)	(2,526,233)	(2,500,606)	(2,474,188)	(2,446,954)	(2,418,878)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(1,020,141)
State Tax Refund (Paid)	(197,479)	234,178	(138,751)	(420,179)	(636,322)	(688,779)	(742,400)	(1,007,314)	(1,274,043)	(1,334,982)	(1,313,046)	(1,376,426)	(1,442,433)	(1,511,181)	(1,582,793)	(1,657,395)	(1,735,122)	(1,816,112)	(1,900,513)	(1,988,477)
Federal Tax Refund (Paid)	(712,755)	845,213	(500,792)	(1,516,543)	(2,296,664)	(2,485,995)	(2,679,527)	(3,635,673)	(4,598,373)	(4,818,320)	(4,739,145)	(4,967,903)	(5,206,138)	(5,454,269)	(5,712,735)	(5,981,996)	(6,262,533)	(6,554,850)	(6,859,475)	(7,176,962)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(910,234)	1,079,391	(639,544)	(1,936,722)	(2,932,986)	(3,174,775)	(3,421,928)	(4,642,987)	(5,872,415)	(6,153,302)	(6,052,191)	(6,344,330)	(6,648,571)	(6,965,450)	(7,295,528)	(7,639,391)	(7,997,654)	(8,370,962)	(8,759,988)	(9,165,439)
Equity Investment (InvestedBeforeProject)	(43,191,965)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	7,835,686	10,264,070	9,000,002	8,174,413	7,667,098	7,932,280	8,210,807	7,534,852	6,870,693	7,176,014	6,919,446	7,227,987	7,546,939	7,876,639	8,217,429	8,569,663	8,933,703	9,309,921	9,698,698	12,435,843

Run 12: Base Case with High Gas Price and Low Energy Price 2X P4P

Table A-18
Run 12

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	38,747,614	0
Financing Costs (Debt)	21,045,017	0
Operating Costs	67,417,808	0
Taxes (Refund or Paid)	75,062,858	0
Electricity Sales	0	44,988,067
System Electric Supply Capacity	0	35,305,557
Non-synchronous Reserve (Non-spin)	0	26,449
Synchronous Reserve (Spin)	0	7,852,911
Frequency Regulation	0	209,134,732
Total	**202,273,298**	**297,307,717**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	4,460	3,883
$/kWh**	2,230	1,941
Benefit-to-Cost Ratio		1.47
Breakeven Residual Capacity Value		$0
Capacity Factor		0.00%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	4,479,323	4,658,496	4,844,835	5,038,629	5,240,174	5,449,781	5,667,772	5,894,483	6,130,262	6,375,473	6,630,492	6,895,712	7,171,540	7,458,402	7,756,738	8,067,007	8,389,688	8,725,275	9,074,286	9,437,257
BenefitRevenues	25,632,998	26,577,754	27,558,689	28,577,217	29,634,811	30,732,998	31,873,368	33,057,575	34,287,335	35,564,434	36,890,730	38,268,152	39,698,707	41,184,480	42,727,641	44,330,444	45,995,233	47,724,445	49,520,613	51,386,372
Operating Revenue	30,112,321	31,236,250	32,403,524	33,615,846	34,874,985	36,182,779	37,541,141	38,952,058	40,417,597	41,939,907	43,521,222	45,163,864	46,870,247	48,642,882	50,484,379	52,397,451	54,384,920	56,449,720	58,594,899	60,823,630
Total Revenue	30,112,321	31,236,250	32,403,524	33,615,846	34,874,985	36,182,779	37,541,141	38,952,058	40,417,597	41,939,907	43,521,222	45,163,864	46,870,247	48,642,882	50,484,379	52,397,451	54,384,920	56,449,720	58,594,899	60,823,630
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(36,716)	(37,450)	(38,199)	(38,963)	(39,742)	(40,537)	(41,348)	(42,175)	(43,018)	(43,879)	(44,756)	(45,652)	(46,565)	(47,496)	(48,446)	(49,415)	(50,403)	(51,411)	(52,439)	(53,488)
Charging Costs	(5,578,827)	(5,801,980)	(6,034,059)	(6,275,422)	(6,526,439)	(6,787,496)	(7,058,996)	(7,341,356)	(7,635,010)	(7,940,410)	(8,258,027)	(8,588,348)	(8,931,882)	(9,289,157)	(9,660,723)	(10,047,152)	(10,449,038)	(10,867,000)	(11,301,680)	(11,753,747)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)
Total Operating Costs	(6,946,343)	(7,185,230)	(7,433,358)	(7,691,091)	(7,958,805)	(8,236,894)	(8,525,766)	(8,825,845)	(9,137,573)	(9,461,409)	(9,797,829)	(10,147,330)	(10,510,428)	(10,887,658)	(11,279,578)	(11,686,768)	(12,109,831)	(12,549,392)	(13,006,104)	(13,480,644)
Operating Profit	23,165,978	24,051,020	24,970,166	25,924,756	26,916,180	27,945,885	29,015,375	30,126,213	31,280,024	32,478,499	33,723,393	35,016,534	36,359,819	37,755,224	39,204,800	40,710,683	42,275,090	43,900,328	45,588,795	47,342,986
Interest Expense	(2,394,603)	(2,330,756)	(2,262,963)	(2,190,981)	(2,114,550)	(2,033,396)	(1,947,226)	(1,855,732)	(1,758,582)	(1,655,429)	(1,545,902)	(1,429,605)	(1,306,121)	(1,175,006)	(1,035,788)	(887,967)	(731,010)	(564,353)	(387,396)	(199,504)
Loan Repayment Expense (Principal)	(1,033,122)	(1,096,969)	(1,164,761)	(1,236,743)	(1,313,174)	(1,394,328)	(1,480,498)	(1,571,993)	(1,669,142)	(1,772,295)	(1,881,822)	(1,998,119)	(2,121,603)	(2,252,718)	(2,391,936)	(2,539,758)	(2,696,715)	(2,863,372)	(3,040,328)	(3,228,220)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,335,419
Interest earned on DSRF	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164
Interestearnedon Battery Replacement Fund	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(2,643,292)	(2,621,283)	(2,598,594)	(2,575,204)	(2,551,091)	(2,526,233)	(2,500,606)	(2,474,188)	(2,446,954)	(2,418,878)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(1,020,141)
State Tax Refund (Paid)	(1,238,545)	(848,285)	(1,264,263)	(1,590,455)	(1,853,149)	(1,954,013)	(2,057,972)	(2,375,232)	(2,696,396)	(2,813,941)	(2,850,870)	(2,975,464)	(3,105,126)	(3,240,071)	(3,380,520)	(3,526,707)	(3,678,876)	(3,837,280)	(4,002,183)	(4,173,863)
Federal Tax Refund (Paid)	(4,470,250)	(3,061,695)	(4,563,073)	(5,740,392)	(6,688,526)	(7,052,573)	(7,427,789)	(8,572,867)	(9,732,036)	(10,156,291)	(10,289,575)	(10,739,270)	(11,207,258)	(11,694,309)	(12,201,230)	(12,728,861)	(13,278,079)	(13,849,801)	(14,444,983)	(15,064,624)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(5,708,795)	(3,909,980)	(5,827,335)	(7,330,847)	(8,541,675)	(9,006,586)	(9,485,761)	(10,948,099)	(12,428,431)	(12,970,232)	(13,140,445)	(13,714,734)	(14,312,384)	(14,934,380)	(15,581,750)	(16,255,568)	(16,956,955)	(17,687,081)	(18,447,166)	(19,238,487)
Equity Investment (InvestedBeforeProject)	(43,191,965)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	14,813,891	17,519,756	16,544,237	16,018,705	15,823,414	16,413,067	17,029,007	16,703,926	16,404,639	17,089,388	17,227,389	17,946,240	18,691,876	19,465,285	20,267,491	21,099,555	21,962,575	22,857,687	23,786,069	27,084,358

Run 13: Base Case with Low Gas Price and Low Energy Price 2X Regulation Price

Table A-19
Run 13

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	38,747,614	0
Financing Costs (Debt)	21,045,017	0
Operating Costs	65,449,068	0
Taxes (Refund or Paid)	60,716,574	0
Electricity Sales	0	44,064,493
System Electric Supply Capacity	0	33,864,214
Non-synchronous Reserve (Non-spin)	0	19,116
Synchronous Reserve (Spin)	0	6,550,724
Frequency Regulation	0	175,631,368
Total	**185,958,273**	**260,129,915**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	3,720	3,238
$/kWh**	1,860	1,619
Benefit-to-Cost Ratio		1.40
Breakeven Residual Capacity Value		$0
Capacity Factor		0.00%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	4,387,365	4,562,860	4,745,374	4,935,189	5,132,597	5,337,901	5,551,417	5,773,473	6,004,412	6,244,589	6,494,372	6,754,147	7,024,313	7,305,286	7,597,497	7,901,397	8,217,453	8,546,151	8,887,997	9,243,517
BenefitRevenues	22,002,353	22,805,187	23,638,588	24,503,749	25,401,909	26,334,356	27,302,428	28,307,517	29,351,069	30,434,588	31,559,638	32,727,843	33,940,892	35,200,542	36,508,619	37,867,019	39,277,717	40,742,763	42,264,290	43,844,514
Operating Revenue	26,389,719	27,368,047	28,383,962	29,438,939	30,534,506	31,672,257	32,853,845	34,080,990	35,355,481	36,679,177	38,054,010	39,481,990	40,965,205	42,505,828	44,106,116	45,768,416	47,495,170	49,288,914	51,152,287	53,088,031
Total Revenue	26,389,719	27,368,047	28,383,962	29,438,939	30,534,506	31,672,257	32,853,845	34,080,990	35,355,481	36,679,177	38,054,010	39,481,990	40,965,205	42,505,828	44,106,116	45,768,416	47,495,170	49,288,914	51,152,287	53,088,031
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(35,725)	(36,439)	(37,168)	(37,912)	(38,670)	(39,443)	(40,232)	(41,037)	(41,858)	(42,695)	(43,549)	(44,420)	(45,308)	(46,214)	(47,138)	(48,081)	(49,043)	(50,024)	(51,024)	(52,045)
Charging Costs	(5,383,671)	(5,599,018)	(5,822,979)	(6,055,898)	(6,298,134)	(6,550,059)	(6,812,061)	(7,084,544)	(7,367,926)	(7,662,643)	(7,969,148)	(8,287,914)	(8,619,431)	(8,964,208)	(9,322,776)	(9,695,687)	(10,083,515)	(10,486,855)	(10,906,330)	(11,342,583)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)	(580,800)
Total Operating Costs	(6,750,196)	(6,981,257)	(7,221,247)	(7,470,515)	(7,729,428)	(7,998,363)	(8,277,715)	(8,567,895)	(8,869,328)	(9,182,457)	(9,507,743)	(9,845,664)	(10,196,720)	(10,561,427)	(10,940,324)	(11,333,970)	(11,742,947)	(12,167,860)	(12,609,338)	(13,068,036)
Operating Profit	19,639,523	20,386,789	21,162,715	21,968,423	22,805,079	23,673,894	24,576,129	25,513,095	26,486,154	27,496,720	28,546,268	29,636,325	30,768,485	31,944,401	33,165,792	34,434,447	35,752,223	37,121,054	38,542,948	40,019,995
Interest Expense	(2,394,603)	(2,330,756)	(2,262,963)	(2,190,981)	(2,114,550)	(2,033,396)	(1,947,226)	(1,855,732)	(1,758,582)	(1,655,429)	(1,545,902)	(1,429,605)	(1,306,121)	(1,175,006)	(1,035,788)	(887,967)	(731,010)	(564,353)	(387,396)	(199,504)
Loan Repayment Expense (Principal)	(1,033,122)	(1,096,969)	(1,164,761)	(1,236,743)	(1,313,174)	(1,394,328)	(1,480,498)	(1,571,993)	(1,669,142)	(1,772,295)	(1,881,822)	(1,998,119)	(2,121,603)	(2,252,718)	(2,391,936)	(2,539,758)	(2,696,715)	(2,863,372)	(3,040,328)	(3,228,220)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,335,419
Interest earned on DSRF	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164	72,164
Interestearnedon Battery Replacement Fund	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(2,643,292)	(2,621,283)	(2,598,594)	(2,575,204)	(2,551,091)	(2,526,233)	(2,500,606)	(2,474,188)	(2,446,954)	(2,418,878)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(3,355,560)	(1,020,141)
State Tax Refund (Paid)	(926,806)	(524,367)	(927,684)	(1,240,715)	(1,480,728)	(1,576,369)	(1,665,543)	(1,967,432)	(2,272,617)	(2,373,552)	(2,393,212)	(2,499,853)	(2,610,852)	(2,726,394)	(2,846,672)	(2,971,888)	(3,102,255)	(3,237,992)	(3,379,330)	(3,526,511)
Federal Tax Refund (Paid)	(3,345,099)	(1,892,586)	(3,348,268)	(4,478,085)	(5,376,838)	(5,689,551)	(6,011,403)	(7,101,006)	(8,202,503)	(8,566,805)	(8,637,762)	(9,022,661)	(9,423,287)	(9,840,308)	(10,274,424)	(10,726,365)	(11,196,893)	(11,686,806)	(12,196,935)	(12,728,151)
TaxCredit-FederalTC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(4,271,905)	(2,416,953)	(4,275,952)	(5,718,800)	(6,866,566)	(7,265,920)	(7,676,946)	(9,068,438)	(10,475,121)	(10,940,357)	(11,030,973)	(11,522,514)	(12,034,139)	(12,566,702)	(13,121,096)	(13,698,253)	(14,299,148)	(14,924,798)	(15,576,265)	(16,254,661)
Equity Investment (InvestedBeforeProject)	(43,191,965)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	12,724,325	15,348,553	14,288,170	13,674,419	13,387,422	13,881,741	14,398,577	13,970,469	13,564,079	14,137,485	14,159,735	14,758,251	15,378,787	16,022,140	16,689,137	17,380,634	18,097,516	18,840,697	19,611,123	22,745,193

Run 16: Base Case with Flow Battery Technology

Table A-20
Run 16

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	46,259,452	0
Financing Costs (Debt)	30,229,033	0
Operating Costs	60,356,706	0
Taxes (Refund or Paid)	24,800,318	0
Electricity Sales	0	47,674,175
System Electric Supply Capacity	0	61,776,376
Non-synchronous Reserve (Non-spin)	0	596
Synchronous Reserve (Spin)	0	10,204,133
Frequency Regulation	0	78,994,758
Total	**161,645,509**	**198,650,039**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	3,100	2,699
$/kWh**	775	675
Benefit-to-Cost Ratio		1.23
Breakeven Residual Capacity Value		$15
Capacity Factor		22.40%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	4,746,770	4,936,641	5,134,107	5,339,471	5,553,050	5,775,172	6,006,179	6,246,426	6,496,283	6,756,134	7,026,379	7,307,435	7,599,732	7,903,721	8,219,870	8,548,665	8,890,611	9,246,236	9,616,085	10,000,729
BenefitRevenues	15,924,464	16,420,578	16,933,720	17,464,514	18,013,608	18,581,677	19,169,418	19,777,559	20,406,853	21,058,082	21,732,060	22,429,630	23,151,668	23,899,085	24,672,826	25,473,872	26,303,242	27,161,995	28,051,231	28,972,092
Operating Revenue	20,671,234	21,357,219	22,067,827	22,803,985	23,566,658	24,356,848	25,175,597	26,023,985	26,903,136	27,814,216	28,758,439	29,737,064	30,751,400	31,802,806	32,892,696	34,022,537	35,193,853	36,408,231	37,667,317	38,972,821
Total Revenue	20,671,234	21,357,219	22,067,827	22,803,985	23,566,658	24,356,848	25,175,597	26,023,985	26,903,136	27,814,216	28,758,439	29,737,064	30,751,400	31,802,806	32,892,696	34,022,537	35,193,853	36,408,231	37,667,317	38,972,821
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(29,476)	(30,065)	(30,667)	(31,280)	(31,906)	(32,544)	(33,195)	(33,858)	(34,536)	(35,226)	(35,931)	(36,650)	(37,382)	(38,130)	(38,893)	(39,671)	(40,464)	(41,273)	(42,099)	(42,941)
Charging Costs	(4,579,219)	(4,762,387)	(4,952,883)	(5,150,998)	(5,357,038)	(5,571,319)	(5,794,172)	(6,025,939)	(6,266,977)	(6,517,656)	(6,778,362)	(7,049,497)	(7,331,476)	(7,624,735)	(7,929,725)	(8,246,914)	(8,576,790)	(8,919,862)	(9,276,656)	(9,647,723)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)
Total Operating Costs	(6,333,294)	(6,532,053)	(6,738,449)	(6,952,784)	(7,175,368)	(7,406,524)	(7,646,589)	(7,895,912)	(8,154,857)	(8,423,802)	(8,703,139)	(8,993,277)	(9,294,640)	(9,607,671)	(9,932,827)	(10,270,586)	(10,621,444)	(10,985,916)	(11,364,540)	(11,757,872)
Operating Profit	14,337,940	14,825,167	15,329,377	15,851,201	16,391,290	16,950,325	17,529,008	18,128,073	18,748,279	19,390,415	20,055,301	20,743,788	21,456,760	22,195,136	22,959,869	23,751,951	24,572,410	25,422,315	26,302,777	27,214,949
Interest Expense	(2,858,834)	(2,782,609)	(2,701,674)	(2,615,737)	(2,524,489)	(2,427,602)	(2,324,727)	(2,215,494)	(2,099,511)	(1,976,361)	(1,845,599)	(1,706,757)	(1,559,334)	(1,402,800)	(1,236,592)	(1,060,113)	(872,727)	(673,761)	(462,499)	(238,181)
Loan Repayment Expense (Principal)	(1,233,409)	(1,309,633)	(1,390,569)	(1,476,506)	(1,567,754)	(1,664,641)	(1,767,516)	(1,876,748)	(1,992,731)	(2,115,882)	(2,246,644)	(2,385,486)	(2,532,909)	(2,689,443)	(2,855,651)	(3,032,130)	(3,219,515)	(3,418,481)	(3,629,744)	(3,854,062)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,918,904
Interest earned on DSRF	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094
Interestearnedon Battery Replacement Fund	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(52,245)
State Tax Refund (Paid)	93,769	842,849	242,865	(202,473)	(537,111)	(595,878)	(655,344)	(1,068,059)	(1,482,456)	(1,550,107)	(1,620,442)	(1,693,578)	(1,769,637)	(1,848,747)	(1,931,042)	(2,016,663)	(2,105,757)	(2,198,477)	(2,294,985)	(2,395,451)
Federal Tax Refund (Paid)	338,440	3,042,074	876,567	(730,781)	(1,938,582)	(2,150,687)	(2,365,318)	(3,854,919)	(5,350,592)	(5,594,764)	(5,848,624)	(6,112,591)	(6,387,109)	(6,672,639)	(6,969,665)	(7,278,694)	(7,600,257)	(7,934,910)	(8,283,235)	(8,645,844)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	432,209	3,884,923	1,119,432	(933,254)	(2,475,693)	(2,746,564)	(3,020,662)	(4,922,978)	(6,833,048)	(7,144,872)	(7,469,066)	(7,806,170)	(8,156,746)	(8,521,386)	(8,900,707)	(9,295,357)	(9,706,014)	(10,133,387)	(10,578,221)	(11,041,295)
Equity Investment (InvestedBeforeProject)	(51,565,411)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	10,799,000	14,738,941	12,477,661	10,946,798	9,944,449	10,232,612	10,537,198	9,233,947	7,944,083	8,274,395	8,615,086	8,966,469	9,328,865	9,702,601	10,088,013	10,485,445	10,895,248	11,317,780	11,753,408	16,121,409

Run 16a: Base Case with Flow Battery with High Variable O&M cost

Table A-21
Run 16a

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	46,259,452	0
Financing Costs (Debt)	30,229,033	0
Operating Costs	61,603,239	0
Taxes (Refund or Paid)	20,671,083	0
Electricity Sales	0	39,163,150
System Electric Supply Capacity	0	61,224,838
Non-synchronous Reserve (Non-spin)	0	1,820
Synchronous Reserve (Spin)	0	12,178,193
Frequency Regulation	0	77,194,483
Total	**158,762,807**	**189,762,484**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	2,884	2,511
$/kWh**	721	628
Benefit-to-Cost Ratio		1.20
Breakeven Residual Capacity Value		$38
Capacity Factor		17.80%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	3,899,354	4,055,328	4,217,541	4,386,243	4,561,692	4,744,160	4,933,926	5,131,284	5,336,535	5,549,996	5,771,996	6,002,876	6,242,991	6,492,711	6,752,419	7,022,516	7,303,416	7,595,553	7,899,375	8,215,350
BenefitRevenues	15,879,026	16,374,577	16,887,159	17,417,396	17,965,937	18,533,457	19,120,655	19,728,259	20,357,022	21,007,728	21,681,191	22,378,256	23,099,800	23,846,733	24,620,003	25,420,592	26,249,520	27,107,847	27,996,674	28,917,145
Operating Revenue	19,778,379	20,429,905	21,104,700	21,803,638	22,527,630	23,277,617	24,054,582	24,859,542	25,693,557	26,557,725	27,453,188	28,381,132	29,342,791	30,339,444	31,372,422	32,443,108	33,552,936	34,703,400	35,896,049	37,132,495
Total Revenue	19,778,379	20,429,905	21,104,700	21,803,638	22,527,630	23,277,617	24,054,582	24,859,542	25,693,557	26,557,725	27,453,188	28,381,132	29,342,791	30,339,444	31,372,422	32,443,108	33,552,936	34,703,400	35,896,049	37,132,495
Fixed O&M	(1,500,000)	(1,530,000)	(1,560,600)	(1,591,812)	(1,623,648)	(1,656,121)	(1,689,244)	(1,723,029)	(1,757,489)	(1,792,639)	(1,828,492)	(1,865,061)	(1,902,363)	(1,940,410)	(1,979,218)	(2,018,803)	(2,059,179)	(2,100,362)	(2,142,369)	(2,185,217)
Variable O&M	(23,360)	(23,827)	(24,304)	(24,790)	(25,286)	(25,791)	(26,307)	(26,833)	(27,370)	(27,917)	(28,476)	(29,045)	(29,626)	(30,219)	(30,823)	(31,439)	(32,068)	(32,710)	(33,364)	(34,031)
Charging Costs	(4,053,686)	(4,215,834)	(4,384,467)	(4,559,846)	(4,742,240)	(4,931,929)	(5,129,206)	(5,334,375)	(5,547,750)	(5,769,660)	(6,000,446)	(6,240,464)	(6,490,082)	(6,749,686)	(7,019,673)	(7,300,460)	(7,592,478)	(7,896,178)	(8,212,025)	(8,540,506)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)	(974,600)
Total Operating Costs	(6,551,646)	(6,744,261)	(6,943,971)	(7,151,048)	(7,365,773)	(7,588,442)	(7,819,357)	(8,058,836)	(8,307,209)	(8,564,816)	(8,832,013)	(9,109,170)	(9,396,671)	(9,694,914)	(10,004,314)	(10,325,302)	(10,658,325)	(11,003,849)	(11,362,358)	(11,734,353)
Operating Profit	13,226,733	13,685,644	14,160,729	14,652,591	15,161,856	15,689,175	16,235,225	16,800,706	17,386,348	17,992,909	18,621,174	19,271,962	19,946,120	20,644,530	21,368,108	22,117,806	22,894,611	23,699,551	24,533,692	25,398,142
Interest Expense	(2,858,834)	(2,782,609)	(2,701,674)	(2,615,737)	(2,524,489)	(2,427,602)	(2,324,727)	(2,215,494)	(2,099,511)	(1,976,361)	(1,845,599)	(1,706,757)	(1,559,334)	(1,402,800)	(1,236,592)	(1,060,113)	(872,727)	(673,761)	(462,499)	(238,181)
Loan Repayment Expense (Principal)	(1,233,409)	(1,309,633)	(1,390,569)	(1,476,506)	(1,567,754)	(1,664,641)	(1,767,516)	(1,876,748)	(1,992,731)	(2,115,882)	(2,246,644)	(2,385,486)	(2,532,909)	(2,689,443)	(2,855,651)	(3,032,130)	(3,219,515)	(3,418,481)	(3,629,744)	(3,854,062)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,918,904
Interest earned on DSRF	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094	121,094
Interestearned on Battery Replacement Fund	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(3,971,149)	(52,245)
State Tax Refund (Paid)	192,000	943,583	346,174	(96,516)	(428,429)	(684,392)	(540,974)	(950,720)	(1,362,061)	(1,426,568)	(1,493,666)	(1,563,469)	(1,636,097)	(1,711,674)	(1,790,331)	(1,872,205)	(1,957,436)	(2,046,185)	(2,138,598)	(2,234,845)
Federal Tax Refund (Paid)	692,981	3,405,650	1,249,436	(348,352)	(1,546,318)	(1,748,305)	(1,952,523)	(3,431,409)	(4,916,054)	(5,148,876)	(5,391,051)	(5,642,991)	(5,905,124)	(6,177,903)	(6,461,798)	(6,757,304)	(7,064,939)	(7,385,245)	(7,718,791)	(8,066,173)
TaxCredit-FederalTC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	884,981	4,349,233	1,595,610	(444,868)	(1,974,747)	(2,232,697)	(2,493,497)	(4,382,129)	(6,278,116)	(6,575,444)	(6,884,717)	(7,206,459)	(7,541,221)	(7,889,576)	(8,252,129)	(8,629,509)	(9,022,378)	(9,431,429)	(9,857,389)	(10,301,019)
Equity Investment (InvestedBeforeProject)	(51,565,411)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	10,140,566	14,063,728	11,785,190	10,236,574	9,215,960	9,485,330	9,770,579	8,447,429	7,137,084	7,446,317	7,765,309	8,094,354	8,433,750	8,783,805	9,144,831	9,517,149	9,901,085	10,296,973	10,705,154	15,044,878

Run 17: Base Case with Pumped Hydro

Note: The project life for the pumped hydro case is 100 years, the *pro forma* below only shows the first 20 years due to space limitation.

Table A-22
Run 17

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	204,906,689	0
Financing Costs (Debt)	107,358,864	0
Operating Costs	366,164,965	0
Taxes (Refund or Paid)	117,840,376	0
Electricity Sales	0	473,132,693
System Electric Supply Capacity	0	466,593,036
Non-synchronous Reserve (Non-spin)	0	7,963,642
Synchronous Reserve (Spin)	0	23,421,159
Frequency Regulation	0	88,020,368
Total	**789,185,751**	**1,041,742,338**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	2,048	1,783
$/kWh**	256	223
Benefit-to-Cost Ratio		1.32
Breakeven Residual Capacity Value		$24
Capacity Factor		26.20%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	35,377,388	36,792,484	38,264,183	39,794,751	41,386,541	43,042,002	44,763,682	46,554,230	48,416,399	50,353,055	52,367,177	54,461,864	56,640,339	58,905,952	61,262,190	63,712,678	66,261,185	68,911,633	71,668,098	74,534,822
BenefitRevenues	53,279,561	54,511,808	55,775,366	57,071,128	58,400,016	59,762,979	61,161,001	62,595,093	64,066,303	65,575,708	67,124,425	68,713,605	70,344,436	72,018,145	73,736,002	75,499,316	77,309,439	79,167,771	81,075,755	83,034,883
Operating Revenue	88,656,950	91,304,292	94,039,550	96,865,879	99,786,556	102,804,982	105,924,683	109,149,323	112,482,702	115,928,763	119,491,603	123,175,469	126,984,774	130,924,098	134,998,192	139,211,994	143,570,624	148,079,403	152,743,853	157,569,705
Total Revenue	88,656,950	91,304,292	94,039,550	96,865,879	99,786,556	102,804,982	105,924,683	109,149,323	112,482,702	115,928,763	119,491,603	123,175,469	126,984,774	130,924,098	134,998,192	139,211,994	143,570,624	148,079,403	152,743,853	157,569,705
Fixed O&M	(2,250,000)	(2,295,000)	(2,340,900)	(2,387,718)	(2,435,472)	(2,484,182)	(2,533,865)	(2,584,543)	(2,636,234)	(2,688,958)	(2,742,737)	(2,797,592)	(2,853,544)	(2,910,615)	(2,968,827)	(3,028,204)	(3,088,768)	(3,150,543)	(3,213,554)	(3,277,825)
Variable O&M	(702,283)	(716,329)	(730,655)	(745,268)	(760,174)	(775,377)	(790,885)	(806,702)	(822,836)	(839,293)	(856,079)	(873,201)	(890,665)	(908,478)	(926,647)	(945,180)	(964,084)	(983,366)	(1,003,033)	(1,023,094)
Charging Costs	(22,203,221)	(23,091,350)	(24,015,004)	(24,975,604)	(25,974,629)	(27,013,614)	(28,094,158)	(29,217,925)	(30,386,642)	(31,602,107)	(32,866,192)	(34,180,839)	(35,548,073)	(36,969,996)	(38,448,796)	(39,986,747)	(41,586,217)	(43,249,666)	(44,979,653)	(46,778,839)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)	(4,364,550)
Total Operating Costs	(29,520,054)	(30,467,229)	(31,451,109)	(32,473,141)	(33,534,825)	(34,637,723)	(35,783,458)	(36,973,720)	(38,210,262)	(39,494,909)	(40,829,558)	(42,216,182)	(43,656,831)	(45,153,638)	(46,708,820)	(48,324,681)	(50,003,619)	(51,748,125)	(53,560,790)	(55,444,307)
Operating Profit	59,136,896	60,837,063	62,588,440	64,392,738	66,251,732	68,167,259	70,141,225	72,175,604	74,272,440	76,433,855	78,662,045	80,959,287	83,327,943	85,770,459	88,289,372	90,887,312	93,567,005	96,331,279	99,183,063	102,125,398
Interest Expense	(12,663,233)	(12,661,282)	(12,659,210)	(12,657,010)	(12,654,674)	(12,652,194)	(12,649,560)	(12,646,764)	(12,643,794)	(12,640,642)	(12,637,294)	(12,633,740)	(12,629,966)	(12,625,958)	(12,621,703)	(12,617,185)	(12,612,388)	(12,607,295)	(12,601,886)	(12,596,144)
Loan Repayment Expense (Principal)	(31,576)	(33,527)	(35,599)	(37,799)	(40,135)	(42,616)	(45,249)	(48,046)	(51,015)	(54,167)	(57,515)	(61,069)	(64,844)	(68,851)	(73,106)	(77,624)	(82,421)	(87,515)	(92,923)	(98,666)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Interest earned on DSRF	380,483	380,483	380,483	380,483	380,483	380,483	380,483	380,483	380,483	380,483	380,483	380,483	380,483	380,483	380,483	380,483	380,483	380,483	380,483	380,483
Interestearnedon Battery Replacement Fund	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)	(12,314,326)
State Tax Refund (Paid)	2,885,894	6,952,106	2,299,309	(559,060)	(723,602)	(2,917,160)	(5,115,898)	(5,295,984)	(5,481,607)	(5,672,955)	(5,870,223)	(6,073,613)	(6,283,336)	(6,499,609)	(6,722,657)	(6,952,714)	(7,190,023)	(7,434,835)	(7,687,411)	(7,948,021)
Federal Tax Refund (Paid)	10,415,986	25,092,070	8,298,842	(2,017,803)	(2,611,679)	(10,528,836)	(18,464,688)	(19,114,669)	(19,784,633)	(20,475,260)	(21,187,254)	(21,921,346)	(22,678,294)	(23,458,881)	(24,263,923)	(25,094,264)	(25,950,777)	(26,834,371)	(27,745,987)	(28,686,601)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	13,301,880	32,044,176	10,598,151	(2,576,863)	(3,335,281)	(13,445,996)	(23,580,586)	(24,410,653)	(25,266,240)	(26,148,214)	(27,057,477)	(27,994,959)	(28,961,630)	(29,958,490)	(30,986,580)	(32,046,978)	(33,140,800)	(34,269,206)	(35,433,398)	(36,634,622)
Equity Investment (InvestedBeforeProject)	(228,409,486)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	60,124,450	80,566,914	60,872,266	49,501,549	50,602,125	42,406,937	34,246,314	35,450,625	36,691,875	37,971,315	39,290,242	40,650,002	42,051,988	43,497,643	44,988,466	46,526,009	48,111,879	49,747,746	51,435,339	53,176,450

Run 18: Base Case with CAES

Table A-23
Run 18

Net Present Value Over Project Life	Cost	Benefit
Capital Expenditure (Equity)	87,165,343	0
Financing Costs (Debt)	50,635,583	0
Operating Costs	189,881,327	0
Taxes (Refund or Paid)	50,849,603	0
Electricity Sales	0	141,321,588
System Electric Supply Capacity	0	161,629,211
Non-synchronous Reserve (Non-spin)	0	20,595,117
Synchronous Reserve (Spin)	0	2,694,383
Frequency Regulation	0	153,391,439
Total	**378,531,857**	**479,631,739**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	2,128	1,853
$/kWh**	266	232
Benefit-to-Cost Ratio		1.27
Breakeven Residual Capacity Value		$9
Capacity Factor		27.50%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Electricity Sales	11,576,327	12,041,460	12,523,118	13,024,043	13,545,005	14,086,805	14,650,277	15,236,288	15,845,740	16,479,569	17,138,752	17,824,302
Benefit Revenues	29,947,295	30,831,332	31,744,453	32,687,696	33,662,138	34,668,896	35,709,131	36,784,044	37,894,885	39,042,948	40,229,580	41,456,176
Operating Revenue	41,525,622	42,872,791	44,267,571	45,711,739	47,207,142	48,755,701	50,359,408	52,020,332	53,740,624	55,522,518	57,368,332	59,280,478
Total Revenue	41,525,622	42,872,791	44,267,571	45,711,739	47,207,142	48,755,701	50,359,408	52,020,332	53,740,624	55,522,518	57,368,332	59,280,478
Fixed O&M	(500,000)	(510,000)	(520,200)	(530,604)	(541,216)	(552,040)	(563,081)	(574,343)	(585,830)	(597,546)	(609,497)	(621,687)
Variable O&M	(723,506)	(737,976)	(752,736)	(767,790)	(783,146)	(798,809)	(814,785)	(831,081)	(847,705)	(864,657)	(881,950)	(899,589)
Charging Costs	(6,555,804)	(6,818,068)	(7,090,790)	(7,374,422)	(7,669,399)	(7,976,175)	(8,295,222)	(8,627,031)	(8,972,112)	(9,330,997)	(9,704,296)	(10,092,406)
Housekeeping Power	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	(6,698,556)	(6,966,498)	(7,245,158)	(7,534,964)	(7,836,363)	(8,149,818)	(8,475,810)	(8,814,843)	(9,167,436)	(9,534,134)	(9,915,499)	(10,312,119)
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)
Total Operating Costs	(16,326,928)	(16,881,574)	(17,457,916)	(18,056,813)	(18,679,156)	(19,325,874)	(19,997,930)	(20,696,329)	(21,422,113)	(22,176,365)	(22,960,215)	(23,774,833)
Operating Profit	25,198,693	25,991,217	26,809,654	27,654,926	28,527,986	29,429,827	30,361,477	31,324,003	32,318,511	33,346,152	34,408,118	35,505,645
Interest Expense	(5,386,818)	(5,340,299)	(5,290,905)	(5,238,459)	(5,182,772)	(5,129,642)	(5,060,859)	(4,994,196)	(4,929,415)	(4,848,256)	(4,768,454)	(4,683,720)
Loan Repayment Expense (Principal)	(752,734)	(799,253)	(848,647)	(901,093)	(956,783)	(1,015,910)	(1,078,693)	(1,145,356)	(1,216,139)	(1,291,296)	(1,371,098)	(1,455,832)
Debt Service Reserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0
Interest earned on DSRF	183,258	183,258	183,258	183,258	183,258	183,258	183,258	183,258	183,258	183,258	183,258	183,258
Interest earned on Battery Replacement Fund	0	0	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)
State Tax Refund (Paid)	1,209,742	2,921,958	939,762	(282,884)	(364,985)	(1,307,401)	(2,252,775)	(2,343,755)	(2,437,927)	(2,535,414)	(2,636,346)	(2,740,858)
Federal Tax Refund (Paid)	4,366,294	10,546,153	3,391,861	(1,021,006)	(1,317,333)	(4,718,771)	(8,130,885)	(8,459,258)	(8,799,150)	(9,151,009)	(9,515,302)	(9,892,514)
Tax Credit-Federal ITC	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	5,576,036	13,468,111	4,331,623	(1,303,890)	(1,682,318)	(6,026,172)	(10,383,660)	(10,803,013)	(11,237,077)	(11,686,423)	(12,151,648)	(12,633,372)
Equity Investment (Invested Before Project)	(87,165,208)	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	24,818,435	33,508,034	25,184,983	20,394,742	20,889,374	17,447,362	14,021,523	14,564,695	15,125,140	15,703,435	16,300,176	16,915,979

	2032	2033	2034	2035	2036	2037	2038	2039	21	22	23
Electricity Sales	18,537,274	19,278,765	20,049,916	20,851,912	21,685,989	22,553,428	23,455,566	24,393,788	25,369,540	26,384,321	27,439,694
Benefit Revenues	42,724,183	44,035,106	45,390,505	46,792,000	48,241,272	49,740,067	51,290,197	52,893,542	54,552,056	56,267,766	58,042,777
Operating Revenue	61,261,457	63,313,871	65,440,421	67,648,913	69,927,261	72,293,496	74,745,762	77,287,330	79,921,596	82,652,087	85,482,471
Total Revenue	61,261,457	63,313,871	65,440,421	67,648,913	69,927,261	72,293,496	74,745,762	77,287,330	79,921,596	82,652,087	85,482,471
Fixed O&M	(634,121)	(646,803)	(659,739)	(672,934)	(686,393)	(700,121)	(714,123)	(728,406)	(742,974)	(757,833)	(772,990)
Variable O&M	(917,581)	(935,932)	(954,651)	(973,744)	(993,219)	(1,013,083)	(1,033,345)	(1,054,012)	(1,075,092)	(1,096,594)	(1,118,526)
Charging Costs	(10,496,102)	(10,915,946)	(11,352,584)	(11,806,687)	(12,278,955)	(12,770,113)	(13,280,918)	(13,812,154)	(14,364,640)	(14,939,226)	(15,536,795)
Housekeeping Power	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	(10,724,604)	(11,153,588)	(11,599,732)	(12,063,721)	(12,546,270)	(13,048,121)	(13,570,045)	(14,112,847)	(14,677,361)	(15,264,456)	(15,875,034)
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)
Total Operating Costs	(24,621,440)	(25,501,302)	(26,415,738)	(27,366,118)	(28,353,868)	(29,380,469)	(30,447,463)	(31,556,451)	(32,709,099)	(33,907,140)	(35,152,376)
Operating Profit	36,640,018	37,812,570	39,024,683	40,277,794	41,573,393	42,913,026	44,298,300	45,730,880	47,212,497	48,744,947	50,330,094
Interest Expense	(4,593,749)	(4,496,219)	(4,396,784)	(4,289,081)	(4,174,722)	(4,053,296)	(3,924,365)	(3,787,466)	(3,642,107)	(3,487,765)	(3,329,885)
Loan Repayment Expense (Principal)	(1,545,805)	(1,641,333)	(1,742,768)	(1,850,471)	(1,964,850)	(2,086,257)	(2,215,187)	(2,352,086)	(2,497,445)	(2,651,787)	(2,815,667)
Debt Service Reserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0
Interest earned on DSRF	183,258	183,258	183,258	183,258	183,258	183,258	183,258	183,258	183,258	183,258	183,258
Interest earned on Battery Replacement Fund	0	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)
State Tax Refund (Paid)	(2,849,090)	(2,961,189)	(3,077,306)	(3,197,602)	(3,322,243)	(3,451,400)	(3,585,256)	(3,723,998)	(3,867,822)	(4,016,935)	(4,171,549)
Federal Tax Refund (Paid)	(10,283,153)	(10,687,747)	(11,106,848)	(11,541,029)	(11,990,890)	(12,457,056)	(12,940,178)	(13,440,936)	(13,960,039)	(14,498,227)	(15,056,272)
Tax Credit-Federal ITC	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(13,132,243)	(13,648,936)	(14,184,154)	(14,738,631)	(15,313,133)	(15,908,456)	(16,525,434)	(17,164,934)	(17,827,861)	(18,515,161)	(19,227,821)
Equity Investment (Invested Before Project)	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	17,551,481	18,207,340	18,884,235	19,582,869	20,303,966	21,048,276	21,816,572	22,609,652	23,428,342	24,273,491	25,145,980

	24	25	26	27	28	29	30	31	32	33	34	35
Electricity Sales	28,537,282	29,678,773	30,865,924	32,100,561	33,384,584	34,719,967	36,108,766	37,553,116	39,055,241	40,617,450	42,242,148	43,931,834
Benefit Revenues	59,879,274	61,779,527	63,745,891	65,780,814	67,886,836	70,066,594	72,322,828	74,658,383	77,076,213	79,579,386	82,171,088	84,854,629
Operating Revenue	88,416,556	91,458,300	94,611,815	97,881,375	101,271,419	104,786,561	108,431,593	112,211,499	116,131,454	120,196,836	124,413,237	128,786,464
Total Revenue	88,416,556	91,458,300	94,611,815	97,881,375	101,271,419	104,786,561	108,431,593	112,211,499	116,131,454	120,196,836	124,413,237	128,786,464
Fixed O&M	(788,450)	(804,219)	(820,303)	(836,709)	(853,443)	(870,512)	(887,922)	(905,681)	(923,794)	(942,270)	(961,116)	(980,338)
Variable O&M	(1,140,896)	(1,163,714)	(1,186,989)	(1,210,728)	(1,234,943)	(1,259,641)	(1,284,834)	(1,310,531)	(1,336,742)	(1,363,476)	(1,390,746)	(1,418,561)
Charging Costs	(16,158,267)	(16,804,598)	(17,476,782)	(18,175,853)	(18,902,887)	(19,659,002)	(20,445,362)	(21,263,177)	(22,113,704)	(22,998,252)	(23,918,182)	(24,874,910)
Housekeeping Power	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	(16,510,035)	(17,170,436)	(17,857,254)	(18,571,544)	(19,314,406)	(20,086,982)	(20,890,461)	(21,726,080)	(22,595,123)	(23,498,928)	(24,438,885)	(25,416,440)
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)	(1,849,032)
Total Operating Costs	(36,446,680)	(37,791,998)	(39,190,359)	(40,643,866)	(42,154,711)	(43,725,170)	(45,357,613)	(47,054,501)	(48,818,395)	(50,651,959)	(52,557,961)	(54,539,281)
Operating Profit	51,969,876	53,666,301	55,421,457	57,237,509	59,116,708	61,061,391	63,073,981	65,156,998	67,313,059	69,544,877	71,855,276	74,247,183
Interest Expense	(3,149,877)	(2,965,115)	(2,768,985)	(2,560,650)	(2,359,453)	(2,104,607)	(1,855,247)	(1,590,477)	(1,309,344)	(1,010,898)	(693,883)	(357,341)
Loan Repayment Expense (Principal)	(2,989,675)	(3,174,457)	(3,370,618)	(3,578,922)	(3,800,099)	(4,034,945)	(4,284,305)	(4,549,075)	(4,830,208)	(5,128,714)	(5,445,669)	(5,762,211)
Debt Service Reserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	5,930,686
Interest earned on DSRF	183,258	183,258	183,258	183,258	183,258	183,258	183,258	183,258	183,258	183,258	183,258	183,256
Interest earned on Battery Replacement Fund	0	0	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,956,294)	(5,608)
State Tax Refund (Paid)	(4,331,888)	(4,498,185)	(4,670,683)	(4,849,636)	(5,035,309)	(5,227,980)	(5,427,936)	(5,635,480)	(5,850,928)	(6,074,609)	(6,306,867)	(6,548,062)
Federal Tax Refund (Paid)	(15,634,979)	(16,235,191)	(16,857,784)	(17,503,675)	(18,173,821)	(18,869,222)	(19,590,920)	(20,340,005)	(21,117,615)	(21,924,941)	(22,763,224)	(23,633,763)
Tax Credit-Federal ITC	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(19,966,867)	(20,733,376)	(21,528,467)	(22,353,311)	(23,209,131)	(24,097,201)	(25,018,855)	(25,975,485)	(26,968,544)	(27,999,550)	(29,070,091)	(30,181,826)
Equity Investment (Invested Before Project)	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	26,046,715	26,976,631	27,936,696	28,927,904	29,951,284	31,007,895	32,098,831	33,225,219	34,388,221	35,589,033	36,828,890	44,039,750

Run 19: Regulation Only

Table A-24
Run19

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	8,683,116	0
Financing Costs (Debt)	5,460,367	0
Operating Costs	8,994,322	0
Taxes (Refund or Paid)	9,207,973	0
Electricity Sales	0	4,233,087
Frequency Regulation	0	40,933,939
Total	32,345,778	45,167,026

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	1928	1678
$/kWh**	7710	6712
Benefit-to-Cost Ratio		1.40
Breakeven Residual Capacity Value		$0
Capacity Factor		6.00%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	421,475	438,334	455,868	474,103	493,067	512,789	533,301	554,633	576,818	599,891	623,887	648,842	674,796	701,788	729,859	759,053	789,416	820,992	853,832	887,985
BenefitRevenues	4,075,666	4,238,692	4,408,240	4,584,570	4,767,952	4,958,671	5,157,017	5,363,298	5,577,830	5,800,943	6,032,981	6,274,300	6,525,272	6,786,283	7,057,734	7,340,044	7,633,646	7,938,991	8,256,551	8,586,813
Operating Revenue	4,497,141	4,677,027	4,864,108	5,058,672	5,261,019	5,471,460	5,690,318	5,917,931	6,154,648	6,400,834	6,656,867	6,923,142	7,200,068	7,488,071	7,787,593	8,099,097	8,423,061	8,759,983	9,110,383	9,474,798
Total Revenue	4,497,141	4,677,027	4,864,108	5,058,672	5,261,019	5,471,460	5,690,318	5,917,931	6,154,648	6,400,834	6,656,867	6,923,142	7,200,068	7,488,071	7,787,593	8,099,097	8,423,061	8,759,983	9,110,383	9,474,798
Fixed O&M	(300,000)	(306,000)	(312,120)	(318,362)	(324,730)	(331,224)	(337,849)	(344,606)	(351,498)	(358,528)	(365,698)	(373,012)	(380,473)	(388,082)	(395,844)	(403,761)	(411,836)	(420,072)	(428,474)	(437,043)
Variable O&M	(3,142)	(3,205)	(3,269)	(3,335)	(3,401)	(3,469)	(3,539)	(3,610)	(3,682)	(3,755)	(3,830)	(3,907)	(3,985)	(4,065)	(4,146)	(4,229)	(4,314)	(4,400)	(4,488)	(4,578)
Charging Costs	(499,155)	(519,122)	(539,887)	(561,482)	(583,941)	(607,299)	(631,591)	(656,855)	(683,129)	(710,454)	(738,872)	(768,427)	(799,164)	(831,131)	(864,376)	(898,951)	(934,909)	(972,305)	(1,011,197)	(1,051,645)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)	(171,160)
Total Operating Costs	(973,458)	(999,487)	(1,026,436)	(1,054,339)	(1,083,232)	(1,113,153)	(1,144,138)	(1,176,230)	(1,209,468)	(1,243,897)	(1,279,561)	(1,316,506)	(1,354,782)	(1,394,437)	(1,435,526)	(1,478,100)	(1,522,218)	(1,567,938)	(1,615,319)	(1,664,426)
Operating Profit	3,523,683	3,677,540	3,837,672	4,004,333	4,177,787	4,358,307	4,546,180	4,741,701	4,945,180	5,156,937	5,377,307	5,606,636	5,845,286	6,093,633	6,352,068	6,620,997	6,900,843	7,192,046	7,495,064	7,810,372
Interest Expense	(536,617)	(522,309)	(507,117)	(490,986)	(473,858)	(455,672)	(436,362)	(415,859)	(394,088)	(370,972)	(346,428)	(320,366)	(292,694)	(263,312)	(232,114)	(198,988)	(163,815)	(126,468)	(86,813)	(44,708)
Loan Repayment Expense (Principal)	(231,517)	(245,824)	(261,016)	(277,147)	(294,275)	(312,461)	(331,771)	(352,274)	(374,045)	(397,161)	(421,706)	(447,767)	(475,439)	(504,821)	(536,019)	(569,145)	(604,318)	(641,665)	(681,320)	(723,425)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	688,241
Interest earned on DSRF	21,267	21,267	21,267	21,267	21,267	21,267	21,267	21,267	21,267	21,267	21,267	21,267	21,267	21,267	21,267	21,267	21,267	21,267	21,267	21,267
Interestearnedon Battery Replacement Fund	35,613	36,714	37,848	39,018	40,223	41,466	42,748	44,069	45,430	46,834	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(711,253)	(710,153)	(709,018)	(707,849)	(706,643)	(705,400)	(704,119)	(702,798)	(701,436)	(700,032)	(746,866)	(746,866)	(746,866)	(746,866)	(746,866)	(746,866)	(746,866)	(746,866)	(746,866)	(58,626)
State Tax Refund (Paid)	(72,525)	52,813	(59,071)	(144,109)	(210,030)	(227,844)	(246,134)	(326,833)	(408,213)	(429,099)	(446,610)	(469,186)	(492,729)	(517,280)	(542,884)	(569,586)	(597,433)	(626,477)	(656,769)	(688,365)
Federal Tax Refund (Paid)	(261,764)	190,617	(213,204)	(520,128)	(758,058)	(822,350)	(888,366)	(1,179,629)	(1,473,352)	(1,548,738)	(1,611,938)	(1,693,423)	(1,778,395)	(1,867,008)	(1,959,418)	(2,055,791)	(2,156,301)	(2,261,129)	(2,370,462)	(2,484,498)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(334,289)	243,430	(272,275)	(664,236)	(968,088)	(1,050,194)	(1,134,501)	(1,506,462)	(1,881,564)	(1,977,838)	(2,058,547)	(2,162,609)	(2,271,124)	(2,384,288)	(2,502,302)	(2,625,377)	(2,753,735)	(2,887,606)	(3,027,231)	(3,172,863)
Equity Investment (InvestedBeforeProject)	(9,679,069)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	2,478,141	3,210,817	2,856,378	2,632,248	2,503,055	2,602,713	2,707,560	2,532,441	2,362,180	2,479,067	2,571,893	2,697,161	2,827,295	2,962,479	3,102,900	3,248,753	3,400,242	3,557,574	3,720,966	4,578,883

Run 20: Base Case with 2015 Start Year

Table A-25
Run 20

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	42,663,482	0
Financing Costs (Debt)	23,603,908	0
Operating Costs	48,309,416	0
Taxes (Refund or Paid)	16,632,475	0
Electricity Sales	0	35,400,633
System Electric Supply Capacity	0	27,918,702
Non-synchronous Reserve (Non-spin)	0	7,821
Synchronous Reserve (Spin)	0	8,126,725
Frequency Regulation	0	69,898,185
Total	**131,209,281**	**141,352,067**

Other Metrics		
Breakeven Capital Costs		
	2015 Nominal	2013 Real***
$/kW*	1,570	1,509
$/kWh**	785	755
Benefit-to-Cost Ratio		1.08
Breakeven Residual Capacity Value		$62
Capacity Factor		21.40%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Electricity Sales	3,524,732	3,665,721	3,812,350	3,964,844	4,123,437	4,288,375	4,459,910	4,638,306	4,823,839	5,016,792	5,217,464	5,426,162	5,643,209	5,868,937	6,103,695	6,347,842	6,601,756	6,865,826	7,140,459	7,426,078
Benefit Revenues	9,513,102	10,152,300	10,865,796	11,665,742	13,140,504	13,585,079	14,045,817	14,523,331	15,018,259	15,531,264	16,063,035	16,614,288	17,185,764	17,778,238	18,392,512	19,029,420	19,689,828	20,374,637	21,084,783	21,821,238
Operating Revenue	13,037,834	13,818,021	14,678,145	15,630,585	17,263,941	17,873,454	18,505,727	19,161,637	19,842,098	20,548,057	21,280,499	22,040,450	22,828,973	23,647,176	24,496,207	25,377,262	26,291,584	27,240,464	28,225,243	29,247,316
Total Revenue	13,037,834	13,818,021	14,678,145	15,630,585	17,263,941	17,873,454	18,505,727	19,161,637	19,842,098	20,548,057	21,280,499	22,040,450	22,828,973	23,647,176	24,496,207	25,377,262	26,291,584	27,240,464	28,225,243	29,247,316
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(28,161)	(28,724)	(29,299)	(29,885)	(30,482)	(31,092)	(31,714)	(32,348)	(32,995)	(33,655)	(34,328)	(35,015)	(35,715)	(36,429)	(37,158)	(37,901)	(38,659)	(39,432)	(40,221)	(41,025)
Charging Costs	(3,620,282)	(3,765,093)	(3,915,697)	(4,072,325)	(4,235,218)	(4,404,627)	(4,580,812)	(4,764,044)	(4,954,606)	(5,152,790)	(5,358,902)	(5,573,258)	(5,796,188)	(6,028,036)	(6,269,157)	(6,519,924)	(6,780,721)	(7,051,949)	(7,334,027)	(7,627,389)
Housekeeping Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)
Total Operating Costs	(5,061,743)	(5,222,118)	(5,388,596)	(5,561,416)	(5,740,825)	(5,927,079)	(6,120,448)	(6,321,207)	(6,529,646)	(6,746,065)	(6,970,776)	(7,204,104)	(7,446,385)	(7,697,970)	(7,959,224)	(8,230,526)	(8,512,269)	(8,804,863)	(9,108,733)	(9,424,322)
Operating Profit	7,976,090	8,595,903	9,289,549	10,069,169	11,523,116	11,946,375	12,385,279	12,840,431	13,312,452	13,801,992	14,309,723	14,836,346	15,382,588	15,949,205	16,536,983	17,146,736	17,779,315	18,435,601	19,116,510	19,822,994
Interest Expense	(2,636,603)	(2,566,304)	(2,491,660)	(2,412,403)	(2,328,248)	(2,238,893)	(2,144,015)	(2,043,273)	(1,936,306)	(1,822,729)	(1,702,132)	(1,574,082)	(1,438,119)	(1,293,753)	(1,140,666)	(977,705)	(804,886)	(621,387)	(426,547)	(219,666)
Loan Repayment Expense (Principal)	(1,137,530)	(1,207,829)	(1,282,473)	(1,361,730)	(1,445,885)	(1,535,240)	(1,630,118)	(1,730,860)	(1,837,827)	(1,951,404)	(2,072,001)	(2,200,051)	(2,336,014)	(2,480,380)	(2,633,667)	(2,796,428)	(2,969,247)	(3,152,746)	(3,347,586)	(3,554,467)
Debt Service Reserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,667,155
Interest earned on DSRF	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415
Interest earned on Battery Replacement Fund	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(2,979,450)	(2,957,441)	(2,934,752)	(2,911,362)	(2,887,249)	(2,862,391)	(2,836,765)	(2,810,347)	(2,783,112)	(2,755,036)	(3,691,718)	(3,691,718)	(3,691,718)	(3,691,718)	(3,691,718)	(3,691,718)	(3,691,718)	(3,691,718)	(3,691,718)	(1,024,563)
State Tax Refund (Paid)	219,471	700,232	257,173	(87,345)	(415,211)	(663,257)	(512,176)	(801,926)	(1,093,258)	(1,149,055)	(1,121,797)	(1,179,670)	(1,239,977)	(1,302,827)	(1,368,338)	(1,436,628)	(1,507,825)	(1,582,062)	(1,659,478)	(1,740,220)
Federal Tax Refund (Paid)	792,130	2,527,331	928,209	(315,253)	(1,498,613)	(1,672,023)	(1,848,584)	(2,894,373)	(3,945,868)	(4,147,257)	(4,048,873)	(4,257,753)	(4,475,418)	(4,702,264)	(4,938,708)	(5,185,186)	(5,442,157)	(5,710,099)	(5,989,515)	(6,280,933)
Tax Credit - Federal ITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	1,011,601	3,227,564	1,185,383	(402,598)	(1,913,824)	(2,135,280)	(2,360,759)	(3,696,299)	(5,039,126)	(5,296,312)	(5,170,670)	(5,437,423)	(5,715,394)	(6,005,091)	(6,307,046)	(6,621,814)	(6,949,982)	(7,292,161)	(7,648,993)	(8,021,153)
Equity Investment (Invested Before Project)	(47,556,983)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	6,008,241	8,866,025	7,540,180	6,755,210	6,722,043	6,948,704	7,187,755	6,333,785	5,490,214	5,750,644	5,447,335	5,707,205	5,975,476	6,252,396	6,538,219	6,833,204	7,137,616	7,451,722	7,775,799	10,777,278

Run 21: Base Case with 2015 Start Year 2X Regulation Price

Table A-26
Run 21

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	42,663,482	0
Financing Costs (Debt)	23,603,908	0
Operating Costs	61,576,972	0
Taxes (Refund or Paid)	45,240,253	0
Electricity Sales	0	40,780,665
System Electric Supply Capacity	0	27,417,351
Non-synchronous Reserve (Non-spin)	0	16,166
Synchronous Reserve (Spin)	0	5,727,238
Frequency Regulation	0	150,888,230
Total	**173,084,615**	**224,829,650**

Other Metrics		
Breakeven Capital Costs		
	2015 Nominal	2013 Real***
$/kW*	3,060	2,941
$/kWh**	1,530	1,471
Benefit-to-Cost Ratio		1.30
Breakeven Residual Capacity Value		$0
Capacity Factor		26.70%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	4,060,405	4,222,821	4,391,734	4,567,403	4,750,099	4,940,103	5,137,707	5,343,216	5,556,944	5,779,222	6,010,391	6,250,806	6,500,839	6,760,872	7,031,307	7,312,559	7,605,062	7,909,264	8,225,635	8,554,660
BenefitRevenues	17,307,763	18,254,083	19,286,110	20,416,288	22,222,948	23,032,256	23,872,344	24,744,411	25,649,705	26,589,521	27,565,206	28,578,160	29,629,839	30,721,757	31,855,486	33,032,661	34,254,982	35,524,217	36,842,201	38,210,846
Operating Revenue	21,368,168	22,476,904	23,677,844	24,983,691	26,973,047	27,972,359	29,010,051	30,087,627	31,206,649	32,368,743	33,575,596	34,828,966	36,130,678	37,482,629	38,886,793	40,345,220	41,860,044	43,433,481	45,067,836	46,765,506
Total Revenue	21,368,168	22,476,904	23,677,844	24,983,691	26,973,047	27,972,359	29,010,051	30,087,627	31,206,649	32,368,743	33,575,596	34,828,966	36,130,678	37,482,629	38,886,793	40,345,220	41,860,044	43,433,481	45,067,836	46,765,506
Fixed O&M	(750,000)	(765,000)	(780,300)	(795,906)	(811,824)	(828,061)	(844,622)	(861,514)	(878,745)	(896,319)	(914,246)	(932,531)	(951,181)	(970,205)	(989,609)	(1,009,401)	(1,029,589)	(1,050,181)	(1,071,185)	(1,092,608)
Variable O&M	(35,093)	(35,795)	(36,511)	(37,241)	(37,986)	(38,745)	(39,520)	(40,311)	(41,117)	(41,939)	(42,778)	(43,634)	(44,506)	(45,396)	(46,304)	(47,230)	(48,175)	(49,139)	(50,121)	(51,124)
Charging Costs	(4,935,238)	(5,132,647)	(5,337,953)	(5,551,472)	(5,773,530)	(6,004,472)	(6,244,650)	(6,494,436)	(6,754,214)	(7,024,382)	(7,305,358)	(7,597,572)	(7,901,475)	(8,217,534)	(8,546,235)	(8,888,085)	(9,243,608)	(9,613,352)	(9,997,887)	(10,397,802)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)	(663,300)
Total Operating Costs	(6,383,631)	(6,596,742)	(6,818,064)	(7,047,918)	(7,286,640)	(7,534,578)	(7,792,093)	(8,059,561)	(8,337,375)	(8,625,941)	(8,925,682)	(9,237,036)	(9,560,463)	(9,896,435)	(10,245,449)	(10,608,016)	(10,984,672)	(11,375,972)	(11,782,493)	(12,204,834)
Operating Profit	14,984,537	15,880,161	16,859,780	17,935,773	19,686,407	20,437,781	21,217,959	22,028,065	22,869,274	23,742,801	24,649,915	25,591,930	26,570,215	27,586,194	28,641,344	29,737,204	30,875,372	32,057,509	33,285,344	34,560,672
Interest Expense	(2,636,603)	(2,566,304)	(2,491,660)	(2,412,403)	(2,328,248)	(2,238,893)	(2,144,015)	(2,043,273)	(1,936,306)	(1,822,729)	(1,702,132)	(1,574,082)	(1,438,119)	(1,293,753)	(1,140,466)	(977,705)	(804,886)	(621,387)	(426,547)	(219,666)
Loan Repayment Expense (Principal)	(1,137,530)	(1,207,829)	(1,282,473)	(1,361,730)	(1,445,885)	(1,535,240)	(1,630,118)	(1,730,860)	(1,837,827)	(1,951,404)	(2,072,001)	(2,200,051)	(2,336,014)	(2,480,380)	(2,633,667)	(2,796,428)	(2,969,247)	(3,152,746)	(3,347,586)	(3,554,467)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,667,155
Interest earned on DSRF	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415	82,415
Interestearned on Battery Replacement Fund	712,267	734,277	756,966	780,356	804,469	829,327	854,953	881,371	908,606	936,682	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(2,979,450)	(2,957,441)	(2,934,752)	(2,911,362)	(2,887,249)	(2,862,391)	(2,836,765)	(2,810,347)	(2,783,112)	(2,755,036)	(3,691,718)	(3,691,718)	(3,691,718)	(3,691,718)	(3,691,718)	(3,691,718)	(3,691,718)	(3,691,718)	(3,691,718)	(1,024,563)
State Tax Refund (Paid)	(400,076)	56,304	(412,035)	(782,753)	(1,136,846)	(1,213,897)	(1,292,985)	(1,614,113)	(1,938,081)	(2,027,823)	(2,035,869)	(2,130,463)	(2,228,963)	(2,331,537)	(2,438,363)	(2,549,625)	(2,665,516)	(2,786,239)	(2,912,003)	(3,043,030)
Federal Tax Refund (Paid)	(1,443,985)	203,216	(1,487,148)	(2,825,171)	(4,103,192)	(4,381,291)	(4,666,738)	(5,825,780)	(6,995,068)	(7,318,971)	(7,348,015)	(7,689,430)	(8,044,942)	(8,415,161)	(8,800,726)	(9,202,301)	(9,620,585)	(10,056,305)	(10,510,223)	(10,983,137)
TaxCredit-FederalTC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(1,844,061)	259,520	(1,899,183)	(3,607,924)	(5,240,039)	(5,595,188)	(5,959,723)	(7,439,893)	(8,933,148)	(9,346,794)	(9,383,884)	(9,819,893)	(10,273,905)	(10,746,699)	(11,239,089)	(11,751,926)	(12,286,101)	(12,842,543)	(13,422,226)	(14,026,167)
Equity Investment (InvestedBeforeProject)	(47,556,983)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	10,161,026	13,182,240	12,025,844	11,416,487	11,559,119	11,980,202	12,421,471	11,777,826	11,153,013	11,640,971	11,574,312	12,080,319	12,604,593	13,147,777	13,710,538	14,293,560	14,897,553	15,523,248	16,171,400	19,509,942

Run 22: Base Case for Distributed Storage Use Case 2015 Start Year

Table A-27
Run 22

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	1,491,428	0
Financing Costs (Debt)	803,588	0
Operating Costs	1,223,720	0
Taxes (Refund or Paid)	1,004,847	0
Distribution Investment Deferral	0	1,714,098
Electricity Sales	0	973,526
System Electric Supply Capacity	0	1,045,941
Non-synchronous Reserve (Non-spin)	0	46
Synchronous Reserve (Spin)	0	64,602
Frequency Regulation	0	1,620,494
Total	4,523,583	5,418,707

Other Metrics		
Breakeven Capital Costs		
	2015 Nominal	2013 Real***
$/kW*	3604	3464
$/kWh**	901	866
Benefit-to-Cost Ratio		1.20
Breakeven Residual Capacity Value		$0
Capacity Factor		28.20%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	96,948	99,962	103,960	108,119	110,639	118,626	123,371	128,306	133,438	138,776	144,327	150,100	156,104	162,348	168,842	175,596	182,620	189,924	197,521	205,422
BenefitRevenues	699,651	718,565	740,580	765,884	816,478	360,690	371,996	383,691	395,791	408,310	421,264	434,668	448,539	462,895	477,753	493,133	509,053	525,533	542,596	560,261
Operating Revenue	796,598	818,526	844,540	874,003	927,118	479,316	495,367	511,998	529,230	547,086	565,591	584,768	604,643	625,243	646,595	668,728	691,672	715,458	740,117	765,684
Total Revenue	796,598	818,526	844,540	874,003	927,118	479,316	495,367	511,998	529,230	547,086	565,591	584,768	604,643	625,243	646,595	668,728	691,672	715,458	740,117	765,684
Fixed O&M	(15,000)	(15,300)	(15,606)	(15,918)	(16,236)	(16,561)	(16,892)	(17,230)	(17,575)	(17,926)	(18,285)	(18,651)	(19,024)	(19,404)	(19,792)	(20,188)	(20,592)	(21,004)	(21,424)	(21,852)
Variable O&M	(738)	(749)	(764)	(779)	(786)	(817)	(834)	(851)	(868)	(885)	(903)	(921)	(939)	(958)	(977)	(997)	(1,016)	(1,037)	(1,058)	(1,079)
Charging Costs	(91,168)	(94,214)	(97,983)	(101,902)	(104,763)	(111,427)	(115,884)	(120,519)	(125,340)	(130,353)	(135,568)	(140,990)	(146,630)	(152,495)	(158,595)	(164,939)	(171,536)	(178,398)	(185,534)	(192,955)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)
Total Operating Costs	(128,906)	(132,263)	(136,352)	(140,599)	(143,786)	(150,805)	(155,610)	(160,600)	(165,782)	(171,165)	(176,755)	(182,561)	(188,592)	(194,857)	(201,364)	(208,123)	(215,144)	(222,438)	(230,015)	(237,886)
Operating Profit	667,693	686,264	708,188	733,404	783,331	328,511	339,757	351,398	363,448	375,922	388,836	402,206	416,051	430,386	445,231	460,605	476,528	493,020	510,102	527,798
Interest Expense	(92,170)	(89,713)	(87,103)	(84,333)	(81,391)	(78,267)	(74,950)	(71,429)	(67,689)	(63,719)	(59,503)	(55,027)	(50,274)	(45,227)	(39,868)	(34,179)	(28,137)	(21,722)	(14,911)	(7,679)
Loan Repayment Expense (Principal)	(39,766)	(42,223)	(44,833)	(47,603)	(50,545)	(53,669)	(56,986)	(60,507)	(64,247)	(68,217)	(72,433)	(76,909)	(81,662)	(86,709)	(92,068)	(97,757)	(103,799)	(110,214)	(117,025)	(124,257)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	88,463
Interest earned on DSRF	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734
Interestearnedon Battery Replacement Fund	28,491	29,371	30,279	31,214	32,179	33,173	34,198	35,255	36,344	37,467	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(100,712)	(99,831)	(98,924)	(97,988)	(97,024)	(96,029)	(95,004)	(93,948)	(92,858)	(91,735)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(40,740)
State Tax Refund (Paid)	(28,372)	(12,275)	(26,900)	(38,297)	(49,350)	(9,525)	(10,885)	(20,222)	(29,599)	(31,152)	(29,355)	(30,932)	(32,576)	(34,290)	(36,076)	(37,938)	(39,879)	(41,904)	(44,017)	(46,220)
Federal Tax Refund (Paid)	(102,401)	(44,303)	(97,089)	(138,223)	(178,116)	(34,379)	(39,288)	(72,987)	(106,833)	(112,438)	(105,949)	(111,643)	(117,577)	(123,761)	(130,207)	(136,928)	(143,936)	(151,244)	(158,868)	(166,821)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(130,773)	(56,578)	(123,989)	(176,520)	(227,466)	(43,904)	(50,174)	(93,210)	(136,432)	(143,590)	(135,304)	(142,576)	(150,153)	(158,051)	(166,283)	(174,866)	(183,815)	(193,149)	(202,884)	(213,041)
Equity Investment (InvestedBeforeProject)	(1,662,494)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	436,208	529,854	485,275	458,896	458,842	188,577	194,579	164,241	134,157	140,596	124,330	130,428	136,695	143,133	149,746	156,537	163,510	170,669	178,016	274,017

Run 22 No Reg: Re-Run Run 22 with No Regulation

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	1,491,428	0
Operating Costs	803,588	0
Financing Costs (Debt)	813,526	0
Taxes (Refund or Paid)	717,723	0
Non-synchronous Reserve (Non-spin)	0	1,714,098
Synchronous Reserve (Spin)	0	808,787
Electricity Sales	0	1,049,757
System Electric Supply Capacity	0	271
Distribution Investment Deferral	0	730,931
Total	3,826,264	4,303,845

Other Metrics		
Breakeven Capital Costs		
	2015 Nominal	2013 Real***
$/kW*	2856	2745
$/kWh**	714	686
Benefit-to-Cost Ratio		1.12
Breakeven Residual Capacity Value		$44
Capacity Factor		20.80%

Table A-28
Run 22 No Reg

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	80,517	83,042	86,363	89,818	91,880	98,564	102,506	106,606	110,871	115,305	119,918	124,714	129,703	134,891	140,287	145,898	151,734	157,803	164,116	170,680
BenefitRevenues	605,007	620,400	638,536	659,815	707,230	245,379	252,061	258,947	266,044	273,361	280,903	288,679	296,697	304,965	313,492	322,287	331,358	340,716	350,371	360,332
Operating Revenue	685,524	703,442	724,899	749,633	799,110	343,943	354,567	365,553	376,915	388,666	400,821	413,393	426,400	439,856	453,779	468,185	483,092	498,520	514,486	531,012
Total Revenue	685,524	703,442	724,899	749,633	799,110	343,943	354,567	365,553	376,915	388,666	400,821	413,393	426,400	439,856	453,779	468,185	483,092	498,520	514,486	531,012
Fixed O&M	(15,000)	(15,300)	(15,606)	(15,918)	(16,236)	(16,561)	(16,892)	(17,230)	(17,575)	(17,926)	(18,285)	(18,651)	(19,024)	(19,404)	(19,792)	(20,188)	(20,592)	(21,004)	(21,424)	(21,852)
Variable O&M	(545)	(554)	(565)	(576)	(582)	(605)	(617)	(629)	(642)	(654)	(667)	(681)	(694)	(708)	(722)	(737)	(752)	(767)	(782)	(798)
Charging Costs	(50,471)	(52,196)	(54,284)	(56,455)	(58,117)	(61,709)	(64,178)	(66,745)	(69,415)	(72,191)	(75,079)	(78,082)	(81,205)	(84,454)	(87,832)	(91,345)	(94,999)	(98,799)	(102,751)	(106,861)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)
Total Operating Costs	(88,016)	(90,050)	(92,455)	(94,950)	(96,935)	(100,875)	(103,687)	(106,604)	(109,631)	(112,772)	(116,031)	(119,414)	(122,924)	(126,566)	(130,346)	(134,270)	(138,342)	(142,569)	(146,957)	(151,511)
Operating Profit	597,508	613,392	632,444	654,683	702,174	243,068	250,880	258,949	267,284	275,894	284,789	293,980	303,477	313,290	323,433	333,915	344,750	355,951	367,530	379,501
Interest Expense	(92,170)	(89,713)	(87,103)	(84,333)	(81,391)	(78,267)	(74,950)	(71,429)	(67,689)	(63,719)	(59,503)	(55,027)	(50,274)	(45,227)	(39,868)	(34,179)	(28,137)	(21,722)	(14,911)	(7,679)
Loan Repayment Expense	(39,766)	(42,223)	(44,833)	(47,603)	(50,545)	(53,669)	(56,986)	(60,507)	(64,247)	(68,217)	(72,433)	(76,900)	(81,662)	(86,709)	(92,068)	(97,757)	(103,799)	(110,214)	(117,025)	(124,257)
DebtServiceReserve	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	88,463
Interest earned on DSRF	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734
Interestearnedon Battery	28,491	29,371	30,279	31,214	32,179	33,173	34,198	35,255	36,344	37,467	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(100,712)	(99,831)	(98,924)	(97,988)	(97,024)	(96,029)	(95,004)	(93,948)	(92,858)	(91,735)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(40,740)
State Tax Refund (Paid)	(22,167)	(5,833)	(20,204)	(31,338)	(42,175)	(1,972)	(3,029)	(12,050)	(21,099)	(22,310)	(20,157)	(21,365)	(22,625)	(23,938)	(25,309)	(26,738)	(28,230)	(29,787)	(31,413)	(33,111)
Federal Tax Refund (Paid)	(80,008)	(21,053)	(72,922)	(113,106)	(152,222)	(7,117)	(10,931)	(43,491)	(76,151)	(80,523)	(72,752)	(77,113)	(81,659)	(86,400)	(91,346)	(96,506)	(101,891)	(107,511)	(113,379)	(119,506)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(102,176)	(26,886)	(93,126)	(144,444)	(194,397)	(9,089)	(13,960)	(55,540)	(97,249)	(102,833)	(92,909)	(98,478)	(104,284)	(110,339)	(116,655)	(123,244)	(130,121)	(137,298)	(144,792)	(152,616)
(InvestedBeforeProject)	(1,662,494)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	394,621	486,675	440,394	412,251	410,753	137,949	141,916	109,461	77,176	81,326	62,678	66,300	69,990	73,749	77,575	81,468	85,427	89,450	93,536	186,145

Run 22b: Base Case for Distributed Storage Use Case 2015 Start Year, Two-Hour Duration

Table A-29
Run 22b

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	797,925	0
Financing Costs (Debt)	435,913	0
Operating Costs	1,060,162	0
Taxes (Refund or Paid)	974,040	0
Distribution Investment Deferral	0	1,441,734
Electricity Sales	0	777,821
System Electric Supply Capacity	0	523,676
Non-synchronous Reserve (Non-spin)	0	128
Synchronous Reserve (Spin)	0	95,136
Frequency Regulation	0	1,564,006
Total	3,268,041	4,402,502

Other Metrics		
Breakeven Capital Costs		
	2015 Nominal	2013 Real***
$/kW*	3140	3018
$/kWh**	1570	1509
Benefit-to-Cost Ratio		1.35
Breakeven Residual Capacity Value		$0
Capacity Factor		24.30%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	77,382	79,991	83,191	86,518	88,705	94,702	98,490	102,429	106,527	110,788	115,219	119,828	124,621	129,606	134,790	140,182	145,789	151,621	157,685	163,993
BenefitRevenues	665,901	678,330	692,718	708,887	267,492	279,684	289,308	299,286	309,631	320,358	331,480	343,013	354,974	367,377	380,240	393,582	407,420	421,773	436,661	452,106
Operating Revenue	743,283	758,321	775,908	795,405	356,196	374,386	387,798	401,716	416,158	431,145	446,699	462,841	479,595	496,983	515,031	533,764	553,209	573,393	594,347	616,098
Total Revenue	743,283	758,321	775,908	795,405	356,196	374,386	387,798	401,716	416,158	431,145	446,699	462,841	479,595	496,983	515,031	533,764	553,209	573,393	594,347	616,098
Fixed O&M	(15,000)	(15,300)	(15,606)	(15,918)	(16,236)	(16,561)	(16,892)	(17,230)	(17,575)	(17,926)	(18,285)	(18,651)	(19,024)	(19,404)	(19,792)	(20,188)	(20,592)	(21,004)	(21,424)	(21,852)
Variable O&M	(637)	(647)	(660)	(673)	(680)	(706)	(720)	(734)	(749)	(764)	(779)	(795)	(811)	(827)	(844)	(860)	(878)	(895)	(913)	(931)
Charging Costs	(82,500)	(85,404)	(88,821)	(92,373)	(94,925)	(100,924)	(104,961)	(109,159)	(113,526)	(118,067)	(122,789)	(127,701)	(132,809)	(138,121)	(143,646)	(149,392)	(155,368)	(161,583)	(168,046)	(174,768)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)	(12,100)
Total Operating Costs	(110,236)	(113,451)	(117,187)	(121,065)	(123,941)	(130,291)	(134,673)	(139,224)	(143,950)	(148,857)	(153,954)	(159,247)	(164,744)	(170,453)	(176,382)	(182,541)	(188,937)	(195,581)	(202,483)	(209,651)
Operating Profit	633,047	644,870	658,722	674,341	232,255	244,095	253,125	262,492	272,208	282,288	292,746	303,595	314,851	326,530	338,648	351,223	364,271	377,812	391,864	406,447
Interest Expense	(49,312)	(47,997)	(46,601)	(45,119)	(43,545)	(41,873)	(40,099)	(38,215)	(36,214)	(34,090)	(31,835)	(29,440)	(26,897)	(24,197)	(21,330)	(18,286)	(15,054)	(11,622)	(7,978)	(4,108)
Loan Repayment Expense (Principal)	(21,275)	(22,590)	(23,986)	(25,468)	(27,042)	(28,713)	(30,488)	(32,372)	(34,372)	(36,497)	(38,752)	(41,147)	(43,690)	(46,390)	(49,257)	(52,301)	(55,533)	(58,965)	(62,609)	(66,478)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48,655
Interest earned on DSRF	1,503	1,503	1,503	1,503	1,503	1,503	1,503	1,503	1,503	1,503	1,503	1,503	1,503	1,503	1,503	1,503	1,503	1,503	1,503	1,503
Interestearnedon Battery Replacement Fund	14,245	14,686	15,139	15,607	16,089	16,587	17,099	17,627	18,172	18,734	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(54,838)	(54,398)	(53,944)	(53,476)	(52,994)	(52,497)	(51,984)	(51,456)	(50,911)	(50,350)	(69,083)	(69,083)	(69,083)	(69,083)	(69,083)	(69,083)	(69,083)	(69,083)	(69,083)	(20,429)
State Tax Refund (Paid)	(39,099)	(30,381)	(38,575)	(44,991)	(9,554)	(10,802)	(11,792)	(17,180)	(22,601)	(23,730)	(23,197)	(24,368)	(25,588)	(26,859)	(28,184)	(29,565)	(31,004)	(32,504)	(34,068)	(35,700)
Federal Tax Refund (Paid)	(141,118)	(109,652)	(139,229)	(162,383)	(34,482)	(38,986)	(42,562)	(62,009)	(81,574)	(85,647)	(83,726)	(87,952)	(92,354)	(96,942)	(101,723)	(106,707)	(111,901)	(117,316)	(122,962)	(128,850)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(180,217)	(140,032)	(177,805)	(207,374)	(44,035)	(49,788)	(54,354)	(79,189)	(104,175)	(109,377)	(106,923)	(112,320)	(117,942)	(123,801)	(129,907)	(136,271)	(142,905)	(149,820)	(157,031)	(164,550)
Equity Investment (InvestedBeforeProject)	(889,447)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	397,992	450,439	426,973	413,491	135,226	141,810	146,786	131,847	117,122	122,562	116,739	122,192	127,825	133,645	139,658	145,868	152,283	158,908	165,750	221,469

Run 23: Distributed Storage Use Case 2X Regulation Price

Table A-30
Run 23

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	1,491,428	0
Financing Costs (Debt)	803,588	0
Operating Costs	1,560,637	0
Taxes (Refund or Paid)	1,733,230	0
Distribution Investment Deferral	0	1,714,098
Electricity Sales	0	1,025,006
System Electric Supply Capacity	0	1,039,256
Non-synchronous Reserve (Non-spin)	0	36
Synchronous Reserve (Spin)	0	16,382
Frequency Regulation	0	3,748,463
Total	5,588,882	7,543,241

Other Metrics		
Breakeven Capital Costs		
	2015 Nominal	2013 Real***
$/kW*	5520	5306
$/kWh**	1380	1326
Benefit-to-Cost Ratio		1.35
Breakeven Residual Capacity Value		$0
Capacity Factor		33.60%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Electricity Sales	102,089	105,358	109,572	113,955	116,807	124,811	129,803	134,995	140,395	146,011	151,852	157,926	164,243	170,812	177,645	184,751	192,141	199,826	207,819	216,132
Benefit Revenues	906,182	932,908	963,421	997,547	1,054,976	612,211	633,598	655,779	678,788	702,642	727,391	753,062	779,692	807,316	835,975	865,707	896,555	928,560	961,769	996,227
Operating Revenue	1,008,271	1,038,266	1,072,992	1,111,501	1,171,783	737,022	763,402	790,774	819,178	848,654	879,242	910,988	943,934	978,129	1,013,620	1,050,458	1,088,695	1,128,386	1,169,588	1,212,359
Total Revenue	1,008,271	1,038,266	1,072,992	1,111,501	1,171,783	737,022	763,402	790,774	819,178	848,654	879,242	910,988	943,934	978,129	1,013,620	1,050,458	1,088,695	1,128,386	1,169,588	1,212,359
Fixed O&M	(15,000)	(15,300)	(15,606)	(15,918)	(16,236)	(16,561)	(16,892)	(17,230)	(17,575)	(17,926)	(18,285)	(18,651)	(19,024)	(19,404)	(19,792)	(20,188)	(20,592)	(21,004)	(21,424)	(21,852)
Variable O&M	(881)	(895)	(913)	(931)	(941)	(976)	(996)	(1,016)	(1,036)	(1,057)	(1,078)	(1,099)	(1,121)	(1,144)	(1,167)	(1,190)	(1,214)	(1,238)	(1,263)	(1,288)
Charging Costs	(124,564)	(128,933)	(134,090)	(139,454)	(143,331)	(152,170)	(158,257)	(164,588)	(171,171)	(178,018)	(185,139)	(192,544)	(200,246)	(208,256)	(216,586)	(225,249)	(234,259)	(243,630)	(253,375)	(263,510)
Housekeeping Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)
Total Operating Costs	(162,445)	(167,128)	(172,609)	(178,303)	(182,508)	(191,708)	(198,145)	(204,834)	(211,782)	(219,001)	(226,501)	(234,294)	(242,391)	(250,804)	(259,545)	(268,628)	(278,065)	(287,872)	(298,062)	(308,650)
Operating Profit	845,826	871,138	900,383	933,198	989,275	545,314	565,256	585,940	607,396	629,653	652,741	676,693	701,543	727,325	754,075	781,830	810,630	840,515	871,527	903,709
Interest Expense	(92,170)	(89,713)	(87,103)	(84,333)	(81,391)	(78,267)	(74,950)	(71,429)	(67,689)	(63,719)	(59,503)	(55,027)	(50,274)	(45,227)	(39,868)	(34,179)	(28,137)	(21,722)	(14,911)	(7,679)
Loan Repayment Expense (Principal)	(39,766)	(42,223)	(44,833)	(47,603)	(50,545)	(53,669)	(56,986)	(60,507)	(64,247)	(68,217)	(72,433)	(76,909)	(81,662)	(86,709)	(92,068)	(97,757)	(103,799)	(110,214)	(117,025)	(124,257)
Debt Service Reserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	88,463
Interest earned on DSRF	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734
Interest earned on Battery Replacement Fund	28,491	29,371	30,279	31,214	32,179	33,173	34,198	35,255	36,344	37,467	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(100,712)	(99,831)	(98,924)	(97,988)	(97,024)	(96,029)	(95,004)	(93,948)	(92,858)	(91,735)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(40,740)
State Tax Refund (Paid)	(44,119)	(28,618)	(43,890)	(55,958)	(67,555)	(28,691)	(30,820)	(40,956)	(51,165)	(53,582)	(52,684)	(55,197)	(57,814)	(60,539)	(63,377)	(66,334)	(69,414)	(72,623)	(75,966)	(79,451)
Federal Tax Refund (Paid)	(159,237)	(103,289)	(158,411)	(201,969)	(243,825)	(103,552)	(111,236)	(147,821)	(184,667)	(193,393)	(190,151)	(199,221)	(208,666)	(218,502)	(228,747)	(239,418)	(250,534)	(262,116)	(274,184)	(286,760)
Tax Credit - Federal ITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(203,355)	(131,907)	(202,301)	(257,927)	(311,380)	(132,243)	(142,056)	(188,776)	(235,832)	(246,976)	(242,835)	(254,418)	(266,480)	(279,041)	(292,124)	(305,752)	(319,948)	(334,739)	(350,150)	(366,210)
Equity Investment (Invested Before Project)	(1,662,494)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	541,759	639,400	599,159	577,282	580,872	317,042	328,196	303,217	278,706	290,942	280,704	293,073	305,861	319,081	332,748	346,876	361,479	376,573	392,174	496,759

Run 24: Distributed Storage Use Case High Load Growth Rate

Table A-31
Run 24

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	1,491,428	0
Financing Costs (Debt)	803,588	0
Operating Costs	1,228,133	0
Taxes (Refund or Paid)	635,272	0
Distribution Investment Deferral	0	798,665
Electricity Sales	0	977,400
System Electric Supply Capacity	0	1,052,326
Non-synchronous Reserve (Non-spin)	0	70
Synchronous Reserve (Spin)	0	65,333
Frequency Regulation	0	1,622,305
Total	**4,158,421**	**4,516,099**

Other Metrics		
Breakeven Capital Costs		
	2015 Nominal	2013 Real***
$/kW*	2640	2537
$/kWh**	660	634
Benefit-to-Cost Ratio		1.09
Breakeven Residual Capacity Value		$69
Capacity Factor		28.20%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	96,240	100,090	105,501	109,721	114,110	118,674	123,421	128,358	133,492	138,832	144,385	150,160	156,167	162,414	168,910	175,666	182,693	190,001	197,601	205,505
BenefitRevenues	699,669	718,982	272,789	298,242	350,716	361,666	372,992	384,708	396,828	409,369	422,344	435,770	449,663	464,042	478,924	494,328	510,272	526,778	543,866	561,558
Operating Revenue	795,910	819,072	378,290	407,962	464,826	480,340	496,413	513,065	530,320	548,200	566,729	585,930	605,830	626,456	647,834	669,994	692,965	716,779	741,467	767,062
Total Revenue	795,910	819,072	378,290	407,962	464,826	480,340	496,413	513,065	530,320	548,200	566,729	585,930	605,830	626,456	647,834	669,994	692,965	716,779	741,467	767,062
Fixed O&M	(15,000)	(15,300)	(15,606)	(15,918)	(16,236)	(16,561)	(16,892)	(17,230)	(17,575)	(17,926)	(18,285)	(18,651)	(19,024)	(19,404)	(19,792)	(20,188)	(20,592)	(21,004)	(21,424)	(21,852)
Variable O&M	(735)	(750)	(771)	(787)	(803)	(819)	(835)	(852)	(869)	(886)	(904)	(922)	(940)	(959)	(978)	(998)	(1,018)	(1,038)	(1,059)	(1,080)
Charging Costs	(90,788)	(94,419)	(99,277)	(103,248)	(107,378)	(111,673)	(116,140)	(120,786)	(125,617)	(130,642)	(135,867)	(141,302)	(146,954)	(152,832)	(158,946)	(165,303)	(171,915)	(178,792)	(185,944)	(193,382)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)	(22,000)
Total Operating Costs	(128,523)	(132,469)	(137,654)	(141,953)	(146,417)	(151,053)	(155,867)	(160,868)	(166,061)	(171,454)	(177,056)	(182,875)	(188,918)	(195,196)	(201,716)	(208,489)	(215,525)	(222,834)	(230,427)	(238,314)
Operating Profit	667,387	686,603	240,635	266,009	318,409	329,287	340,545	352,198	364,260	376,746	389,673	403,056	416,912	431,260	446,118	461,505	477,440	493,945	511,040	528,749
Interest Expense	(92,170)	(89,713)	(87,103)	(84,333)	(81,391)	(78,267)	(74,950)	(71,429)	(67,689)	(63,719)	(59,503)	(55,027)	(50,274)	(45,227)	(39,868)	(34,179)	(28,137)	(21,722)	(14,911)	(7,679)
Loan Repayment Expense (Principal)	(39,766)	(42,223)	(44,833)	(47,603)	(50,545)	(53,669)	(56,986)	(60,507)	(64,247)	(68,217)	(72,433)	(76,909)	(81,662)	(86,709)	(92,068)	(97,757)	(103,799)	(110,214)	(117,025)	(124,257)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	88,463
Interest earned on DSRF	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734	2,734
Interestearnedon Battery Replacement Fund	28,491	29,371	30,279	31,214	32,179	33,173	34,198	35,255	36,344	37,467	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(100,712)	(99,831)	(98,924)	(97,988)	(97,024)	(96,029)	(95,004)	(93,948)	(92,858)	(91,735)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(129,202)	(40,740)
State Tax Refund (Paid)	(28,345)	(12,305)	14,432	3,021	(8,250)	(9,594)	(10,955)	(20,293)	(29,671)	(31,225)	(29,429)	(31,007)	(32,652)	(34,367)	(36,154)	(38,017)	(39,960)	(41,986)	(44,099)	(46,304)
Federal Tax Refund (Paid)	(102,304)	(44,412)	52,088	10,904	(29,778)	(34,626)	(39,540)	(73,243)	(107,092)	(112,701)	(106,216)	(111,914)	(117,852)	(124,040)	(130,490)	(137,215)	(144,227)	(151,539)	(159,167)	(167,125)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(130,648)	(56,716)	66,520	13,925	(38,028)	(44,220)	(50,495)	(93,536)	(136,763)	(143,926)	(135,645)	(142,922)	(150,504)	(158,407)	(166,644)	(175,232)	(184,187)	(193,526)	(203,266)	(213,429)
Equity Investment (InvestedBeforeProject)	(1,662,494)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	436,027	530,055	208,232	181,946	183,357	189,037	195,046	164,715	134,638	141,085	124,825	130,931	137,205	143,651	150,271	157,070	164,051	171,217	178,571	274,580

Run 26: Distributed Storage Use Case Flow Battery

Table A-32
Run26

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	1,100,759	0
Financing Costs (Debt)	742,319	0
Operating Costs	995,567	0
Taxes (Refund or Paid)	859,163	0
Distribution Investment Deferral	0	1,714,466
Electricity Sales	0	679,268
System Electric Supply Capacity	0	972,094
Non-synchronous Reserve (Non-spin)	0	58
Synchronous Reserve (Spin)	0	93,615
Frequency Regulation	0	1,446,488
Total	**3,697,808**	**4,905,989**

Other Metrics		
Breakeven Capital Costs		
	2015 Nominal	2013 Real***
$/kW*	4200	4037
$/kWh**	1050	1009
Benefit-to-Cost Ratio		1.32
Breakeven Residual Capacity Value		$2
Capacity Factor		20.40%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
ElectricitySales	73,330	75,608	78,632	81,778	83,508	89,739	93,329	97,062	100,944	104,982	109,182	113,549	118,091	122,814	127,727	132,836	138,149
BenefitRevenues	698,386	717,196	739,193	764,488	815,174	359,295	370,534	382,161	394,188	406,632	419,506	432,828	446,614	460,880	475,646	490,928	506,747
Operating Revenue	771,716	792,804	817,826	846,266	898,682	449,034	463,863	479,223	495,133	511,614	528,688	546,377	564,705	583,695	603,373	623,764	644,896
Total Revenue	771,716	792,804	817,826	846,266	898,682	449,034	463,863	479,223	495,133	511,614	528,688	546,377	564,705	583,695	603,373	623,764	644,896
Fixed O&M	(15,000)	(15,300)	(15,606)	(15,918)	(16,236)	(16,561)	(16,892)	(17,230)	(17,575)	(17,926)	(18,285)	(18,651)	(19,024)	(19,404)	(19,792)	(20,188)	(20,592)
Variable O&M	(445)	(451)	(460)	(469)	(474)	(493)	(503)	(513)	(523)	(533)	(544)	(555)	(566)	(577)	(589)	(601)	(613)
Charging Costs	(75,431)	(77,894)	(81,010)	(84,250)	(86,561)	(92,208)	(95,896)	(99,732)	(103,721)	(107,870)	(112,185)	(116,672)	(121,339)	(126,193)	(131,240)	(136,490)	(141,950)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(23,100)	(23,100)	(23,100)	(23,100)	(23,100)	(23,100)	(23,100)	(23,100)	(23,100)	(23,100)	(23,100)	(23,100)	(23,100)	(23,100)	(23,100)	(23,100)	(23,100)
Total Operating Costs	(113,975)	(116,745)	(120,176)	(123,738)	(126,372)	(132,362)	(136,391)	(140,575)	(144,919)	(149,430)	(154,114)	(158,978)	(164,029)	(169,274)	(174,722)	(180,379)	(186,254)
Operating Profit	657,741	676,059	697,650	722,528	772,311	316,672	327,472	338,648	350,214	362,184	374,574	387,399	400,676	414,421	428,651	443,385	458,642
Interest Expense	(68,027)	(65,654)	(63,134)	(60,459)	(57,618)	(54,602)	(51,399)	(47,998)	(44,387)	(40,553)	(36,482)	(32,160)	(27,570)	(22,697)	(17,522)	(12,028)	(6,194)
Loan Repayment Expense	(38,399)	(40,772)	(43,292)	(45,967)	(48,808)	(51,825)	(55,027)	(58,428)	(62,039)	(65,873)	(69,944)	(74,266)	(78,856)	(83,729)	(88,904)	(94,398)	(100,232)
DebtServiceReserve	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	101,518
Interest earned on DSRF	3,137	3,137	3,137	3,137	3,137	3,137	3,137	3,137	3,137	3,137	3,137	3,137	3,137	3,137	3,137	3,137	3,137
Interestearnedon Battery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(103,289)	(103,289)	(103,289)	(103,289)	(103,289)	(103,289)	(103,289)	(103,289)	(103,289)	(103,289)	(103,289)	(103,289)	(103,289)	(103,280)	(103,289)	(103,289)	(1,771)
State Tax Refund (Paid)	(25,880)	(8,774)	(23,900)	(35,618)	(46,879)	(6,885)	(8,105)	(17,691)	(27,312)	(28,709)	(30,165)	(31,680)	(33,260)	(34,906)	(36,621)	(38,409)	(40,274)
Federal Tax Refund (Paid)	(93,408)	(31,667)	(86,262)	(128,554)	(169,197)	(24,851)	(29,251)	(63,852)	(98,578)	(103,620)	(108,872)	(114,344)	(120,044)	(125,984)	(132,176)	(138,630)	(145,359)
Tax Credit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(119,288)	(40,441)	(110,162)	(164,172)	(216,076)	(31,736)	(37,356)	(81,544)	(125,890)	(132,330)	(139,037)	(146,024)	(153,304)	(160,890)	(168,797)	(177,039)	(185,633)
(InvestedBeforeProject)	(1,227,016)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	435,163	532,328	484,199	455,067	452,946	181,647	186,827	153,815	121,034	126,565	132,248	138,086	144,083	150,242	156,565	163,057	271,239

Run 35: Distributed Storage Use Case, 2020 Start Year

Table A-33
Run 35

Net Present Value Over Project Life		
	Cost	Benefit
Capital Expenditure (Equity)	1,360,899	0
Financing Costs (Debt)	718,292	0
Operating Costs	1,351,701	0
Taxes (Refund or Paid)	1,371,114	0
Distribution Investment Deferral	0	1,892,921
Electricity Sales	0	1,131,975
System Electric Supply Capacity	0	1,247,010
Non-synchronous Reserve (Non-spin)	0	53
Synchronous Reserve (Spin)	0	73,971
Frequency Regulation	0	1,881,187
Total	**4,802,006**	**6,227,117**

Other Metrics		
Breakeven Capital Costs		
	2020 Nominal	2013 Real***
$/kW*	4320	3761
$/kWh**	1080	940
Benefit-to-Cost Ratio		1.30
Breakeven Residual Capacity Value		$0
Capacity Factor		28.30%

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
ElectricitySales	112,728	116,236	120,886	125,721	128,625	137,934	143,451	149,189	155,156	161,363	167,817	174,530	181,511	188,772	196,322	204,175	212,342	220,836	229,670	238,856
BenefitRevenues	854,933	865,166	876,143	887,501	897,431	394,375	407,011	420,089	433,626	447,639	462,147	477,166	492,717	508,820	525,494	542,762	560,645	579,167	598,352	618,225
Operating Revenue	967,662	981,403	997,029	1,013,222	1,026,057	532,309	550,462	569,278	588,783	609,002	629,964	651,696	674,229	697,591	721,817	746,937	772,988	800,004	828,022	857,082
Total Revenue	967,662	981,403	997,029	1,013,222	1,026,057	532,309	550,462	569,278	588,783	609,002	629,964	651,696	674,229	697,591	721,817	746,937	772,988	800,004	828,022	857,082
Fixed O&M	(15,000)	(15,300)	(15,606)	(15,918)	(16,236)	(16,561)	(16,892)	(17,230)	(17,575)	(17,926)	(18,285)	(18,651)	(19,024)	(19,404)	(19,792)	(20,188)	(20,592)	(21,004)	(21,424)	(21,852)
Variable O&M	(740)	(751)	(766)	(782)	(789)	(820)	(836)	(853)	(870)	(888)	(905)	(923)	(942)	(961)	(980)	(1,000)	(1,020)	(1,040)	(1,061)	(1,082)
Charging Costs	(106,025)	(109,569)	(113,952)	(118,510)	(121,803)	(129,583)	(134,766)	(140,157)	(145,763)	(151,593)	(157,657)	(163,963)	(170,522)	(177,343)	(184,437)	(191,814)	(199,487)	(207,466)	(215,765)	(224,395)
HousekeepingPower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Fuel Start-Up Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Tax	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)	(19,250)
Total Operating Costs	(141,015)	(144,870)	(149,574)	(154,460)	(158,078)	(166,214)	(171,745)	(177,490)	(183,458)	(189,657)	(196,097)	(202,787)	(209,737)	(216,958)	(224,459)	(232,252)	(240,348)	(248,760)	(257,499)	(266,579)
Operating Profit	826,647	836,532	847,455	858,762	867,979	366,095	378,717	391,788	405,325	419,345	433,867	448,909	464,491	480,634	497,358	514,686	532,640	551,244	570,523	590,502
Interest Expense	(84,104)	(81,861)	(79,480)	(76,952)	(74,267)	(71,417)	(68,391)	(65,177)	(61,765)	(58,142)	(54,295)	(50,211)	(45,874)	(41,269)	(36,379)	(31,187)	(25,675)	(19,821)	(13,606)	(7,007)
Loan Repayment Expense (Principal)	(36,285)	(38,528)	(40,909)	(43,437)	(46,121)	(48,972)	(51,998)	(55,212)	(58,624)	(62,247)	(66,094)	(70,178)	(74,515)	(79,120)	(84,010)	(89,202)	(94,714)	(100,568)	(106,783)	(113,382)
DebtServiceReserve Withdrawal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77,405
Interest earned on DSRF	2,392	2,392	2,392	2,392	2,392	2,392	2,392	2,392	2,392	2,392	2,392	2,392	2,392	2,392	2,392	2,392	2,392	2,392	2,392	2,392
Interestearnedon Battery Replacement Fund	28,491	29,371	30,279	31,214	32,179	33,173	34,198	35,255	36,344	37,467	0	0	0	0	0	0	0	0	0	0
Net Finance Costs	(89,506)	(88,626)	(87,719)	(86,783)	(85,818)	(84,824)	(83,799)	(82,742)	(81,653)	(80,530)	(117,997)	(117,997)	(117,997)	(117,997)	(117,997)	(117,997)	(117,997)	(117,997)	(117,997)	(40,582)
State Tax Refund (Paid)	(46,264)	(31,635)	(43,720)	(52,761)	(59,405)	(15,394)	(16,853)	(25,301)	(33,795)	(35,454)	(33,766)	(35,456)	(37,217)	(39,051)	(40,962)	(42,953)	(45,027)	(47,189)	(49,443)	(51,792)
Federal Tax Refund (Paid)	(166,980)	(114,179)	(157,798)	(190,428)	(214,411)	(55,562)	(60,826)	(91,317)	(121,975)	(127,963)	(121,869)	(127,972)	(134,327)	(140,947)	(147,843)	(155,028)	(162,515)	(170,319)	(178,453)	(186,933)
TaxCredit-FederalITC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Refunded (Paid)	(213,244)	(145,813)	(201,518)	(243,189)	(273,816)	(70,956)	(77,679)	(116,618)	(155,770)	(163,417)	(155,635)	(163,428)	(171,544)	(179,998)	(188,805)	(197,981)	(207,543)	(217,508)	(227,896)	(238,726)
Equity Investment (InvestedBeforeProject)	(1,516,994)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
After-Tax Equity Cash Flow	523,896	602,093	558,219	528,790	508,344	210,315	217,239	192,428	167,902	175,398	160,235	167,484	174,950	182,638	190,556	198,708	207,100	215,739	224,630	311,185

B
DERIVATION OF CAPACITYVALUE USING COMBUSTION TURBINE BENCHMARK

What Is System Capacity Value?

Across the United States, it is common for new combustion turbines to be insufficiently profitable in providing energy ancillary services to recover their capital costs at a sufficient rate of return. However, it is often required for resource adequacy reasons for new capacity resources to be built. This difference between net present value of cost and benefit is often referred to as "missing money."

In California, requirement for additional capacity is identified several years in advance through the Long Term Procurement Proceedings (LTPP) at the CPUC. These proceedings direct investor owned utilities to procure additional capacity resources in a specific timeframe, to support increasing load or generator retirements. As a result of this directive and the insufficient inherent profitability for the generators, utilities may need to provide new generators with a yearly capacity payment to make up for "missing money." To approximate the resulting capacity value required to cause a newly built generator to break even and meet required rate of return, a metric often referred to as Cost of New Entry (CONE) is generated.

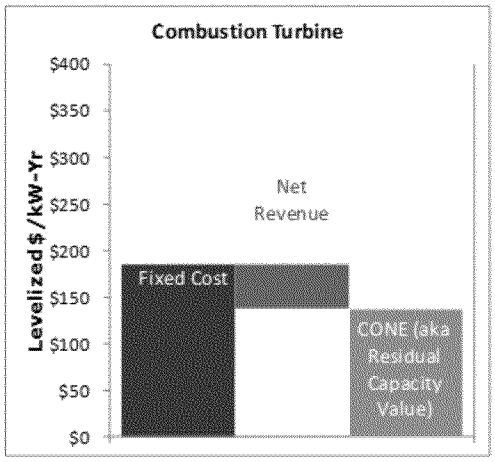

Figure B-1
Illustration of Cost of New Entry (CONE)

Other resources that can provide system capacity include renewable generation, demand response, etc. Energy storage can also provide system capacity but is not currently compensated for because of lack of market mechanism.

Resource Balance Year: Short-Term and Long-Term Capacity Value

It should be noted that currently California has available generation capacity exceeding demand. As a result, there is no system-wide requirement to build new generation for additional capacity (with the exception of some transmission constrained load pockets). The year when California is

roughly expected to require additional generation is 2020, an assumption provided by the CPUC technical staff and core stakeholder group. In the years preceding 2020, it is expected that capacity values would be lower. Therefore, for ESVT runs that begin in 2015, a starting capacity value was estimated by fitting an exponential curve from current year capacity value to the resource balance year.

CONE Calculation

CONE is derived in the Energy Storage Valuation Tool by simulating the operation of a combustion turbine (defined by the CPUC technical staff as LM6000 w/ SPRINT). See Table B-1. The ESVT calculates the annual capacity payment required for the combustion turbine to earn its required return on investment.

Table B-1
LM6000 SPRINT Inputs

CT Input	
System Name	LM6000/SPRINT
Plant life	20
Optimal Efficiency (Heat Rate)	9387
Overnight CapEX	$1619/kW
Variable O&M	$4.1685
Fixed O&M	$17.40
Minimum Operating Level	40.0%
Temperature Derate	105%

Because the CONE value is dependent on generator performance and cost characteristics, as well as the prevailing CAISO market prices, it is necessary to generate a unique CONE for any change in these assumptions. Due to transmission and distribution losses between generation and load, capacity value may be greater for energy storage or distributed generation located at the distribution substation or at the customer. It was roughly estimated in this analysis that due to avoided transmission losses, the substation-sited storage earned an enhanced capacity value by five percent (5%).

The seven (7) CONE scenarios observed, the ESVT runs utilizing them, and the resulting CONE value are summarized in Table B-2.

Table B-2
CONE Value Summary Table by Analysis Run

CONE #	CONE	Run	Notes
1	161	run1	Use Case 1: Base Case
7	165	run1 2010	Use Case 1 Sensitivity: 2010 Ref Year
7	165	run1 2010P4P	Use Case 1 Sensitivity: 2010 Ref Year with P4P regulation prices
2	152	run1 LMS100	Use Case 1:CONE derived with LMS100
6	50	run1 lowCONE	Use Case 1 Sensitivity: low CONE
1	161	run1a	Use Case 1 Sensitivity: 2 Replacements
1	161	run1b	Use Case 1 Sensitivity: No regulation services
1	161	run1c	Use Case 1: higher CapEX assumption
1	161	run1d	Use Case 1: higher variable O&M assumption
1	161	run1e	Use Case 1 Sensitivity: 3 Replacements
1	161	run2	Use Case 1 Sensitivity: 2X Regulation Price
1	161	run3	Use Case 1 Sensitivity: 3 Hour Duration
1	161	run4	Use Case 1 Sensitivity: 4 Hour Duration
3	174.7	run10	Use Case 1 Sensitivity: Market Scenario 1
4	167.7	run11	Use Case 1 Sensitivity: Market Scenario 2
3	174.7	run12	Use Case 1 Sensitivity: Market Scenario 3
4	167.7	run13	Use Case 1 Sensitivity: Market Scenario 4
1	161	run16	Use Case 1 Sensitivity: Flow Battery
1	161	run16a	Use Case 1 Sensitivity: Flow Battery (high variable O&M)
1	161	run17	Use Case 1 Sensitivity: Pumped Hydro
1	161	run18	Use Case 1 Sensitivity: CAES
N/A	N/A	run19	Use Case 2: Ancillary Service Only
1	161	run20	Use Case 1 Sensitivity: Project Start Year 2015
1	161	run21	Use Case 1 Sensitivity: Project Start Year 2015 with P4P regulation prices
5	169.05	run22	Use Case 3: Base Case
5	169.05	run22no reg	Use Case 3 Sensitivity: No regulation
5	169.05	run22b	Use Case 3 Sensitivity: 2 Hour Duration
5	169.05	run23	Use Case 3 Sensitivity: 2X P4P regulation prices
5	169.05	run24	Use Case 3 Sensitivity: High Load Growth Rate
5	169.05	run26	Use Case 3 Sensitivity: Flow Battery
5	169.05	run35	Use Case 3 Sensitivity: Project Start Year 2020

Alternative Methods of Determining CONE Value

The calculation of CONE value is under the assumption that a "new entry" would be necessary in the resource balance year. In another situation, when growth in renewable generation offsets load growth, it may be possible to use mothballed generators to serve as reserve capacity for occasional usage during peak times. In this case, rather than basing capacity value on recovering fixed investment in new generator, it may be based more on a much lower fixed O&M value of keeping those generators on. Alternatively, in the situation where there are enough demand response to provide capacity value in 2020, this will significantly lower demand for generators to provide capacity, thus reducing CONE. To capture part of the uncertainties about CONE value, a case with a "low CONE" escalated from the 2011 system capacity value was done as sensitivity.

Validation of ESVT-Derived CONE

Previously, in the draft results of the analysis provided at the March 25, 2013, public workshop at the CPUC, results were based upon an externally derived CONE value from the "E3 DER Avoided Cost Calculator."[5] At the time, the ESVT was not able to generate CONE for a CT with sufficient fidelity. The disadvantage of using the externally derived CONE was inflexibility to generate new CONE values based on different market scenarios and turbine technologies. The CONE value used in the draft results was $155/kW-yr, compared with $161/kW-yr for the

ESVT-derived CONE value for the base case. The difference between the two is only 3-4%, well within the margin of error expected for this type of analysis. The investigators found it important to capture the impact of market scenario changes on the CONE value and maintain the key relationship between generator capital costs, market benefits, and CONE.

Capacity Derate

At this stage, the capacity value for a conventional generator has been determined for every run in the analysis. However, when the capacity value for energy storage is being estimated, the limited duration of the resource should be accounted for, when attempting to compare storage side-by-side in its ability to provide capacity service equivalent to a CT. The ESVT model estimates this impact through a derating of the CT capacity value (based on CONE). This derating is accomplished by multiplying the capacity value by [(# of capacity hours available) / (# of total capacity hours)]. This method is not accepted by PUC's to estimate capacity value for limited energy resources, but it serves to estimate impact and capture a relationship between storage duration and capacity value. Capacity value of limited duration resources may be an important area of research looking forward.

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 also provides technology, policy and economic analyses to drive long-range research and development planning, and supports research in emerging technologies. EPRI's members represent approximately 90 percent of the electricity generated and delivered in the United States, and international participation extends to more than 30 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

3002001162

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