Case Studies on the Future of Regulated Electric Utilities in the US:

The Impact of Distributed Generation on the Financial Viability of PSE&G and Southern California Edison in 2030

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Abbreviations

FERC - Federal Energy Regulatory Commission

IOU – Investor Owned Utility

kW - Kilowatts

kWh - Kilowatt Hours

LCOE - Levelized Cost of Energy

MHI - Median Household Income

PGP - Pseudo Grid Parity

PSE&G - Public Service Electric Gas and Company

RR - Revenue Requirement

RMI - Rocky Mountain Institute

SCE - Southern California Edison

T&D - Transmission and Distribution

See Section 3B For Definitions

Nothing in this paper is intended to provide investment or other advice. All discussions about the future of PSE&G and Southern California Edison are based on a number of hypothetical scenarios.

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I. Introduction

Regulated utilities in the United States largely operate under a business model that dates back to the late 1800's. These private companies (investor owned utilities or "IOU"), non-profits, and governmental entities engage in three primary activities related to electricity (though many utilities also provide gas related services): Generation, transmission, and distribution of electric power to residential, commercial, industrial customers, public entities (lighting), and others. Power *generation* involves converting mechanical and chemical energy into electricity. Examples include power plants that utilize fossil fuels, nuclear materials, and hydropower. Power *transmission* refers to the transportation of electricity at high voltages across large distances. Power *distribution* is the last step before electricity reaches retail customers, and involves sending power over the local grid. Some utilities often referred to as "regulated" utilities do not own any power generation, and engage solely in the transmission and distribution ("T&D") of electricity. Others are vertically integrated in all three activities. Due to the deregulation of the power industry, which began in the 1970's, some states prohibit vertical integration, while some jurisdictions sit in a grey area.

While the basic structure and three key activities of the power industry have remained relatively unchanged for a century, over the last decade the United States has seen a minor shift from centralized power generation to small scale production ("distributed generation"). On a relative basis, there has been tremendous growth in consumer use of distributed generation, largely attributable to photovoltaic cells (also referred to as "solar power"), which convert sunlight into electricity. Inexpensive natural gas and technological advancement has also allowed for cost effective, small natural gas plants. David Crane, the President and CEO of NRG Energy, a Fortune 250 company, stated that elements such as green energy and cheap natural gas [as it relates to distributed generation] are “a mortal threat to the existing utility system” (qtd. In Martin, Chris, Mark Chediak, and Ken Wells)[i]. As distributed generation continues to decrease in cost driven by technology and government regulations, utilities face threats from declining revenue attributed to various customer types. The diminishing income will first impact generation activities, but may ultimately affect transmission and distribution businesses if customers combine solar with storage to completely move off of the power grid.

The cost of solar power has declined significantly over the last two decades and is expected to continue this trend. Due to the “clean” nature of solar power, both Federal and State governments have offered strong incentives for the purchase of solar power equipment (though some State incentives have expired). For example, the United States Government allows for a 30% tax credit, while states offer various incentives. These tax rebates helped drive adoption of solar power and in turn technological advancement, leading to an annual price decline of 6%-7% on average from 1998-2013 and 12%-15% from 2013-2014[ii]. In certain locations outside of the United States, such as Germany, the cost of electricity produced by distributed solar is competitive with the price charged by utilities[iii]. Nonetheless, solar power represented less than 1% of US net generation in 2014 (US Energy Information Administration)[iv].

Unlike solar power, energy storage (for sizes relevant to primary power supply) is very expensive. The most likely technology to be currently used in off-grid systems is based on Lithium Ion, which is similar to the batteries used in laptops, cell phones, and Tesla electric vehicles. While the price of these batteries has decreased significantly over recent years (over 26% a year 2009-12 on a per Kwh basis according to Navigant)[v], they are prohibitively expensive for most customers use in an off-grid system. However, in the outlier state Hawaii, the extremely high cost of grid power (3x-4x the national average)[vi] has made the cost of leaving the grid economic for commercial customers.

Due to the cost of energy storage, virtually all existing distributed solar in the US can be attributed to customers who are still connected to the grid. Many locales have “net metering” rules that enable consumers to subtract the power generated by their solar arrays from bill totals. Other jurisdictions require utilities to provide a payment to customers for their photovoltaic production through “feed in tariffs”. Some large utility customers are already exploring the use of independent renewable energy farms as well. Apple invested in an $850 million solar farm to power their headquarters[vii].

Overall, utilities face financial threats from solar power, along with other forms of distributed generation, including small wind farms and cogeneration natural gas plants such as the one owned by New York University located under the Courant Building. The future of distributed generation is unclear, however, and it should be noted that continued adoption faces many headwinds. Certain government incentives for solar installations are set to expire in 2016. Furthermore, the political environment is very volatile for clean energy and climate change, particularly with the lobbying strength of utilities.

II. Background

a. Purpose

As grid-connected distributed solar grows, generation businesses will be impacted due to lessened consumer demand. Distribution costs may go up marginally as the grid will likely require infrastructure improvements to support the intermittent nature of solar power (though these costs are not factored into this analysis). However, the true threat to distribution utilities comes from customers disconnecting from the grid. The question has been raised whether the current utility business model will maintain its viability.

This analysis is in response to that question, and seeks to determine what level of decline in the cost of off-grid distributed generation would result in the aforementioned business model issue. This paper intends to stress test the non-generation business lines of Public Service Electric and Gas Company and Southern California Edison with varying magnitudes of decline in the cost of off-grid generation (along with various projections of each utilities' expenses). The stress tests are performed twice, first with the assumption that current incentives are held at the current level through 2030, and then without the incorporation of public subsidies. This analysis utilizes some relatively optimistic assumptions for each utility in order to look at worst case scenarios, such as the assumption that the utilities can divest generation obligations along with debt, and investment returns are foregone. The results from this paper in reveal the relative impact of each utility's service area, infrastructure characteristics, and organizational costs on each company's financial vulnerability to off-grid distributed generation. The off-grid solution considered herein for retail customers is a system that combines photovoltaic arrays with battery storage.

b. Relevant Work

Studies have looked at the projected decline in the cost of solar power and energy storage, and projections for solar power adoption. Credit ratings reports for utilities discuss the potential impact of grid connected solar arrays. Additionally, The **Rocky Mountain Institute (“RMI”)** published an impressive study entitled ***“The Economics of Grid Defection”***[iv], which examined the cost of leaving the grid using photovoltaic arrays combined with lithium ion battery storage for multiple locations including Westchester County and Los Angeles. The RMI report included the incorporation of Federal subsidies, and also projected the future cost of utility power to determine the year for grid parity (when the cost of being off the grid equals the total cost of being on the grid). RMI calculated multiple cases for the decline in the cost of leaving the grid, and bases the system specifications on a specified level of electricity consumption.

This paper leverages the outputs from the RMI study, by using the calculated cost of off-grid generation in Westchester County and Los Angeles (as found on pages 29, 31, 56, 59, 62, and 65 of the RMI report) as proxies for PSE&G and SCE service territories respectively. The costs are also adjusted to reflect the price without any subsidies in one of the scenarios[1]. The analysis herein differs from existing work by considering the following topics:

- The scenario analysis explores the utilities’ financial viability based on various assumed declines in the cost of off-grid generation, rather than determining an expected decline in cost of leaving the grid. Additionally, the revenues earned from customers represent minimum required funds for the utilities to continue operations.
- The analysis takes annual utility price changes into account. Due to the regulatory environment and utility fixed costs, one would expect a decline in customer base to

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[1] The upfront costs are increased by 30% to reflect the elimination of Federal incentives

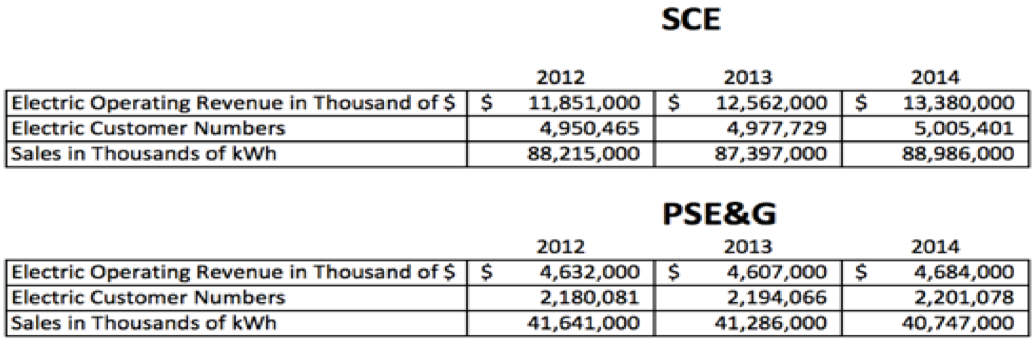
cause higher consumer prices, which in turn accelerates customer departure from the grid, leading to what some call the "snowball effect". Simply put, as customers leave the grid the utility will have to allocate the total costs to fewer customers, who are then more likely to leave the grid.

- The impact of subsidies is reviewed.

c. Background on PSE&G and SCE

- Public Service Electric and Gas ("PSE&G") is an IOU based in New Jersey with electricity and natural gas services, and is a subsidiary of Public Service Enterprise Group ("PSEG"). As of 2014 PSE&G also manages the electric grid on Long Island for the Long Island Power Authority, but those operations are excluded for the purpose of this paper. Additionally, all gas related business lines are excluded from the analysis. PSE&G has negligible generation assets and obligations, but operates significant electrical transmission infrastructure. With around two million electric customers, PSE&G's service area spans a significant portion of New Jersey with 2,600 square miles[viii] [ix].
- Southern California Edison ("SCE") is an IOU based in California with electricity services, and is the largest subsidiary of Edison International. SCE has generation, transmission, and distribution business lines. The company's almost five million customers and 50,000 square mile service territory represent a significant portion of Southern California[x, xi].

Table 1



SCE

	2012	2013	2014
Electric Operating Revenue in Thousand of $	$ 11,851,000	$ 12,562,000	$ 13,380,000
Electric Customer Numbers	4,950,465	4,977,729	5,005,401
Sales in Thousands of kWh	88,215,000	87,397,000	88,986,000

PSE&G

	2012	2013	2014
Electric Operating Revenue in Thousand of $	$ 4,632,000	$ 4,607,000	$ 4,684,000
Electric Customer Numbers	2,180,081	2,194,066	2,201,078
Sales in Thousands of kWh	41,641,000	41,286,000	40,747,000

ix, xii

d. Potential Causes Of Price Reduction For Off-Grid Distributed Generation

While photovoltaic arrays have enjoyed rapid cost declines over recent years, solar technology has been around for decades. Additionally, the limited amount of solar radiation per area creates another headwind for some of the more drastic price reduction scenarios. Nonetheless, with movement on the experience curve and (more importantly) the possibility for new types of solar technologies the costs could see significant declines. The cost of off-grid generation also includes installation costs, which can drop as installation numbers increase.

Lithium Ion batteries have similarly benefitted from recent strong cost reductions, but likely will not follow a sharp move downward represented by some scenarios in this analysis. However, energy storage has garnered significant attention in recent years and the promise of new breakthrough technologies could drastically change the cost for energy storage.

e. Potential Causes Of Utility Fixed Cost Changes

Large annual expense increases could result from aging infrastructure or extraordinary events (e.g. natural disasters). RMI’s study cites numbers on page 22 from Ceres and the Brattle

Group that assert the US utility industry must accelerate investment relative to historical levels in order to simply maintain the aging infrastructure, leading to a doubling of net plant investment from 2010-2030[iv].

Conversely, it is possible that the 2014 RR represents a cost level above that of stressed scenario operations. When utilities receive regulator approval to pursue projects it enables investment returns built into the rates. Accordingly, utilities are likely incentivized to pursue capital expenditures that may not be needed in the event of a stressed scenario. Additionally, transmission projects approved by FERC are often intended to increase reliability and the integrity of the nationwide transmission system. These expenditures may be pared if utilities became distressed. Lastly, it is worth considering that with fewer customers the required level of investment for each utility could decline. However, when customers leave the grid the utilities cannot necessarily shrink their overall infrastructure.

f. Implications Of Utility Business Model Failure

It is unclear what would happen if utilities could not earn sufficient revenue to continue operating. As long as utilities maintain a customer base, and the electric grid and transmission lines are considered a public good, the infrastructure would presumably be maintained. When municipalities default, a solution is usually reached through court and government involvement. This paper already assumes in the analysis that debt can be restructured, extinguished, or subsidized by a public entity. Accordingly, a revenue shortfall might necessitate nationalization of the utility, or a takeover by another public entity that can operate the infrastructure at a loss. Other solutions may include drastically different business models, such as the utility divesting parts of the grid to communities to be used in cooperative micro-grids, or selling transmission lines to the Federal government.

g. Secondary Implications Of The Analysis

- Implication 1: The Proliferation of Off-Grid Distributed Generation Will Incur Social Costs- Assuming that low income individuals are more likely to represent low electricity consumption individuals in multi-unit buildings, the increase in transmission and distribution costs per customer will disproportionately affect the low income group. These customers appear most likely to stay on the grid and therefore bear the burden of grid defectors. Interestingly, residential units may see declines in property value and rent as well, as is discussed in the next paragraph regarding commercial properties.
- Implication 2: Certain Commercial Property Values May Decline - Aside from leaving the grid, commercial customers can also simply leave their building. This provides an interesting implication. If the majority of commercial customers in a service area have the ability to leave the grid, the remaining on-grid businesses (in tall, multi-unit, commercial buildings) that cannot defect would have to pay higher electricity costs. As these costs escalate, the buildings would become less attractive to tenants and may suffer increasing vacancies and declining market value.

III. Methodology

All projected numbers are real not nominal (and therefore are adjusted for inflation).

a. Key Inputs And Variables For Each Utility's Models

- **Input:** *Base Year (2014) Revenue Requirement*
- **Variable:** *Annual Change In Revenue Requirement*
- **Variable:** *Annual Change In Cost of Off-Grid Distributed Generation*

b. Definitions And Explanations Of Acronyms

- **Revenue Requirement** ("***RR***") **–** For this paper the calculated and projected RR are understood to be calculated as the costs of relevant ongoing operations.
- **Earned Revenue** is the amount of revenue that each utility can earn in a given year. It will never exceed the RR.
- **Pseudo grid parity** ("***PGP***") will represent the point at which the cost of leaving the grid is equal to *only* the cost of grid generated power (does not include transmission and distribution costs). Grid parity as it is normally used refers to the point where off-grid LCOE is equal to the total customer cost paid to utilities.
- **Kilowatts** ("**kW**") and **kilowatt hours** ("**kWh**"). kW represents the electricity demanded at any given time while kWh is a measure of usage over time.
- **The Levelized Cost of Electricity** ("**LCOE**") is a measure of cost, and is used interchangeably with the "cost of off-grid distributed generation" or the "cost of off-grid generation" or "cost of an off-grid system" or "the cost of leaving the grid". All phrases are equivalent. For off-grid systems, the LCOE is calculated by taking the total

net present value of costs associated with a system over its life and dividing by the total kWh produced.

- **Retail Customers** represent all customers of a utility that fall under one of the below described customer groups (residential, commercial, industrial, public lighting, and agricultural).
- **Residential Customers** are occupants of residential property including houses, apartments, and condominiums.
- **Commercial and Industrial Customers** are businesses, with the level of usage (often determined by peak demand) segregating the two groups.
- **Public or Public Lighting Customers** usually represent street lighting in municipalities.
- **Agricultural Customers** are consumers whose primary use of electricity is related to agricultural or water pumping services. PSE&G does not have agricultural customers.
- **Transmission and Distribution** (**“T&D”)** refer to non-generation related costs or prices.

c. How Utilities Determine Customer Rates

Utilities charge retail buyers for electricity usage at a publicly regulated rate usually overseen by a state level public commission and the Federal Energy Regulatory Commission (“FERC”) for transmission related rates. These rates are calculated though numerous methods depending on the state, and are often a point of contention between utilities and regulators. The process seeks to assign approved utility costs to retail customer classes based on their relative contribution to the total. Additionally, IOU are allowed to earn a designated rate of return on a rate base, which is effectively the asset base. Charges for generation are designated on a dollar per kWh basis, while transmission and distribution rates can be also be devised on a dollar per kWh assignment or on a fixed basis. Some consumers are also charged based on peak demand kW. For the purposes of this analysis, all transmission and distribution charges are simplified into fixed prices because the utilities set rates based on a total dollar amount of revenue collection.

The costs of managing a transmission system are covered by both retail customers and other utilities that pay to utilize the transmission lines at rates set by FERC.[xxxix]

d. Key Assumptions

The model incorporates a few key assumptions on the power industry in future years, listed below. *For a more detailed discussion of the assumptions please see Appendix B.*

- As PSE&G and SCE become stressed they can and will reallocate most costs among different customer groups on a timely basis. This assumption is mostly reasonable (but also optimistic), because under a stress scenario the regulators, the primary impediments of prompt reallocation of costs, would ensure that adjustments are made to preserve the utility.
- As PSE&G and SCE become stressed the regulators and courts would allow utilities to divest power generation assets and obligations, along with debt. Similar to financial distress of cities and other municipalities, the US political and judicial system would likely allow drastic action to preserve an entity that is needed by the public (optimistic depending on severity of distress).
- Retail customers will continue to pay their current share of the transmission costs.
- Adoption of off-grid systems will not be limited by capital costs due to the availability of financing and leasing options. Solar leasing companies have grown rapidly in recent

years, with SolarCity reporting a cumulative 260,000 customers as of Q2 2015 and adding 44,900 in just that quarter[xiii]. Accordingly, the availability of financing and leasing is likely a reasonable assumption.

- Adoption of off-grid systems will not be limited by supply chain concerns including material availability or production capacity.
- Consumers will perform annual comparisons between their electricity bills on the grid (over the last year) and the cost of leaving the grid. The difference in pricing and demand elasticity will prompt certain consumers to leave the grid. This is discussed further in parts “g” and “h” of the Methodology section, and in Appendix B.

e. Other Assumptions and Calculations

Detailed explanations of these assumptions are included in Appendix B.

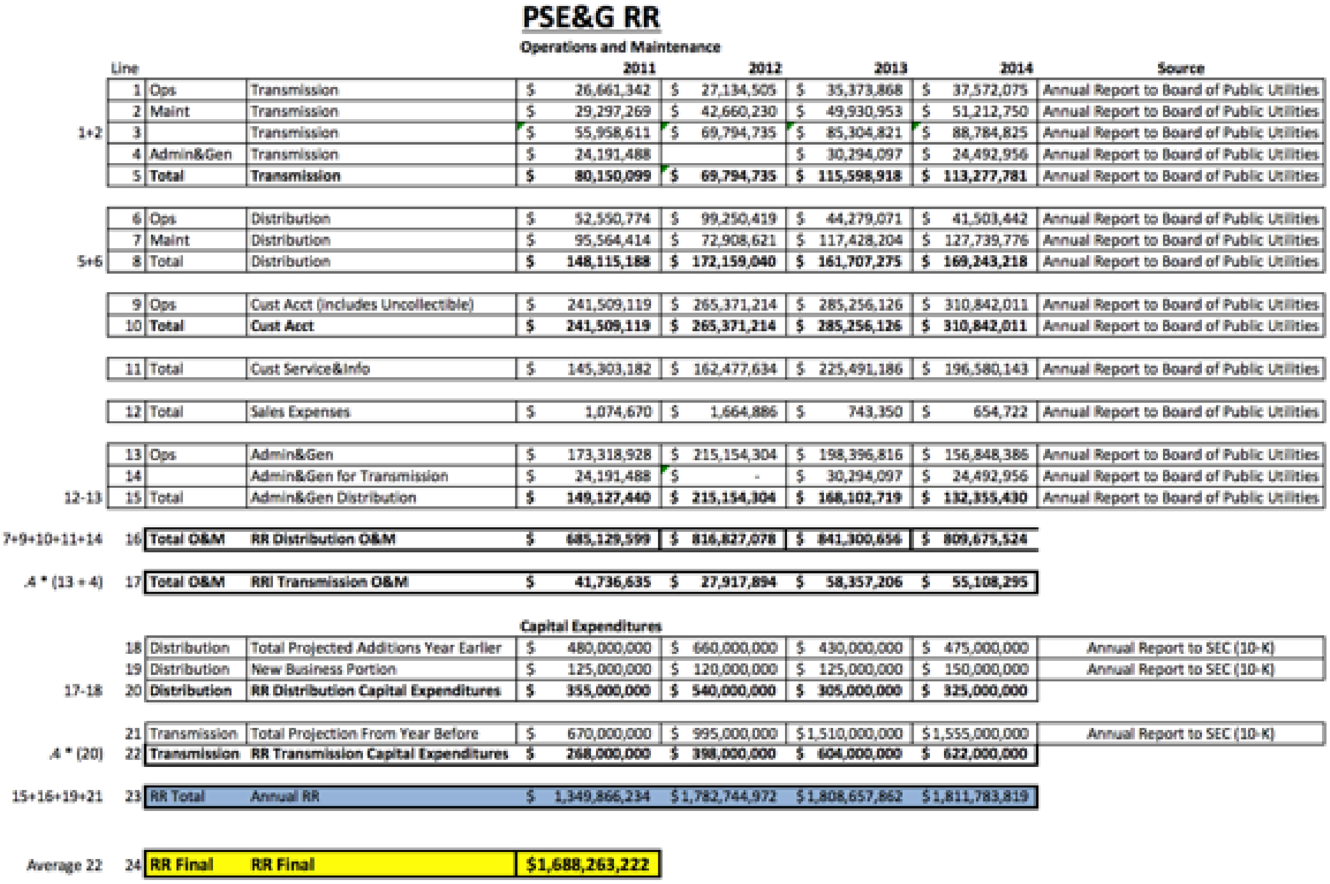
- Residential customers in buildings with at least three units cannot leave the grid. These customers are assumed to be the lowest power usage consumers.
- Residential customers would benefit from political limitations on rates equal to 4.5% of the customers’ median household income.
- All commercial and agricultural customers can leave the grid.
- Industrial customers cannot leave the grid but have a ceiling on revenue per customer.
- Public lighting customers cannot leave the grid but have a ceiling on revenue per customer.
- In RMI’s “Grid Defection” report, the Westchester and Los Angeles LCOE represent the off-grid LCOE for PSE&G’s and SCE’s service areas respectively.
- The off-grid LCOE cannot drop below the on-grid cost of power generated for each customer class (which excludes transmission and distribution costs for on-grid power).

- The cost of leaving the grid declines according to a L-Curve based on an assumed average decline over 15 years, or until the minimum cost level is reached.
- The distribution of usage among residential consumers is based on property valuations in the case of PSE&G, and for SCE zip-code level usage data provided by SCE.
- The distribution for commercial consumers for PSE&G is based on the number of employees among establishments, while the projections for SCE (also applied to Agricultural customers) are based on zip-code level usage data provided by SCE.
- The MHI for each case was the state level figure reported by the US Census Bureau.
- MHI is expected to increase 2% annually.
- The MHI in any given year is adjusted based on the change in customer profile over the time period (the residential customer numbers skew more towards low income over time because the lowest usage/multi-unit individuals cannot leave the grid).
- The demand elasticity of consumers in response to a change in the price of electricity can be approximated using the values calculated in the report by the National Energy Research Laboratory's entitled "Regional Differences in the Price-Elasticity of Demand for Energy". Further discussion of the demand elasticity is provided in part h of this Methodology section.
- The cost of grid power for residential and commercial customers was calculated by dividing the total kWh sold by the total cost of power paid by the Utility, and making slight modifications based on average power costs paid in the State as calculated by the US Energy Information Administration.
- The cost of grid power remains flat on a real basis through 2030, because the analysis focuses on the relative cost of grid power to off-grid power, and does not seek to make detailed projections on the change in grid generation over time.

- For residential customers, the lower usage customers cannot leave the grid until two years after the higher usage consumers begin defection.
- Costs associated with property taxes are not included in the calculations.
- The Federal tax credit can be utilized for its full value.

f. Calculation Of Base Year Revenue Requirement:

Table 2



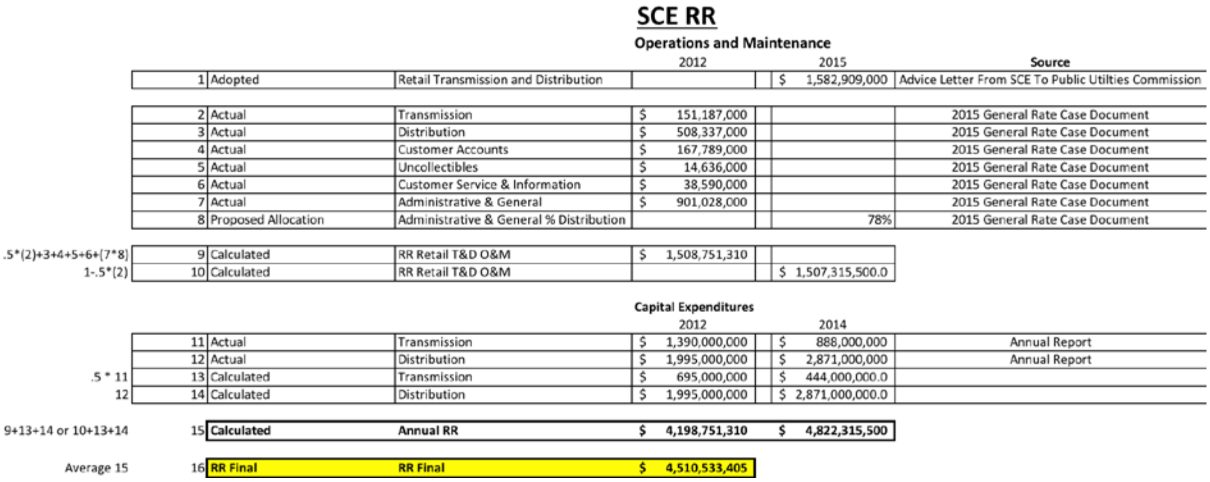
PSE&G RR

Operations and Maintenance

	Line			2011	2012	2013	2014	Source
	1	Ops	Transmission	$ 26,661,342	$ 27,134,505	$ 35,373,868	$ 37,572,075	Annual Report to Board of Public Utilities
	2	Maint	Transmission	$ 29,297,269	$ 42,660,230	$ 49,930,953	$ 51,212,750	Annual Report to Board of Public Utilities
1+2	3		Transmission	$ 55,958,611	$ 69,794,735	$ 85,304,821	$ 88,784,825	Annual Report to Board of Public Utilities
	4	Admin&Gen	Transmission	$ 24,191,488		$ 30,294,097	$ 24,492,956	Annual Report to Board of Public Utilities
	5	**Total**	**Transmission**	**$ 80,150,099**	**$ 69,794,735**	**$ 115,598,918**	**$ 113,277,781**	Annual Report to Board of Public Utilities
	6	Ops	Distribution	$ 52,550,774	$ 99,250,419	$ 44,279,071	$ 41,503,442	Annual Report to Board of Public Utilities
	7	Maint	Distribution	$ 95,564,414	$ 72,908,621	$ 117,428,204	$ 127,739,776	Annual Report to Board of Public Utilities
5+6	8	Total	Distribution	**$ 148,115,188**	**$ 172,159,040**	**$ 161,707,275**	**$ 169,243,218**	Annual Report to Board of Public Utilities
	9	Ops	Cust Acct (includes Uncollectible)	$ 241,509,119	$ 265,371,214	$ 285,256,126	$ 310,842,011	Annual Report to Board of Public Utilities
	10	**Total**	**Cust Acct**	**$ 241,509,119**	**$ 265,371,214**	**$ 285,256,126**	**$ 310,842,011**	Annual Report to Board of Public Utilities
	11	Total	Cust Service&Info	$ 145,303,182	$ 162,477,634	$ 225,491,186	$ 196,580,143	Annual Report to Board of Public Utilities
	12	Total	Sales Expenses	$ 1,074,670	$ 1,664,886	$ 743,350	$ 654,722	Annual Report to Board of Public Utilities
	13	Ops	Admin&Gen	$ 173,318,928	$ 215,154,304	$ 198,396,816	$ 156,848,386	Annual Report to Board of Public Utilities
	14		Admin&Gen for Transmission	$ 24,191,488	$ -	$ 30,294,097	$ 24,492,956	Annual Report to Board of Public Utilities
12-13	15	Total	Admin&Gen Distribution	**$ 149,127,440**	**$ 215,154,304**	**$ 168,102,719**	**$ 132,355,430**	Annual Report to Board of Public Utilities
7+9+10+11+14	16	**Total O&M**	**RR Distribution O&M**	**$ 685,129,599**	**$ 816,827,078**	**$ 841,300,656**	**$ 809,675,524**	
.4 * (13 + 4)	17	**Total O&M**	**RRI Transmission O&M**	**$ 41,736,635**	**$ 27,917,894**	**$ 58,357,206**	**$ 55,108,295**	
			Capital Expenditures					
	18	Distribution	Total Projected Additions Year Earlier	$ 480,000,000	$ 660,000,000	$ 430,000,000	$ 475,000,000	Annual Report to SEC (10-K)
	19	Distribution	New Business Portion	$ 125,000,000	$ 120,000,000	$ 125,000,000	$ 150,000,000	Annual Report to SEC (10-K)
17-18	20	**Distribution**	**RR Distribution Capital Expenditures**	**$ 355,000,000**	**$ 540,000,000**	**$ 305,000,000**	**$ 325,000,000**	
	21	Transmission	Total Projection From Year Before	$ 670,000,000	$ 995,000,000	$1,510,000,000	$1,555,000,000	Annual Report to SEC (10-K)
.4 * (20)	22	**Transmission**	**RR Transmission Capital Expenditures**	**$ 268,000,000**	**$ 398,000,000**	**$ 604,000,000**	**$ 622,000,000**	
15+16+19+21	23	RR Total	Annual RR	$ 1,349,866,234	$1,782,744,972	$1,808,657,862	$1,811,783,819	
Average 22	24	**RR Final**	**RR Final**	**$1,688,263,222**				

xiv, xv, xvi , xvii, xviii, xix, xx, xxi

Table 3



SCE RR

Operations and Maintenance

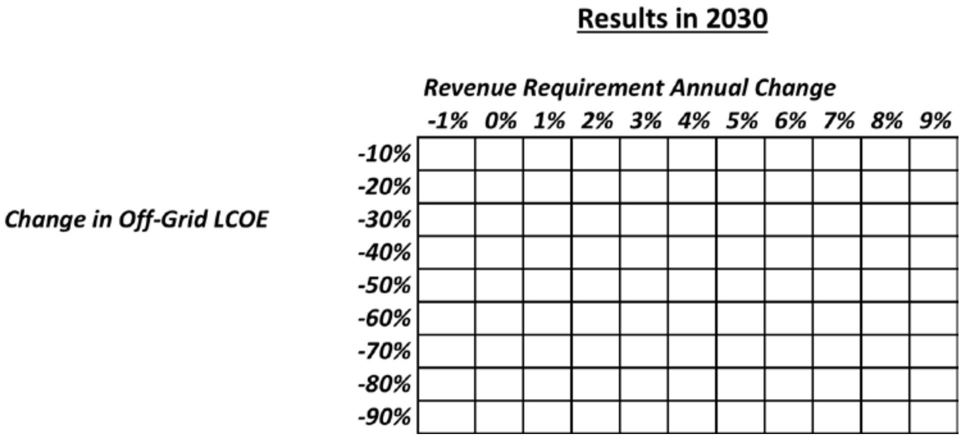
				2012	2015	Source
	1	Adopted	Retail Transmission and Distribution		$ 1,582,909,000	Advice Letter From SCE To Public Utilties Commission
	2	Actual	Transmission	$ 151,187,000		2015 General Rate Case Document
	3	Actual	Distribution	$ 508,337,000		2015 General Rate Case Document
	4	Actual	Customer Accounts	$ 167,789,000		2015 General Rate Case Document
	5	Actual	Uncollectibles	$ 14,636,000		2015 General Rate Case Document
	6	Actual	Customer Service & Information	$ 38,590,000		2015 General Rate Case Document
	7	Actual	Administrative & General	$ 901,028,000		2015 General Rate Case Document
	8	Proposed Allocation	Administrative & General % Distribution		78%	2015 General Rate Case Document
.5*(2)+3+4+5+6+(7*8)	9	Calculated	RR Retail T&D O&M	$ 1,508,751,310		
1-.5*(2)	10	Calculated	RR Retail T&D O&M		$ 1,507,315,500.0	
				Capital Expenditures		
				2012	2014	
	11	Actual	Transmission	$ 1,390,000,000	$ 888,000,000	Annual Report
	12	Actual	Distribution	$ 1,995,000,000	$ 2,871,000,000	Annual Report
.5 * 11	13	Calculated	Transmission	$ 695,000,000	$ 444,000,000.0	
12	14	Calculated	Distribution	$ 1,995,000,000	$ 2,871,000,000.0	
9+13+14 or 10+13+14	15	**Calculated**	**Annual RR**	**$ 4,198,751,310**	**$ 4,822,315,500**	
Average 15	16	**RR Final**	**RR Final**	**$ 4,510,533,405**		

xxii, xxiii, xxiv, xxv

g. The Model And Its Output

The results of the analysis are a snapshot of PSE&G's and SCE's profiles in 2030. There are four models, two for each utility (one including subsidies and one without), though they all operate under similar methodology. The model iterates through each combination of an assumed decline in the cost of off-grid systems coupled with an assumed change in the utility Revenue Requirement. The empty grid below provides an illustration:

Table 4



Results in 2030

		Revenue Requirement Annual Change										
		-1%	***0%***	***1%***	***2%***	***3%***	***4%***	***5%***	***6%***	***7%***	***8%***	***9%***
	-10%											
	-20%											
Change in Off-Grid LCOE	***-30%***											
	-40%											
	-50%											
	-60%											
	-70%											
	-80%											
	-90%											

As this grid shows, the model will provide a snapshot for each utility in 2030 after iterating through 99 scenarios – each box represents a different combination of assumptions (and therefore different scenario). In the top left box (intersection of -1% RR / -10% off-grid LCOE) the model will show how a utility performs in 2030 if the utility's Revenue Requirement decreased by 1% annually through 2030 and the off-grid LCOE declined by 10% annually through 2030 (or until the off-grid LCOE equals the minimum – the cost of on-grid power generation). The base year off-grid LCOE is sourced from the Rocky Mountain Institute Report.

To reach the 2030 results, the model will make a number of calculations for each year to determine the Earned Revenue, the size in dollars of customer electric bills, customer numbers, and how many leave the grid each year). The customer bills are calculated by allocating the Revenue Requirement to consumers using ratios from the base year, and the model reallocates the utility's costs each year. The number of customers who leave the grid in any year is determined by comparing a customer's previous year electric bill with the cost (annualized) that would be incurred from of an off-grid system. If a customer could pay less with an off-grid system[2], then the consumer is added to a pool of those who may leave the grid. The actual number of customers who leave the grid in that year will be a percentage of the pool, and is based on demand elasticity.

For every year, there are tests in place for residential, industrial, and public lighting customers to ensure that the bill per customer does not exceed certain maximums. Residential customers cannot pay more than 4.5% of their median household income, while industrial and public lighting consumers will not pay more than 2x and 2.5x respectively of their share of revenues (calculated from the base year) of the most recent year's Earned Revenue.

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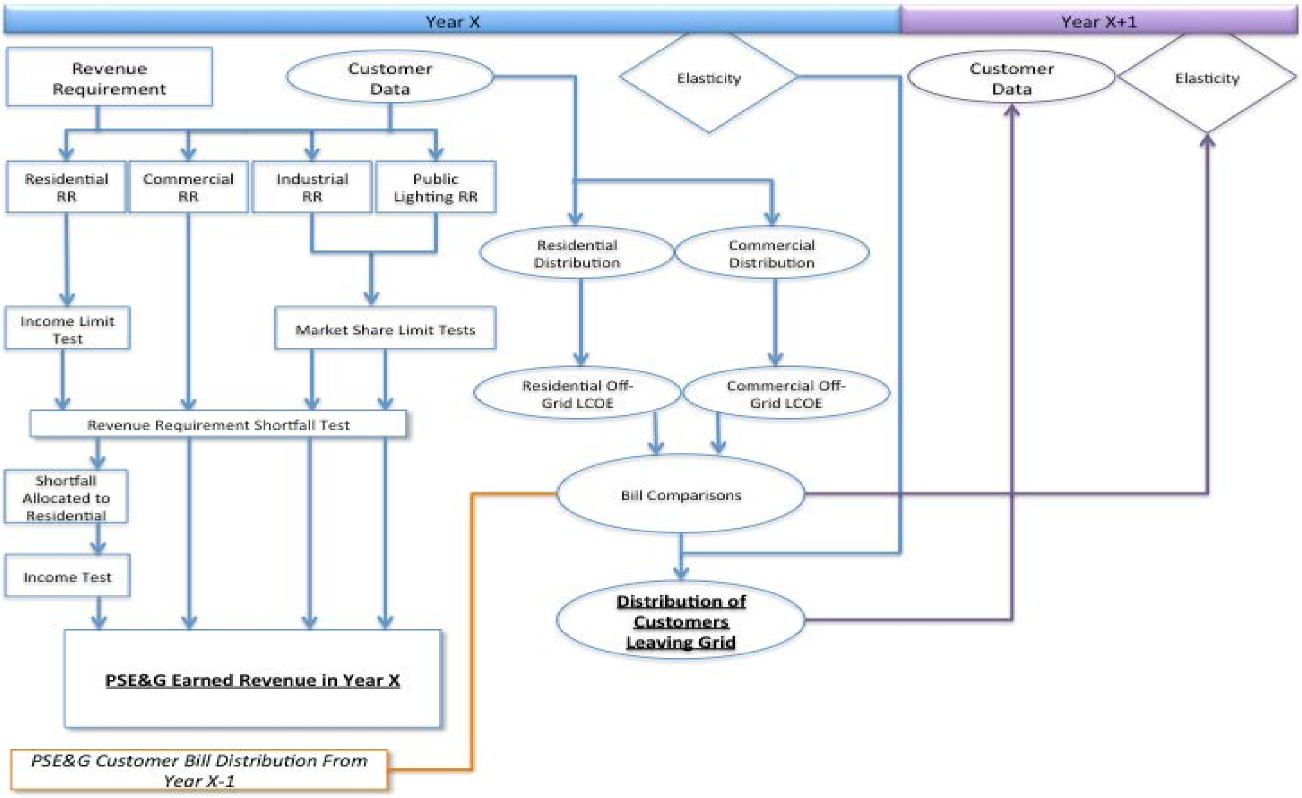
[2] Each year the residential, commercial, and agricultural customers view their previous year's electricity bill and compare it to the current cost of leaving the grid. The cost of leaving the grid is annualized and accordingly presumed to be constant over the life of the system.

The utilities are assumed to only charge prices sufficient to cover the RR in any given year. Below please find a simplified graphical representation of the Model:

Figure 1



h. Elasticity

In the report "Regional Differences in the Price-Elasticity of Demand for Energy", authored by M.A Bernstein and J. Griffin of the Rand Corporation, the authors calculate both the short and long term demand elasticity for customer groups (residential and commercial) across various geographical regions, in response to changes in electricity prices. The long-term demand elasticity is calculated in that paper as an analysis on the change in stock for energy consuming appliances, while the short-term elasticity looks at change in energy prices and amount demanded. For use in this paper's analysis, the long-term demand elasticity coefficient is utilized to determine the expected change in quantity usage for a given customer every year (based on a comparison of a customer's previous year electric bill and the cost of leaving the grid). The expected change in quantity is then broken down into groups, with larger expected changes in usage indicating a higher percentage (estimated) of customers who would leave the grid in that year.[3,4]

i. Subsidies

Both PSE&G and SCE service areas benefit from a 30% Federal Income Tax Credit that can be applied to both the solar array and battery[xxvi]. Residential and commercial customers can utilize these incentives. New Jersey discontinued its tax rebate program and no longer has material incentives used in this analysis (though it should be mentioned that there are a few incentives including a sales tax exemption and certain solar renewable energy credits that are given to some customers, but are not applicable to PSE&G's service area)[xxvii]. However, due to the lack of impact from this exemption it is not considered. California similarly had rebate programs that no longer apply as utilities have reached their limit[xxviii, xxix].

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[3] This paper assumes the long-term coefficient is a overall better approximation, because customers have no true substitute for electricity, and therefore short term reactions to price changes are constrained.

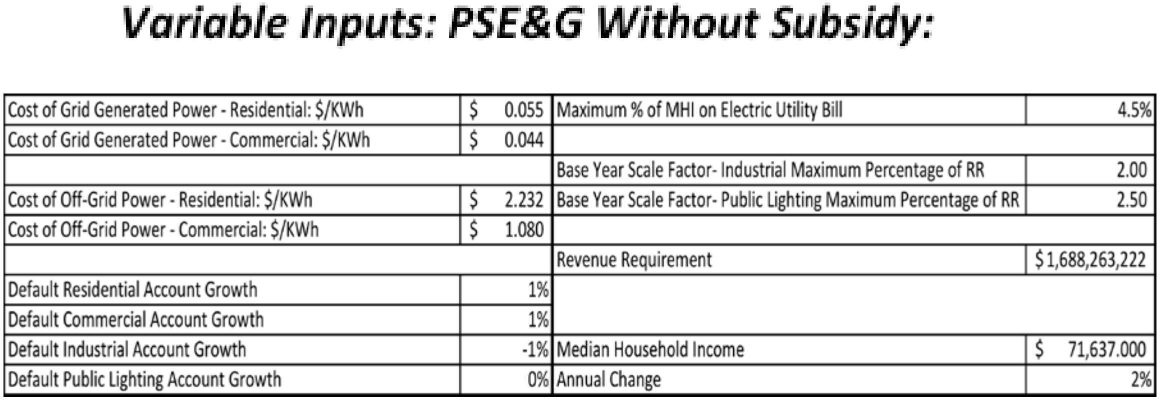
[4] As seen on page 72 of the Bernstein and Griffin report, the short run demand elasticity of residential customers in the New Jersey (Middle Atlantic) region indicate they are more sensitive to price changes than customers in the California (Pacific Coast) region, while the long run elasticity coefficients indicate the opposite. This paper uses the long run elasticity coefficient. In order to accommodate the difference, this paper uses smaller expected quantity changes for PSE&G residential customers (for given speeds of customer departure from the grid), in turn increasing PSE&G residential customers' sensitivity to price differences between off-grid costs and on grid costs, thus adding slight acceleration to customer departure from the grid for PSE&G. Additionally, for reasons such as higher air-conditioning usage in California, these residential customers likely have a larger cushion for which to reduce usage by simply setting the home temperature at a higher level, decreasing customers' incentive to leave the grid. Commercial customer groups were not altered because these consumers are expected to be economically rational. The difference in group quantities can be seen in Table 9.

IV. Results

a. Variable Inputs

Below are the inputs for most variables in each model. The analysis looked at four models: one for PSE&G and SCE without Federal subsidies, and one for each utility with subsidies. Each utility's service area has its own demand elasticity characteristics, in part because the source report calculated elasticity for specific regions, and also because of certain differences in expected residential customer behavior (discussed more in depth in footnote in the Methodology section part h). The calculations for the Revenue Requirements listed below (in 2014) are shown in Table 2.

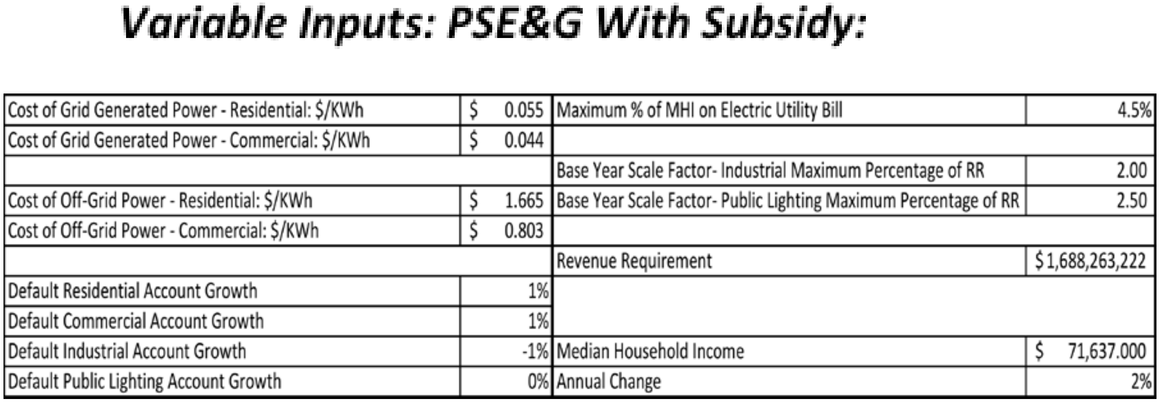
Table 5



Variable Inputs: PSE&G Without Subsidy:

Cost of Grid Generated Power - Residential: $/KWh	$ 0.055	Maximum % of MHI on Electric Utility Bill	4.5%
Cost of Grid Generated Power - Commercial: $/KWh	$ 0.044		
		Base Year Scale Factor- Industrial Maximum Percentage of RR	2.00
Cost of Off-Grid Power - Residential: $/KWh	$ 2.232	Base Year Scale Factor- Public Lighting Maximum Percentage of RR	2.50
Cost of Off-Grid Power - Commercial: $/KWh	$ 1.080		
		Revenue Requirement	$ 1,688,263,222
Default Residential Account Growth	1%		
Default Commercial Account Growth	1%		
Default Industrial Account Growth	-1%	Median Household Income	$ 71,637.000
Default Public Lighting Account Growth	0%	Annual Change	2%

Table 6

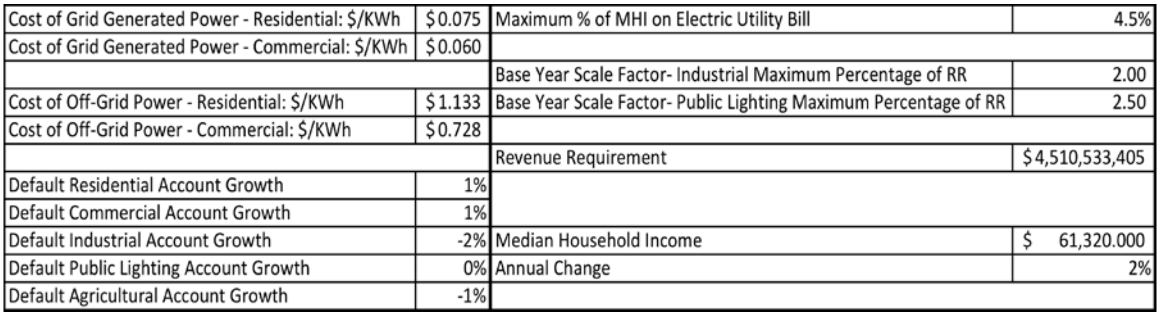


Variable Inputs: PSE&G With Subsidy:

Cost of Grid Generated Power - Residential: $/KWh	$ 0.055	Maximum % of MHI on Electric Utility Bill	4.5%
Cost of Grid Generated Power - Commercial: $/KWh	$ 0.044		
		Base Year Scale Factor- Industrial Maximum Percentage of RR	2.00
Cost of Off-Grid Power - Residential: $/KWh	$ 1.665	Base Year Scale Factor- Public Lighting Maximum Percentage of RR	2.50
Cost of Off-Grid Power - Commercial: $/KWh	$ 0.803		
		Revenue Requirement	$ 1,688,263,222
Default Residential Account Growth	1%		
Default Commercial Account Growth	1%		
Default Industrial Account Growth	-1%	Median Household Income	$ 71,637.000
Default Public Lighting Account Growth	0%	Annual Change	2%

Table 7

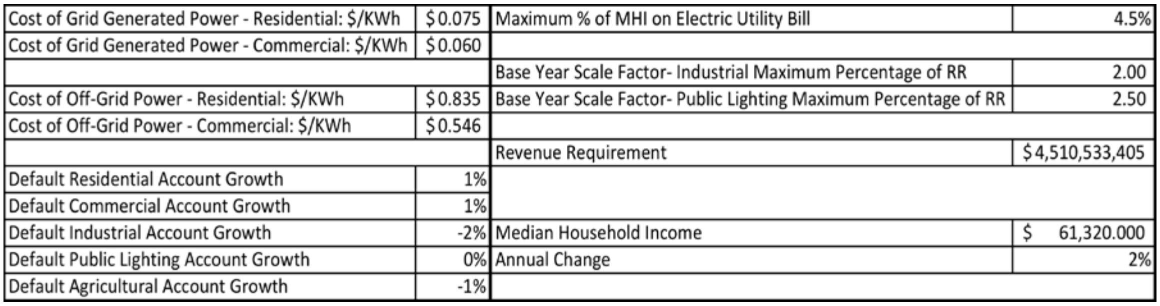
Variable Inputs: SCE Without Subsidy:



Cost of Grid Generated Power - Residential: $/KWh	$ 0.075	Maximum % of MHI on Electric Utility Bill	4.5%
Cost of Grid Generated Power - Commercial: $/KWh	$ 0.060		
		Base Year Scale Factor- Industrial Maximum Percentage of RR	2.00
Cost of Off-Grid Power - Residential: $/KWh	$ 1.133	Base Year Scale Factor- Public Lighting Maximum Percentage of RR	2.50
Cost of Off-Grid Power - Commercial: $/KWh	$ 0.728		
		Revenue Requirement	$ 4,510,533,405
Default Residential Account Growth	1%		
Default Commercial Account Growth	1%		
Default Industrial Account Growth	-2%	Median Household Income	$ 61,320.000
Default Public Lighting Account Growth	0%	Annual Change	2%
Default Agricultural Account Growth	-1%		

Table 8

Variable Inputs: SCE With Subsidy:

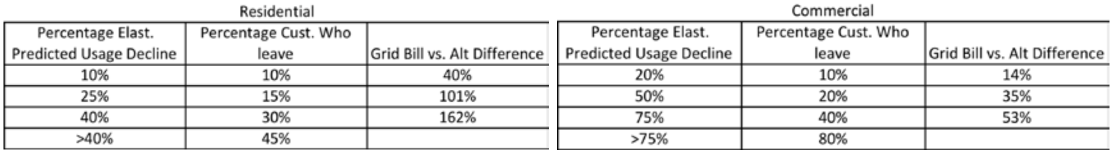


Cost of Grid Generated Power - Residential: $/KWh	$ 0.075	Maximum % of MHI on Electric Utility Bill	4.5%
Cost of Grid Generated Power - Commercial: $/KWh	$ 0.060		
		Base Year Scale Factor- Industrial Maximum Percentage of RR	2.00
Cost of Off-Grid Power - Residential: $/KWh	$ 0.835	Base Year Scale Factor- Public Lighting Maximum Percentage of RR	2.50
Cost of Off-Grid Power - Commercial: $/KWh	$ 0.546		
		Revenue Requirement	$ 4,510,533,405
Default Residential Account Growth	1%		
Default Commercial Account Growth	1%		
Default Industrial Account Growth	-2%	Median Household Income	$ 61,320.000
Default Public Lighting Account Growth	0%	Annual Change	2%
Default Agricultural Account Growth	-1%		

Table 9

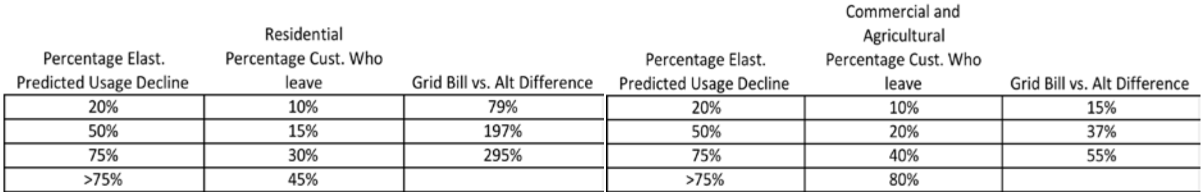
Variable Inputs: Demand Elasticity

PSE&G:



Residential			Commercial		
Percentage Elast. Predicted Usage Decline	Percentage Cust. Who leave	Grid Bill vs. Alt Difference	Percentage Elast. Predicted Usage Decline	Percentage Cust. Who leave	Grid Bill vs. Alt Difference
10%	10%	40%	20%	10%	14%
25%	15%	101%	50%	20%	35%
40%	30%	162%	75%	40%	53%
>40%	45%		>75%	80%	

SCE:



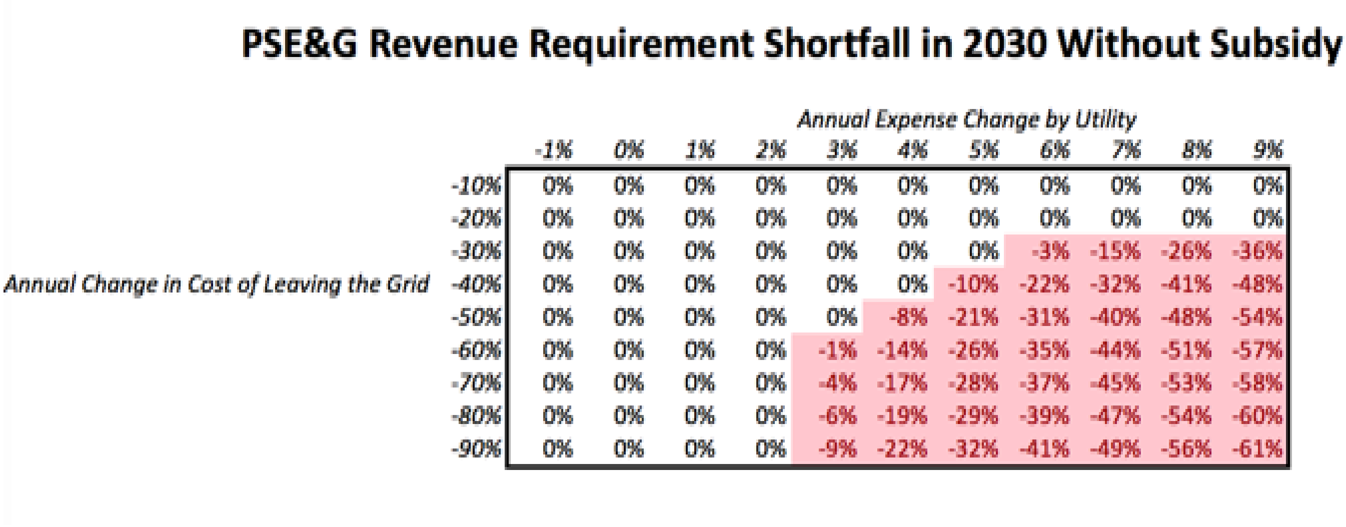
Percentage Elast. Predicted Usage Decline	Residential Percentage Cust. Who leave	Grid Bill vs. Alt Difference	Percentage Elast. Predicted Usage Decline	Commercial and Agricultural Percentage Cust. Who leave	Grid Bill vs. Alt Difference
20%	10%	79%	20%	10%	15%
50%	15%	197%	50%	20%	37%
75%	30%	295%	75%	40%	55%
>75%	45%		>75%	80%	

b. PSE&G Without Subsidy

Below are the results for PSE&G without subsidies. This first table shows the primary ouput of the model – for any given combination of inputs the table illustrates if PSE&G will be able to earn revenue sufficient to cover expenses in 2030. Boxes highlighted in red indicate scenarios in which PSE&G could not earn sufficent revenue in 2030 to cover the Revenue Requirement. Any box in the table that is unshaded has a 0% in it, while the boxes shaded red can have negative percentages listed. These negative percentages indicate how much of a revenue shortfall PSE&G faces in 2030. For example, a box shaded in red with "-5%" listed would indicate that for the given combination of inputs (the inputs are the assumed decline in off-grid costs and assumed annual change in RR) PSE&G would only be able to earn 95% of its revenue requirement (i.e. expenses) in 2030.

In this paper I will refer to scenarios using shorthand. To represent the scenario where the Revenue Requirement changes by 3% annually and the cost of off-grid systems declines by 60% annually, I will use the notation ***"RR 3% / off-grid 60%".***

Table 10



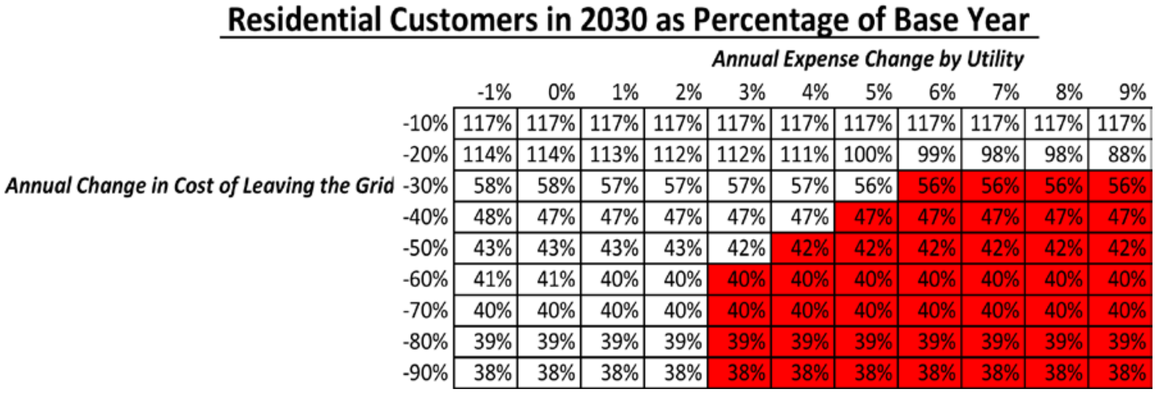
PSE&G Revenue Requirement Shortfall in 2030 Without Subsidy

		Annual Expense Change by Utility										
		-1%	*0%*	*1%*	*2%*	*3%*	*4%*	*5%*	*6%*	*7%*	*8%*	*9%*
	-10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-30%	0%	0%	0%	0%	0%	0%	0%	-3%	-15%	-26%	-36%
Annual Change in Cost of Leaving the Grid	*-40%*	0%	0%	0%	0%	0%	0%	-10%	-22%	-32%	-41%	-48%
	-50%	0%	0%	0%	0%	0%	-8%	-21%	-31%	-40%	-48%	-54%
	-60%	0%	0%	0%	0%	-1%	-14%	-26%	-35%	-44%	-51%	-57%
	-70%	0%	0%	0%	0%	-4%	-17%	-28%	-37%	-45%	-53%	-58%
	-80%	0%	0%	0%	0%	-6%	-19%	-29%	-39%	-47%	-54%	-60%
	-90%	0%	0%	0%	0%	-9%	-22%	-32%	-41%	-49%	-56%	-61%

Table 10 indicates that when excluding subsidies, if PSE&G can keep its Revenue Requirement from increasing more than 2% annually, the utility will be able to cover expenses in 2030 regardless of how quickly the cost of off-grid systems declines. If the RR increases by 3% annually, then PSE&G will not experience a revenue shortfall unless off-grid LCOE declines by at least 60% annually.

The next tables provide a snapshot of PSE&G's customer base in 2030. Each box in the grid below corresponds to the same scenarios as in the table above. Similarly, the red shading indicates the scenarios where PSE&G cannot cover expenses in 2030 (the shading will be identical to the table above). However, in each of these grids, the percentage listed in each box indicates what percentage of PSE&G's customers remain in 2030 as compared to the base year. Each table corresponds to a separate customer group. For example, in Table 11, the results indicate the percentage of residential customers that remain on the grid in 2030. The bottom right box (at the intersection of RR 9% / off-grid -90%) is red and has the percentage "38%" listed. This means that for the scenario RR 9% / off-grid -90%, PSE&G will have a revenue shortfall and will retain only 38% of their residential customers through 2030 as compared to the base year. In other words, RR 9% / off-grid -90% indicates that PSE&G will lose 62% of their residential customers from 2014-2030.

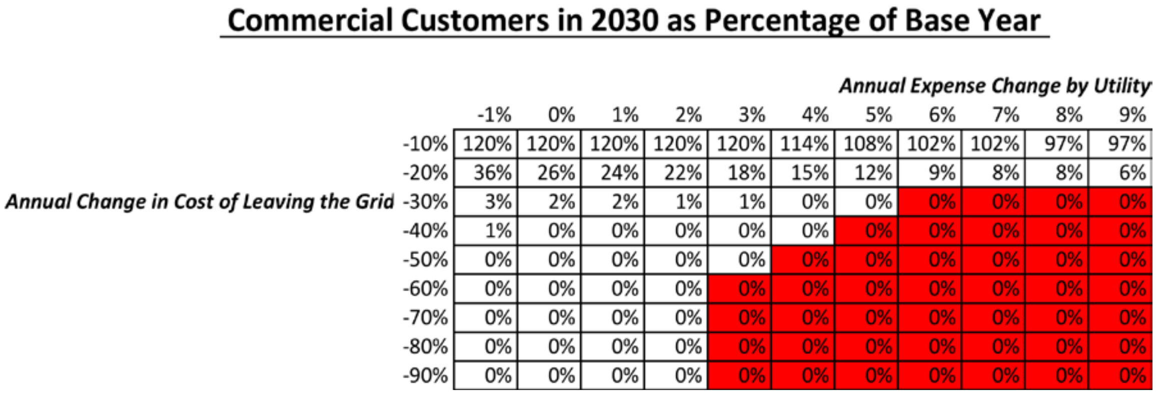
Table 11



Residential Customers in 2030 as Percentage of Base Year

		Annual Expense Change by Utility										
		-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
	-10%	117%	117%	117%	117%	117%	117%	117%	117%	117%	117%	117%
	-20%	114%	114%	113%	112%	112%	111%	100%	99%	98%	98%	88%
Annual Change in Cost of Leaving the Grid	-30%	58%	58%	57%	57%	57%	57%	56%	56%	56%	56%	56%
	-40%	48%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
	-50%	43%	43%	43%	43%	42%	42%	42%	42%	42%	42%	42%
	-60%	41%	41%	40%	40%	40%	40%	40%	40%	40%	40%	40%
	-70%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
	-80%	39%	39%	39%	39%	39%	39%	39%	39%	39%	39%	39%
	-90%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%

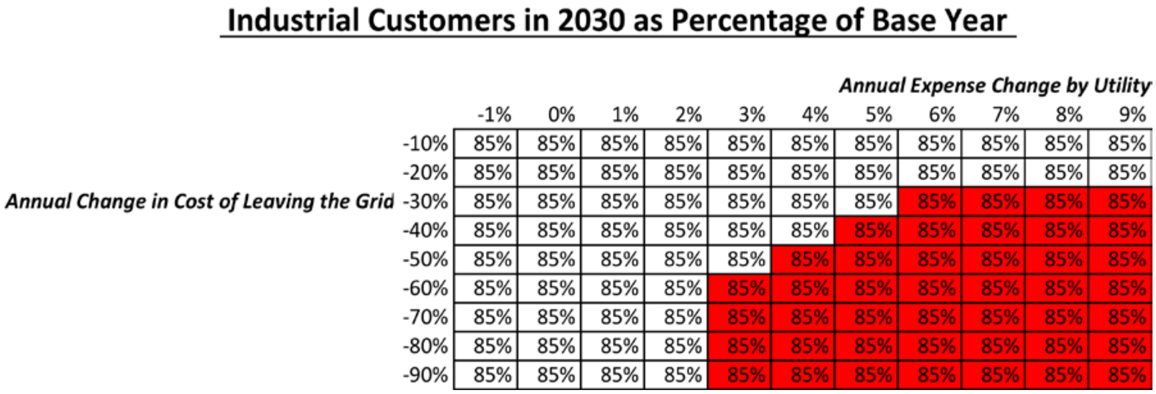
Table 12



Commercial Customers in 2030 as Percentage of Base Year

		Annual Expense Change by Utility										
		-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
	-10%	120%	120%	120%	120%	120%	114%	108%	102%	102%	97%	97%
	-20%	36%	26%	24%	22%	18%	15%	12%	9%	8%	8%	6%
Annual Change in Cost of Leaving the Grid	-30%	3%	2%	2%	1%	1%	0%	0%	0%	0%	0%	0%
	-40%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-60%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-70%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-80%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-90%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

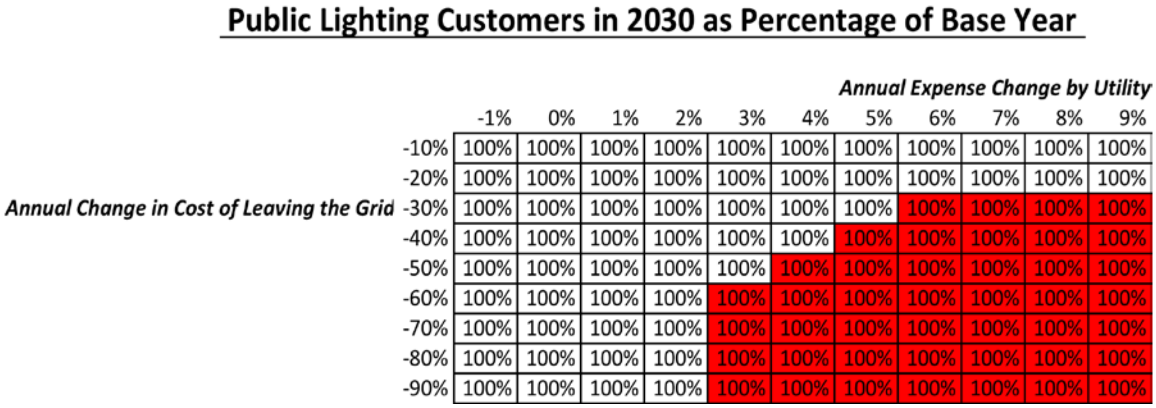
Table 13



Industrial Customers in 2030 as Percentage of Base Year

		Annual Expense Change by Utility										
		-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
	-10%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
	-20%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
Annual Change in Cost of Leaving the Grid	-30%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
	-40%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
	-50%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
	-60%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
	-70%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
	-80%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
	-90%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%

Table 14



Public Lighting Customers in 2030 as Percentage of Base Year

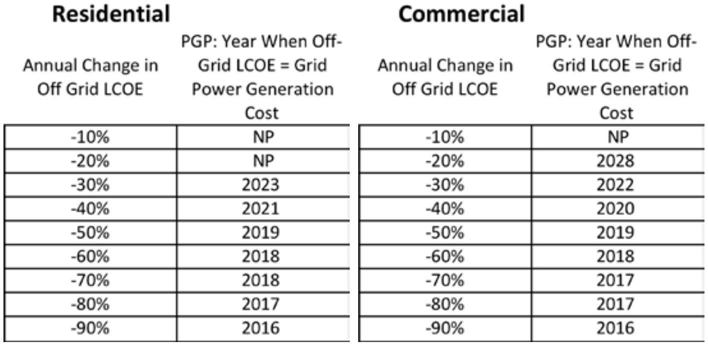
		Annual Expense Change by Utility										
		-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
	-10%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	-20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Annual Change in Cost of Leaving the Grid	-30%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	-40%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	-50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	-60%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	-70%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	-80%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	-90%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 12 indicates that PSE&G loses all commercial customers in scenarios where the utility faces a revenue shortfall in 2030. Conversely, all public lighting customers remain, as they cannot leave the grid. The number of industrial customers is constant across all scenarios because the customer decline is a result of the fact that PSE&G's industrial customer accounts are assumed to decline 1% annually, which is the historical change for industrial customers from 2010-2014.

The charts below are intended to provide a frame of reference for the scenarios. The results above indicated that for the scenario RR 6% / off-grid -30% PSE&G would face a revenue shortfall in 2030, but how large would that make PSE&G's 2030 Revenue Requirement, and what would that entail for off-grid systems?

Tables 15 and 16 below show the year that off-grid systems would reach their minimum cost (the cost of on grid generation, also referred to as PGP), for any given annual decline in off-grid LCOE. Each table shows the outcome for either residential costs or commercial costs, which differ since they have different base year values. For example, in the first chart, when the off-grid LCOE declines by 30% annually, the cost of residential off-grid systems reaches PGP starting in 2023. The letters "NP" stand for "No Parity". NP indicates that the cost of off-grid systems does not equal the cost of on grid generation (this does not include the on grid transmission and distribution charges) by 2030.

Tables 15, 16



Residential

Annual Change in Off Grid LCOE	PGP: Year When Off-Grid LCOE = Grid Power Generation Cost
-10%	NP
-20%	NP
-30%	2023
-40%	2021
-50%	2019
-60%	2018
-70%	2018
-80%	2017
-90%	2016

Commercial

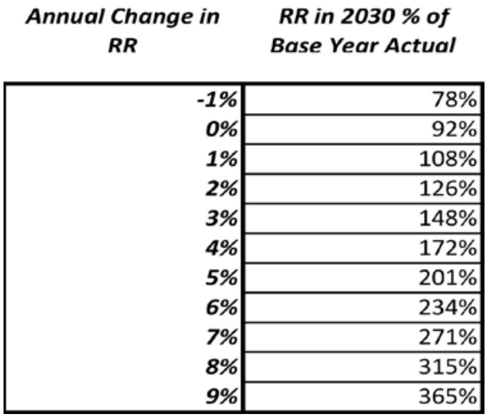
Annual Change in Off Grid LCOE	PGP: Year When Off-Grid LCOE = Grid Power Generation Cost
-10%	NP
-20%	2028
-30%	2022
-40%	2020
-50%	2019
-60%	2018
-70%	2017
-80%	2017
-90%	2016

Tables 15&16 show that for an annual decline in off-grid LCOE of 90%, the off-grid systems would equal on grid generation costs starting in 2016. It should be noted that the analysis uses 2014 as a base year, because that is the most recent comprehensive data, and the year used in

"The Economics of Grid Defection" report by the RMI. Accordingly, any cost declines that have occurred since 2014 are not incorporated into this analysis. Nonetheless, it seems highly unlikely that PGP would occur in 2016.

The following table indicates what each annual change in the Revenue Requirement entails for the RR in 2030, by comparing the 2030 RR to PSE&G's actual 2014 revenues (for retail customers, related only to transmission and distribution).

Table 17



Annual Change in RR	*RR in 2030 % of Base Year Actual*
-1%	78%
0%	92%
1%	108%
2%	126%
3%	148%
4%	172%
5%	201%
6%	234%
7%	271%
8%	315%
9%	365%

This chart shows that in the scenarios where PSE&G's RR is assumed to change by 9% annually, the 2030 Revenue Requirement would be equal to 3.65x PSE&G's actual 2014 revenues. Combining all the tables above, the model indicates that in the scenario of RR 6% / off-grid -30%:

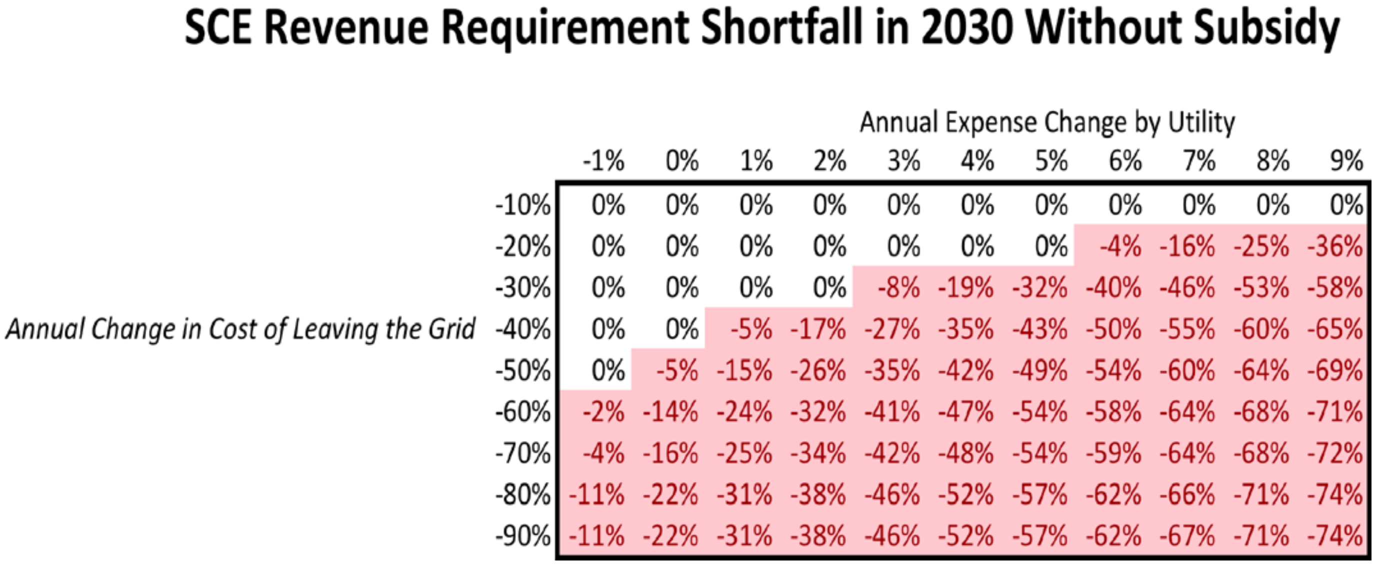
- PSE&G faces a revenue shortfall of 3% in 2030.
- The Revenue Requirement in 2030 is 2.3x actual 2014 revenues.
- The cost of off-grid systems would be equal to on grid generation in 2023 and 2022 for residential and commercial respectively.
- PSE&G would lose all commercial customers and 44% of residential customers.

Reviewing the overall results indicate that PSE&G does not encounter revenue shortfalls as long as its RR does not increase more than 2% annually, regardless of the rate of decline in off-grid costs. Additionally, up until an annual RR increase of 6% the utility can continue operating even with significant declines in off-grid LCOE up to 40% annually, representing a residential PGP in 2021 and commercial PGP in 2020. With an annual RR increase of 6% PSE&G would be charging customers over 2.3x the 2014 actual retail T&D revenues. PSE&G can cover expenses if it keeps its cost of operations within 1.25x of 2014 T&D revenues (regardless of the rate of LCOE decline), or within 2x of 2014 retail T&D revenues provided that off-grid generation not enjoy cost reductions of 30% annually through 2023 (since after 2023 off-grid costs are at a minimum and no longer decline).

c. SCE Without Subsidy

The tables below for SCE are set up identically to those above for PSE&G. Below is the first chart that demonstrates for SCE the magnitude of revenue shortfall in 2030 for every given scenario.

Table 18



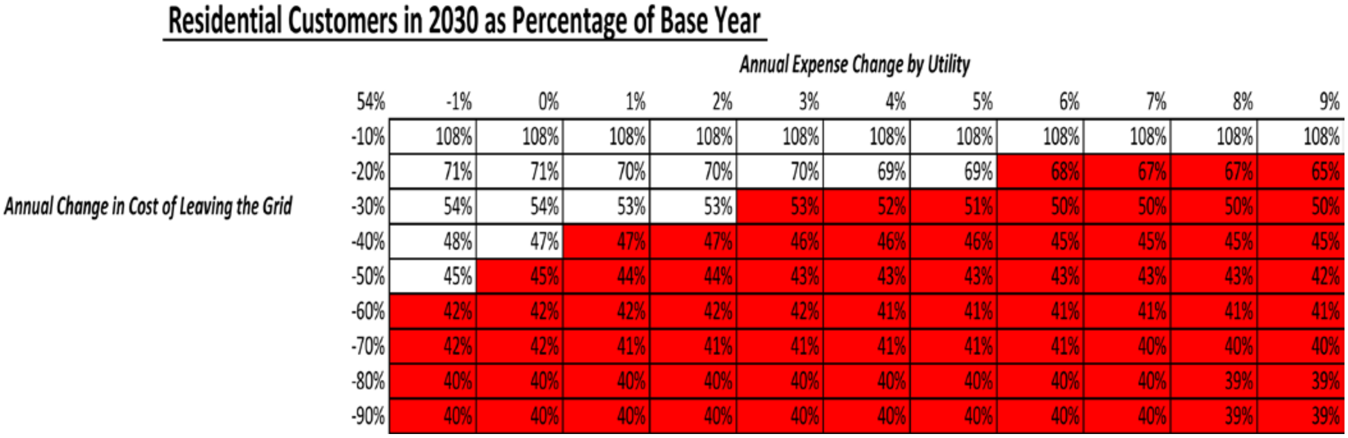
SCE Revenue Requirement Shortfall in 2030 Without Subsidy

		Annual Expense Change by Utility										
		-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
Annual Change in Cost of Leaving the Grid	-10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-20%	0%	0%	0%	0%	0%	0%	0%	-4%	-16%	-25%	-36%
	-30%	0%	0%	0%	0%	-8%	-19%	-32%	-40%	-46%	-53%	-58%
	-40%	0%	0%	-5%	-17%	-27%	-35%	-43%	-50%	-55%	-60%	-65%
	-50%	0%	-5%	-15%	-26%	-35%	-42%	-49%	-54%	-60%	-64%	-69%
	-60%	-2%	-14%	-24%	-32%	-41%	-47%	-54%	-58%	-64%	-68%	-71%
	-70%	-4%	-16%	-25%	-34%	-42%	-48%	-54%	-59%	-64%	-68%	-72%
	-80%	-11%	-22%	-31%	-38%	-46%	-52%	-57%	-62%	-66%	-71%	-74%
	-90%	-11%	-22%	-31%	-38%	-46%	-52%	-57%	-62%	-67%	-71%	-74%

The chart indicates that SCE is vulnerable to some revenue shortfalls in all RR assumptions and every off-grid LCOE decline except for -10%. In the RR 3% / off-grid -30% the utility finds itself able to earn revenues 8% below that of its expenses.

The next five tables are again formatted identically to the customer charts for PSE&G. However, SCE has agricultural customers, so SCE has an additional customer table for that group.

Table 19

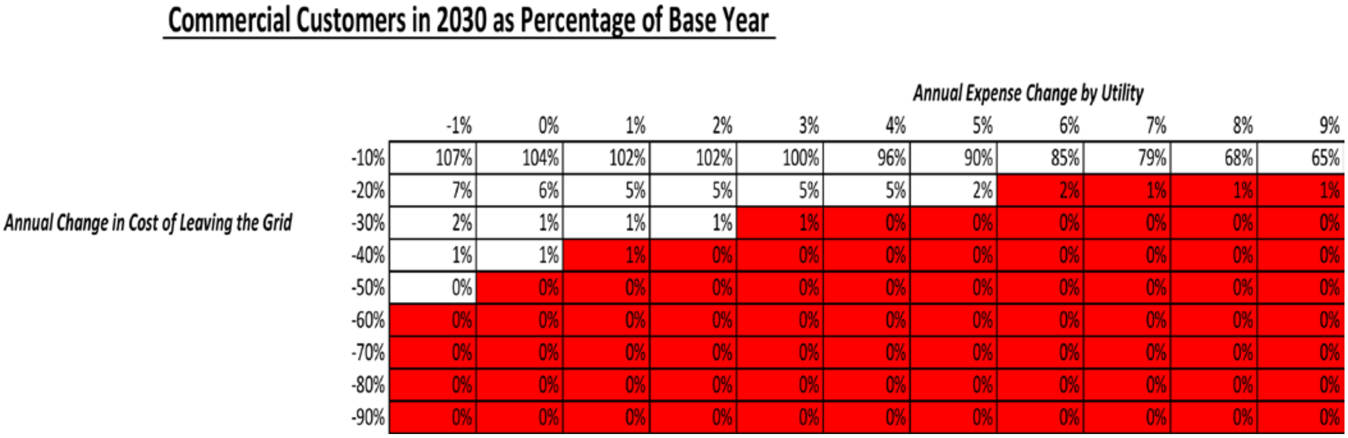


Residential Customers in 2030 as Percentage of Base Year

Annual Expense Change by Utility

	54%	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
Annual Change in Cost of Leaving the Grid	-10%	108%	108%	108%	108%	108%	108%	108%	108%	108%	108%	108%
	-20%	71%	71%	70%	70%	70%	69%	69%	68%	67%	67%	65%
	-30%	54%	54%	53%	53%	53%	52%	51%	50%	50%	50%	50%
	-40%	48%	47%	47%	47%	46%	46%	46%	45%	45%	45%	45%
	-50%	45%	45%	44%	44%	43%	43%	43%	43%	43%	43%	42%
	-60%	42%	42%	42%	42%	42%	41%	41%	41%	41%	41%	41%
	-70%	42%	42%	41%	41%	41%	41%	41%	41%	40%	40%	40%
	-80%	40%	40%	40%	40%	40%	40%	40%	40%	40%	39%	39%
	-90%	40%	40%	40%	40%	40%	40%	40%	40%	40%	39%	39%

Table 20

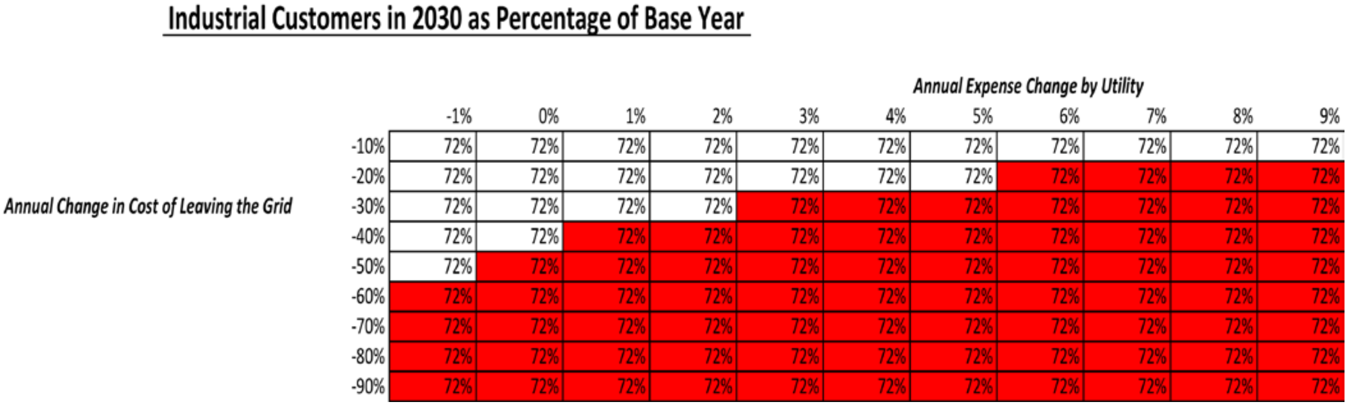


Commercial Customers in 2030 as Percentage of Base Year

Annual Expense Change by Utility

		-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
Annual Change in Cost of Leaving the Grid	-10%	107%	104%	102%	102%	100%	96%	90%	85%	79%	68%	65%
	-20%	7%	6%	5%	5%	5%	5%	2%	2%	1%	1%	1%
	-30%	2%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%
	-40%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%
	-50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-60%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-70%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-80%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-90%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

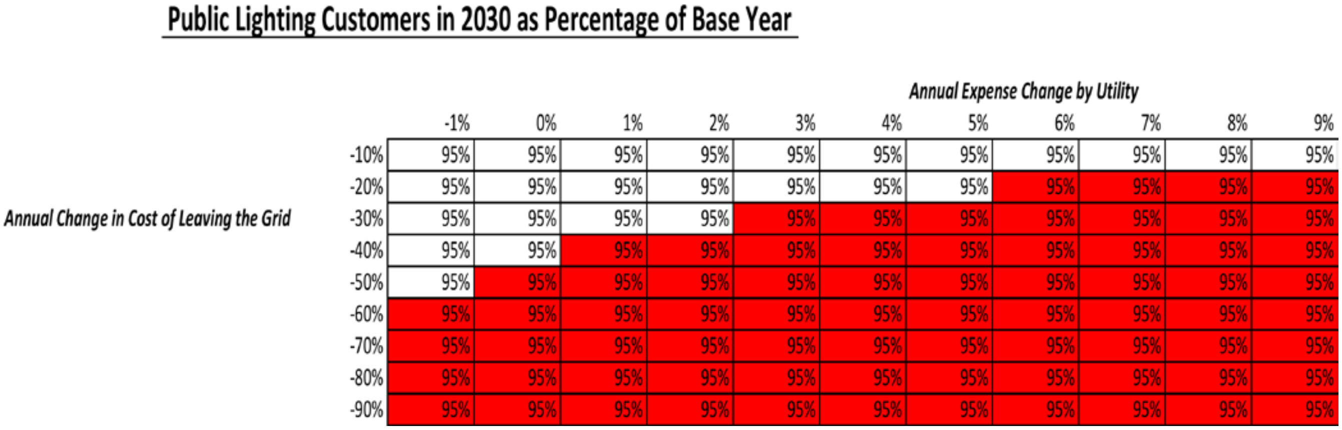
Table 21



Industrial Customers in 2030 as Percentage of Base Year

							Annual Expense Change by Utility					
		-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
	-10%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
	-20%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Annual Change in Cost of Leaving the Grid	-30%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
	-40%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
	-50%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
	-60%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
	-70%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
	-80%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
	-90%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%

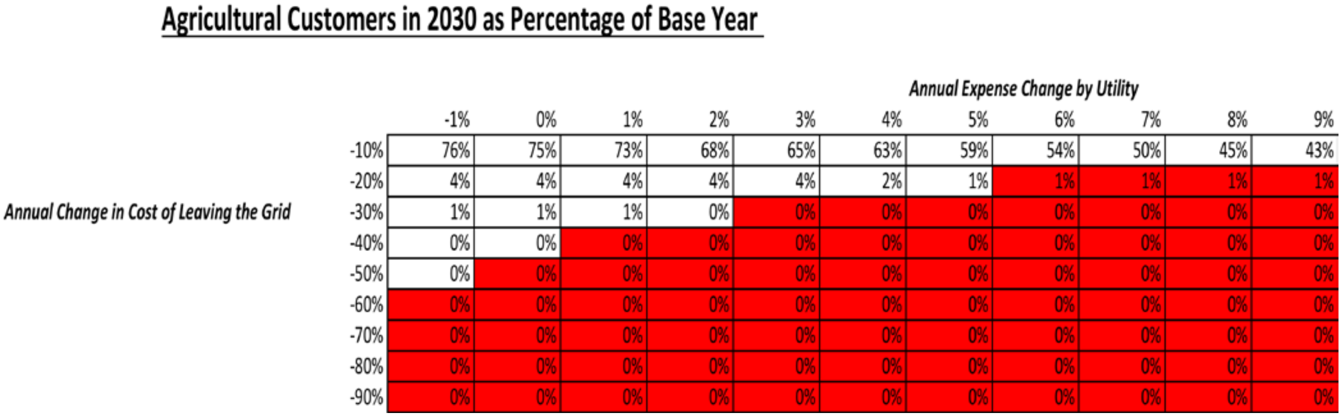
Table 22



Public Lighting Customers in 2030 as Percentage of Base Year

							Annual Expense Change by Utility					
		-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
	-10%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
	-20%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
Annual Change in Cost of Leaving the Grid	-30%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
	-40%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
	-50%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
	-60%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
	-70%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
	-80%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
	-90%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%

Table 23



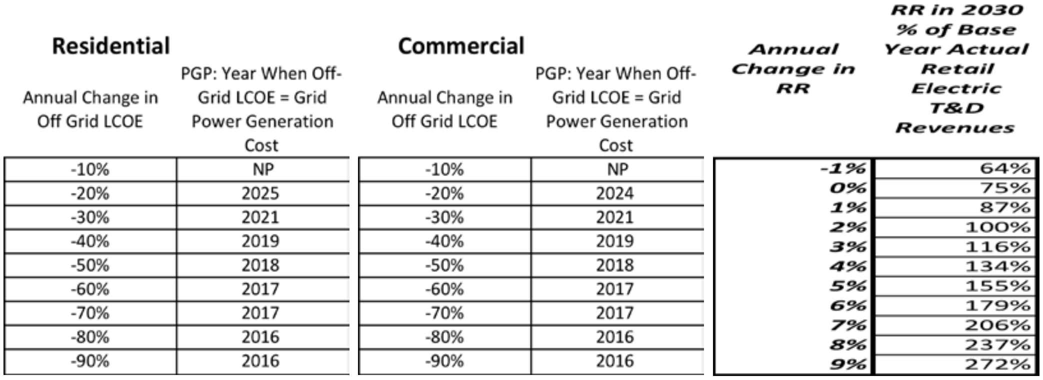
Agricultural Customers in 2030 as Percentage of Base Year

							Annual Expense Change by Utility					
		-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
	-10%	76%	75%	73%	68%	65%	63%	59%	54%	50%	45%	43%
	-20%	4%	4%	4%	4%	4%	2%	1%	1%	1%	1%	1%
Annual Change in Cost of Leaving the Grid	-30%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%
	-40%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-60%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-70%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-80%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-90%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Similar to PSE&G, SCE encounters a drastic loss in commercial customers in scenarios where SCE faces a revenue shortfall. The same trend occurs for SCE's agricultural customers. Unlike PSE&G, SCE can retain 1%-2% of commercial consumers while still encountering a revenue shortfall. In those scenarios SCE loses roughly 30% of residential customers. In all scenarios for SCE, 25% of industrial consumer accounts are lost due to the -2% growth rate for that group (which aligns with SCE's 2010-2014 growth rate), 5% of public lighting customers are lost due to the -.3% growth rate.

Below are the charts intended to provide a frame of reference for the SCE scenarios. They are set up identically to those of PSE&G, with the first two tables demonstrating the year when PGP occurs for any given assumed decline in off-grid costs. The third table shows indicates what each annual change in the Revenue Requirement entails for the RR in 2030, by comparing the 2030 RR to SCE's actual 2014 retail T&D revenues.

Tables 24, 25, 26



Residential

Annual Change in Off Grid LCOE	PGP: Year When Off-Grid LCOE = Grid Power Generation Cost
-10%	NP
-20%	2025
-30%	2021
-40%	2019
-50%	2018
-60%	2017
-70%	2017
-80%	2016
-90%	2016

Commercial

Annual Change in Off Grid LCOE	PGP: Year When Off-Grid LCOE = Grid Power Generation Cost
-10%	NP
-20%	2024
-30%	2021
-40%	2019
-50%	2018
-60%	2017
-70%	2017
-80%	2016
-90%	2016

Annual Change in RR	*RR in 2030 % of Base Year Actual Retail Electric T&D Revenues*
-1%	64%
0%	75%
1%	87%
2%	100%
3%	116%
4%	134%
5%	155%
6%	179%
7%	206%
8%	237%
9%	272%

Tables 24 and 25 reveal that PGP occurs earlier for SCE than for PSE&G for any level of assumed decline in off-grid LCOE. Additionally, when off-grid LCOE declines by 20% annually, SCE's service territory encounters PGP in 2025 while PSE&G's service area does not experience PGP at all before 2030. The reason SCE encounters PGP prior to PSE&G is a result of SCE's lower base year off-grid costs, coupled with higher on grid generation costs (since the model assumes that for each service area the off-grid cost cannot decline below their respective on-grid generation prices).

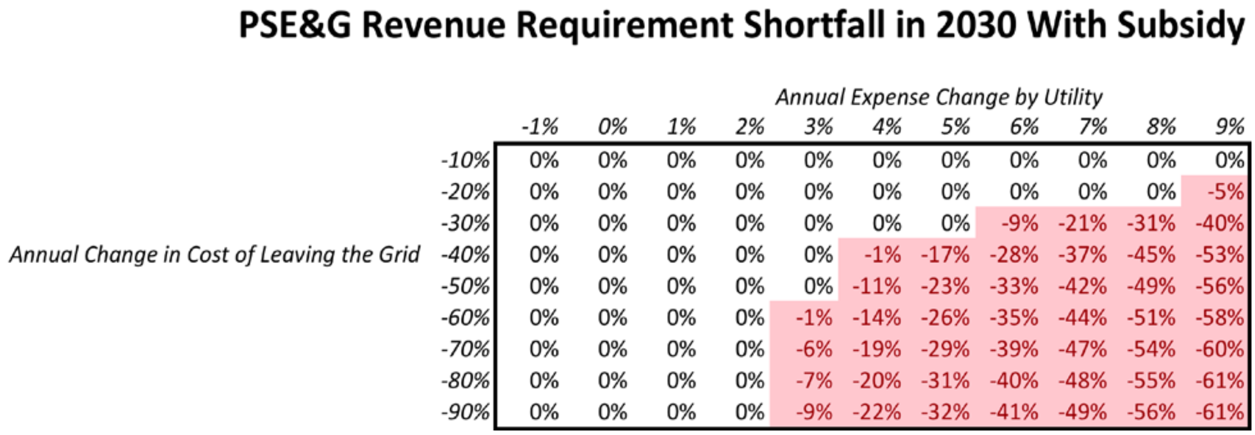
Table 26 shows that scenarios for SCE with a 9% annual increase in RR, SCE's 2030 Revenue Requirement would be equal to 2.7x actual retail T&D revenues in 2014.

Combining all the charts, the model revels that SCE can fall prey to off-grid distributed generation even if its RR *decreased* by 1% annually, representing a 2030 RR equal to only 65% of 2014 actual T&D revenues. However, it should be noted that the required decline in off-grid costs would entail PGP in 2017. SCE would not cover its RR in 2030 if it increased by 6% annually and off-grid LCOE decline by 20% through 2025, with a 2030 RR that is approximately 80% higher than 2014 actual retail T&D revenues. SCE would also face an RR shortfall when off-grid costs decline at 30% a year, PGP occurs in 2021, and RR increases by 3% annually. In this scenario, 2030 RR is less than 20% higher than actual 2014 retail T&D revenues. Accordingly, for declines in off-grid LCOE of 30% and 20% SCE must keep costs within 1.2x and 1.8x respectively of 2014 retail T&D revenues.

d. PSE&G And SCE With Subsidies

The model was run for both utilities with lower base year off-grid costs that incorporate a 30% Federal tax credit. The charts below reveal the level of revenue shortfall in 2030 for each utility when subsidies are included.

Table 27



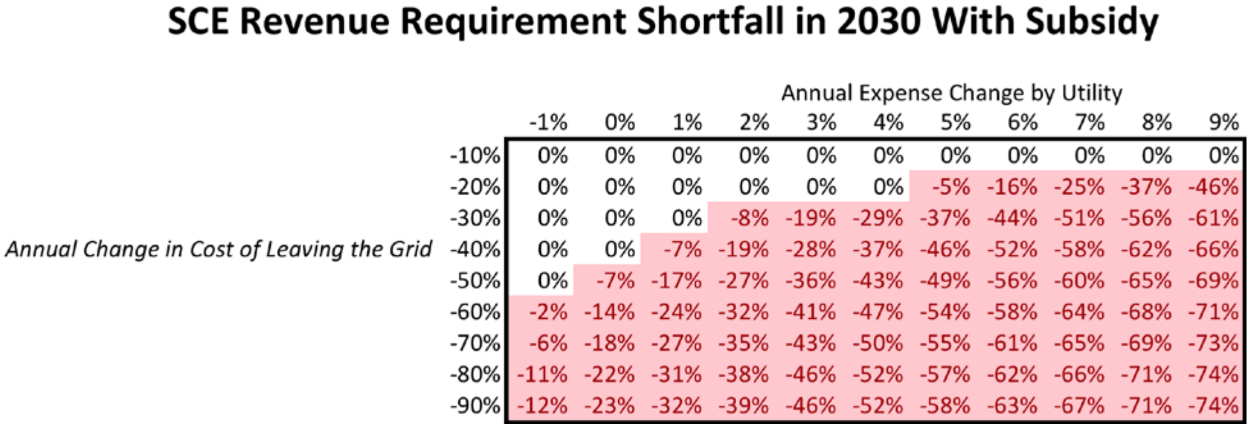
PSE&G Revenue Requirement Shortfall in 2030 With Subsidy

Annual Expense Change by Utility

Annual Change in Cost of Leaving the Grid

	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
-10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
-20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-5%
-30%	0%	0%	0%	0%	0%	0%	0%	-9%	-21%	-31%	-40%
-40%	0%	0%	0%	0%	0%	-1%	-17%	-28%	-37%	-45%	-53%
-50%	0%	0%	0%	0%	0%	-11%	-23%	-33%	-42%	-49%	-56%
-60%	0%	0%	0%	0%	-1%	-14%	-26%	-35%	-44%	-51%	-58%
-70%	0%	0%	0%	0%	-6%	-19%	-29%	-39%	-47%	-54%	-60%
-80%	0%	0%	0%	0%	-7%	-20%	-31%	-40%	-48%	-55%	-61%
-90%	0%	0%	0%	0%	-9%	-22%	-32%	-41%	-49%	-56%	-61%

Table 28



SCE Revenue Requirement Shortfall in 2030 With Subsidy

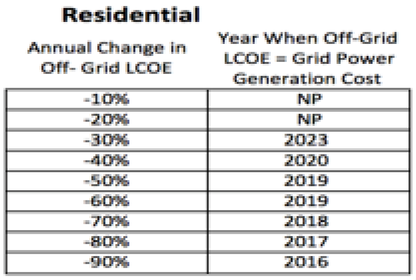
		Annual Expense Change by Utility										
		-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
Annual Change in Cost of Leaving the Grid	-10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-20%	0%	0%	0%	0%	0%	0%	-5%	-16%	-25%	-37%	-46%
	-30%	0%	0%	0%	-8%	-19%	-29%	-37%	-44%	-51%	-56%	-61%
	-40%	0%	0%	-7%	-19%	-28%	-37%	-46%	-52%	-58%	-62%	-66%
	-50%	0%	-7%	-17%	-27%	-36%	-43%	-49%	-56%	-60%	-65%	-69%
	-60%	-2%	-14%	-24%	-32%	-41%	-47%	-54%	-58%	-64%	-68%	-71%
	-70%	-6%	-18%	-27%	-35%	-43%	-50%	-55%	-61%	-65%	-69%	-73%
	-80%	-11%	-22%	-31%	-38%	-46%	-52%	-57%	-62%	-66%	-71%	-74%
	-90%	-12%	-23%	-32%	-39%	-46%	-52%	-58%	-63%	-67%	-71%	-74%

These tables indicate that the subsidies did not have a large impact on the utilities' abilities to cover their Revenue Requirements in 2030. For PSE&G, the only changes for occurrences of RR shortfalls were in the 4% RR / -40% annual off-grid change, and 9% RR / -20% annual off-grid change. The percentage shortfall increased modestly in the various scenarios but was not significant. Similarly, for SCE, the only occurrence variations were at 5% RR / -20% off-grid and 2% RR / -30% off-grid changes. Individual scenario shortfalls increased modestly again.

The charts below are set up identically to those of the models without subsidies. The first two tables demonstrate the year when PGP occurs for any given assumed decline in off-grid costs for PSE&G when including subsidies, while the second two tables reveal the same information for SCE when including subsidies.

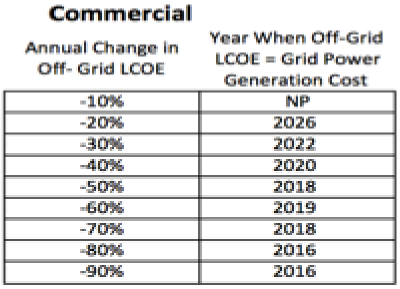
PSE&G:

Tables 29, 30



Residential

Annual Change in Off- Grid LCOE	Year When Off-Grid LCOE = Grid Power Generation Cost
-10%	NP
-20%	NP
-30%	2023
-40%	2020
-50%	2019
-60%	2019
-70%	2018
-80%	2017
-90%	2016

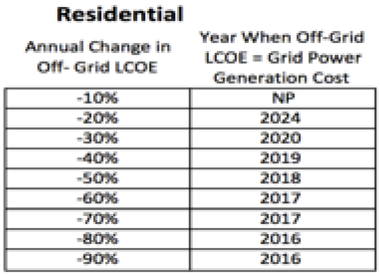


Commercial

Annual Change in Off- Grid LCOE	Year When Off-Grid LCOE = Grid Power Generation Cost
-10%	NP
-20%	2026
-30%	2022
-40%	2020
-50%	2018
-60%	2019
-70%	2018
-80%	2016
-90%	2016

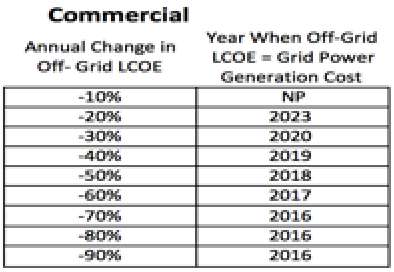
SCE:

Tables 30, 31



Residential

Annual Change in Off- Grid LCOE	Year When Off-Grid LCOE = Grid Power Generation Cost
-10%	NP
-20%	2024
-30%	2020
-40%	2019
-50%	2018
-60%	2017
-70%	2017
-80%	2016
-90%	2016



Commercial

Annual Change in Off- Grid LCOE	Year When Off-Grid LCOE = Grid Power Generation Cost
-10%	NP
-20%	2023
-30%	2020
-40%	2019
-50%	2018
-60%	2017
-70%	2016
-80%	2016
-90%	2016

The above charts indicate that for almost all declines in off-grid costs, when including subsidies PGP occurs in the same year as, or one year earlier than the same scenario without including subsidies. The largest deviation caused by the subsidy is a two year difference for commercial customers of PSE&G when off-grid costs decline by 20% annually.

V. Discussion of Results

a. PSE&G And SCE Without Subsidies

SCE appears more vulnerable to the threat of off-grid distributed generation than PSE&G. This is likely a result of multiple factors. SCE's service area enjoys less expensive off-grid systems than that of PSE&G, which is partly driven by the increased solar irradiance (sun exposure) in Los Angeles as compared to the northeast. Additionally, commercial customers contributed 43% of PSE&G base year Revenue Requirement, while commercial and agricultural consumers (the two customer groups that can leave the grid without restriction) represent 49% of SCE's base year RR. Likewise, SCE's customers pay higher average bills for most consumer groups. It seems probable that the higher customer charges result from the overall utility profiles. PSE&G has a service area of 2,600 square miles (with 23,000 circuit miles of transmission and distribution lines)[xxx] compared to 50,000 square miles for SCE (with 133,000 circuit miles)[xxxi], but SCE only has five million customers compared to 2.2 million for PSE&G[xxxii, xxxiii]. Accordingly, SCE has proportionately fewer total consumers over which to allocate infrastructure expenses.

The most extreme scenarios with 90% declines in off-grid prices would be exceedingly difficult to come to fruition, as they would require technological breakthroughs and commercialization in 2016 (though it should be noted that the off-grid distributed generation data was from 2014, and therefore additional declines that have already occurred are not factored into the analysis).

In virtually all scenarios where both utilities cannot meet their RR, all commercial and agricultural customers who can leave the grid do in fact move off-grid. As mentioned in the assumptions section, while it seems unlikely that all commercial customers could install off-grid systems at their current locations, commercial customers in tall office buildings could simply move to other locations where off-grid systems are feasible, or even move to an area outside of the utilities' service territories (in the event another location is more economic due either to better electricity rates, rent, or other characteristics). Interestingly, however, these utilities can face a shortfall in revenues without losing all eligible residential customers. Of PSE&G's residential customers, 64% can defect (the remaining stuck in large multi-unit buildings) as compared to 66% for SCE. PSE&G can encounter revenue shortfalls while losing only 44% of residential customers while SCE faces shortfalls when losing only 49% of residential customers. The rate of departure for residential customers from the grid is likely lessened by the ceiling on residential revenue attributed to politically driven income limitations, coupled with lower demand elasticity.

The acceleration of customer departure from the grid attributed to increased pricing (the "Snowball Effect") adds to the financial strain of the utilities. Exploring the RR 0% / off-grid -20% scenario for PSE&G, residential off-grid costs do not achieve PGP by 2030 while commercial off-grid costs reach PGP only by 2028. Prior to 2022 costs per customer for residential and commercial customers decline annually due to customer growth and a flat RR. In 2022 commercial off-grid LCOE are $.14/kWh vs. $.04/kWh for on-grid generation, but commercial customers begin to leave the grid due to T&D charges. After 2022, costs per customer for all groups see accelerating annual increases with an 8% rise in 2028 when PGP occurs for commercial power.

Net metering, which was not considered in this analysis, could have varying effects on the speed of consumer departure from the grid. It's possible that net metering could preserve the utilities' customer base in the event that individuals purchase photovoltaic systems without batteries, and then are locked into their owned systems or contracts. That would in turn preclude consumers from buying newer and less expensive systems. Conversely, those same customers could move off-grid more quickly because they simply add batteries to existing systems when they become economic. This outcome seems more realistic since the greatest reduction in off-grid prices will likely be attributed to the batteries. Additionally, net metering is a contentious program for many utilities and may not survive in its current form in a stress scenario.

b. Subsidy Discussion

The largest noticeable impacts from subsidies were seen in the context of cost declines of lesser magnitude for off-grid LCOE. This intuitively makes sense since subsidies apply a blanket discount to each year’s off-grid LCOE (though it never falls bellow the minimum), which is more significant when the annual reduction is modest. Accordingly, the influence of subsidies on the utilities’ fiscal health could be material in real world occurrences of declines slower than -20% a year but where utilities struggle to manage costs. One of the SCE scenarios impacted (discussed above), with 5% RR / -20% off-grid change, represents a 2030 RR that is 55% above 2014 retail T&D revenues. An increase of 55% is significant (since it’s on a real basis) but not outlandish considering extraordinary events (natural disasters) or even escalating infrastructure costs.

c. Limitation Of This Analysis

The analysis used in this paper is based on a number of assumptions related to current data that was unavailable, and to political, business, and individual economic behavior in the future. Additionally, the examination looked only at solar and battery systems. Discussion around some limitations is included below:

Lesser Usage Customers Have Seemingly Higher Economic Incentive to Leave the Grid – In this analysis customers who are connected to the grid pay both a fixed cost for their connection and a variable cost for power generation. Accordingly, on a per kWh basis, lower usage customers pay higher prices since the fixed cost is distributed over less usage. However, lesser usage customers are assumed to be lower income, since the two would be expected to be correlated. Lower income individuals seem intuitively less likely to leave the grid and make large financial commitments. Additionally, lower income consumers would likely require financing and pay a higher cost of capital, which could both be factors that would decrease the economic incentive of leaving the grid for lower usage customers relative to larger consumption groups. The analysis in this paper tries to compensate for this limitation by adding the two-year lag for smaller residential customers.

All Commercial Customers are Assumed to be Able to Leave The Grid- Due to the lack of data on commercial property characteristics in the service territories, no consideration was given to space or weight requirements. RMI's report similarly ignores space limitation due in part to the diversity among commercial customers. However, this paper did not consider the potential for commercial customers to combine solar with diesel generators. RMI calculated the cost of leaving the grid for solar and diesel systems, and found them to be less expensive (and one would imagine less space consuming). Additionally, aside from leaving the grid, businesses can also simply leave their building.

The Allocation of Transmission Revenue Remains Constant – It is unclear how transmission revenues would be spread among retail and non-retail customers in stress scenarios.

Variation in System Size Within Residential And Commercial Groups – While the RMI report provided off-grid LCOE for both residential and commercial customers, these numbers represent costs associated with specific system sizes and characteristics. Residential or commercial customers who consume varying levels of electricity may experience different off-grid LCOE. Within the residential group, it is generally accepted that larger systems decrease the LCOE. However, the residential systems specified by RMI in their report are of sizes 10 kW (Los Angeles) and 20 kW (Westchester). According to a 2015 report entitled “Tracking the Sun VIII” by the Department of Energy and the Berkley Lab, economies of scale decline significantly after 10 kW for residential systems. While the smallest customer group may require a system smaller than 10 kW, it is unlikely to produce a meaningful difference, and would additionally be difficult to quantify. For commercial systems, however, the consumption level of the smallest group is sufficiently close to residential usage that the off-grid LCOE applied in this analysis is based on a small modification to the residential off-grid LCOE (from the RMI report) rather than using the commercial LCOE as proxy. The true variation in price as a function of system size is not available.

Shading – Without data on the amount of rooftop shade in the utilities’ service territories, its impossible to know the true off-grid LCOE or maximum number of customers who can leave the grid. While trees can be trees can be removed, this solution comes at a price (which increases off-grid LCOE), counters environmental benefits, and likely is not appealing to many customers. Additionally, shade resulting from adjacent buildings or other structures may be unavoidable.

VI. Sensitivity Analysis

Interestingly, the two most sensitive variables were factors for the maximum amount of revenue that can be derived from residential customers. The Maximum Percentage of Bill Paid By Residential Customers (“Res Max”) greatly affected both utilities, while the Median Household Income Growth (“MHI Growth”) had more impact on PSE&G. The results are discussed in more detail in Appendix A, but a notable deviation in RR shortfall outcomes occurred for both utilities when changing Res Max +/- .5%. PSE&G’s results were influenced by changing MHI Growth by -2%, and less so when increasing 2%.

The demand elasticity of customers was somewhat less sensitive, though it had an impact on a number of scenarios. When elasticity was decreased significantly a number of shortfall scenarios no longer occurred, primarily in scenarios where the utilities’ RR increased at lesser rates. The elasticity in the sensitivity test is seemingly low, however, as only 9% of PSE&G residential customers who could save 50% by leaving the grid actually do so in a given year. It is discussed further in Appendix A.

VI. Conclusion

This paper does not proffer an opinion on the likely outcome for off-grid distributed generation or electric utilities, but instead explores the ramifications of different scenarios on the fiscal health of PSE&G and SCE. The analysis indicated that PSE&G is less vulnerable than SCE to declining costs of leaving the grid. Furthermore, PSE&G does not experience revenue requirement shortfalls in 2030 unless the relevant technology becomes drastically less expensive or the utility faces sharp expense escalation. SCE could encounter financial issues in 2030 in the event of more modest changes over the time period. With regards to subsides, the Federal tax credits had minimal impact on the viability of both utilities even when assuming the subsidies continue throughout the time horizon.

Lastly, it appears that the contribution of residential customers to these utilities can greatly impact the utilities' financial strength. Accordingly, service area income growth and political forces are important factors in these utilities' vulnerability to off-grid distributed generation.

Appendix A – Sensitivity Analysis Discussion

The following variables were subject to sensitivity testing:

- Maximum Percentage of Bill Paid by Residential Customers ("Res Max")
- Customer Elasticity
- Median Household Income Growth ("MHI Growth")
- Maximum Revenue Factor For Industrial Customers ("Ind Max")
- Maximum Revenue Factor For Public Lighting Customers ("Light Max")

For both utilities the variables with the highest levels of sensitivity included Res Max, Comm Min, and MHI Growth. Elasticity was modestly sensitive.

- *Res Max:*

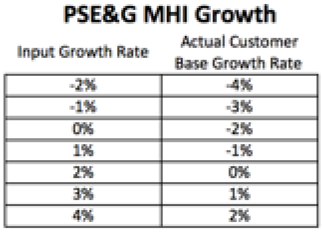
  PSE&G: The assumed maximum was 4.5%. A 4% input adds 6 occurrences of RR shortfall in 2030, 3 of which were for scenarios with RR changes of 2% (-70% through -90% change in Off-Grid). Another occurrence change presents in RR 9% Off-grid -20%, which implies that if PSE&G encounters significant expense issues (2030 RR would be equal to over 3.6x 2014 actual retail T&D revenues) their financial strength will be tied to political will on residential bill limitation. Conversely, a 5% Res Max removes more than 5 shortfall occurrences, including all scenarios with RR increasing by 3%, and an RR 6% off-grid -30% scenario.

  SCE: The assumed maximum was 4.5%. Res Max was less sensitive for SCE than for PSE&G. A 4% input adds 2 shortfall occurrences, including the scenario with RR 5% off-grid -20%. This scenario has the 2030 RR at 1.55x actual 2014 retail T&D revenues, and PGP in 2024/2025. Conversely, a 5% Res Max removes 4 occurrences of RR shortfalls.

- MHI Growth

PSE&G: The assumed real growth rate was 2%. Lower inputs (relative to the assumed 2%) for MHI growth had more of an effect than higher growth rates. A real growth rate of 0% added many shortfall occurrences, primarily in lower RR growth scenarios such as 1% and 2%. Conversely, a real growth rate of 4% removed all shortfalls in scenarios with RR growth of 3% and 4%, but these were also in sharp off-grid decline scenarios. Because of the assumptions around grid defection and redistribution PSE&G customer incomes, the following growth rates correspond to the percentage of base year MHI:

Table 32

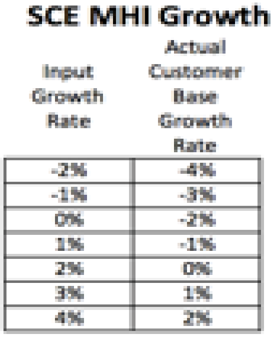


PSE&G MHI Growth

Input Growth Rate	Actual Customer Base Growth Rate
-2%	-4%
-1%	-3%
0%	-2%
1%	-1%
2%	0%
3%	1%
4%	2%

SCE: The assumed real growth rate was 2%. MHI Growth for SCE was sensitive on both the upside and downside. A real growth rate of 0% added a few shortfall occurrences, including one at RR 0% off-grid -30% (which represents a 2030 RR equal to 75% of actual 2014 retail T&D revenues, and PGP in 2021). A real growth rate of 4% removed a number of shortfalls in scenarios with RR growth below 2%. Because of the assumptions around grid defection and redistribution of PSE&G customer incomes, the following growth rates correspond to the percentage of base year MHI:

Table 33



SCE MHI Growth

Input Growth Rate	Actual Customer Base Growth Rate
-2%	-4%
-1%	-3%
0%	-2%
1%	-1%
2%	0%
3%	1%
4%	2%

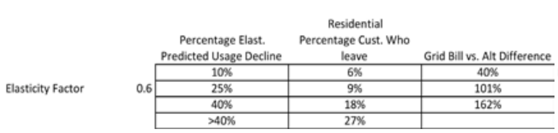
- *Elasticity*

  PSE&G: Using a scaling factor (with the assumed elasticity using a scaling factor of 1), the elasticity was stressed. When the scaling factor was .6 there was a significant decline in RR shortfall occurrences for RR annual increases of 3% and 4%. However, the elasticity factor entailed minimal consumer reaction at the prospect of economic savings from leaving the grid. Conversely, increasing the elasticity factor to 1.6 had almost no effect.

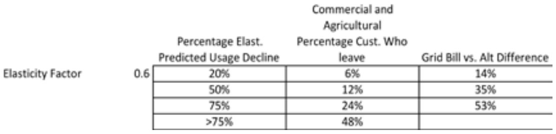
  SCE: Similar to PSE&G, the elasticity scaling factor had a more meaningful impact when decreased below the assumed value, showing more deviation from the base case than PSE&G. At a factor of .6, all RR shortfalls were eliminated below RR increases of less than 2%. The elasticity factors are increased by 10% for each year in which a consumer is economically indifferent from or incentivized to leave the grid.

PSE&G:

Table 34, 35

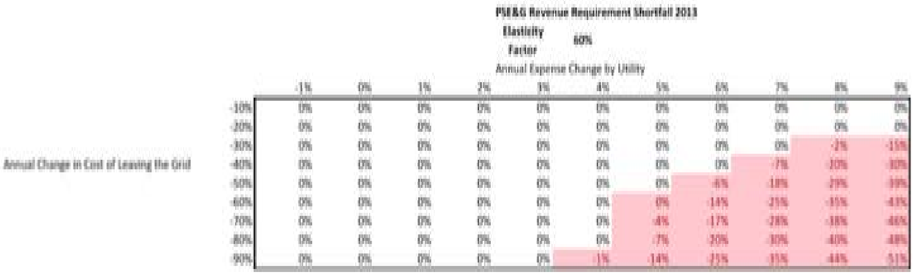


		Percentage Elast. Predicted Usage Decline	Residential Percentage Cust. Who leave	Grid Bill vs. Alt Difference
Elasticity Factor	0.6	10%	6%	40%
		25%	9%	101%
		40%	18%	162%
		>40%	27%	



		Percentage Elast. Predicted Usage Decline	Commercial and Agricultural Percentage Cust. Who leave	Grid Bill vs. Alt Difference
Elasticity Factor	0.6	20%	6%	14%
		50%	12%	35%
		75%	24%	53%
		>75%	48%	

Table 36



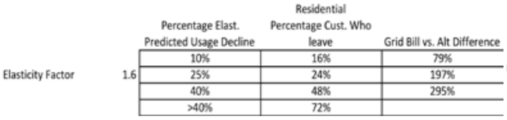
PSE&G Revenue Requirement Shortfall 2013

Elasticity Factor 60%

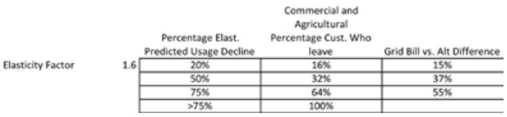
Annual Expense Change by Utility

		-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
Annual Change in Cost of Leaving the Grid	-10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-30%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-2%	-15%
	-40%	0%	0%	0%	0%	0%	0%	0%	0%	-7%	-20%	-30%
	-50%	0%	0%	0%	0%	0%	0%	0%	-6%	-18%	-29%	-39%
	-60%	0%	0%	0%	0%	0%	0%	0%	-14%	-25%	-35%	-43%
	-70%	0%	0%	0%	0%	0%	0%	-4%	-17%	-28%	-38%	-46%
	-80%	0%	0%	0%	0%	0%	0%	-7%	-20%	-30%	-40%	-48%
	-90%	0%	0%	0%	0%	0%	-1%	-14%	-25%	-35%	-44%	-51%

Table 37, 38

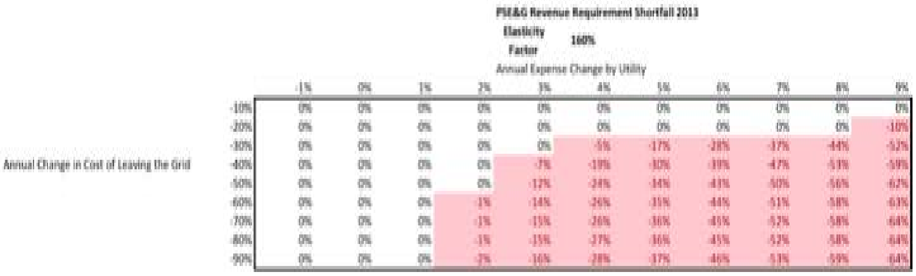


		Percentage Elast. Predicted Usage Decline	Residential Percentage Cust. Who leave	Grid Bill vs. Alt Difference
Elasticity Factor	1.6	10%	16%	79%
		25%	24%	197%
		40%	48%	295%
		>40%	72%	



		Percentage Elast. Predicted Usage Decline	Commercial and Agricultural Percentage Cust. Who leave	Grid Bill vs. Alt Difference
Elasticity Factor	1.6	20%	16%	15%
		50%	32%	37%
		75%	64%	55%
		>75%	100%	

Table 39



PSE&G Revenue Requirement Shortfall 2013

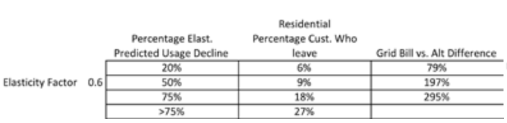
Elasticity Factor 160%

Annual Expense Change by Utility

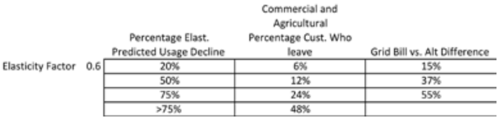
		-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
Annual Change in Cost of Leaving the Grid	-10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-10%
	-30%	0%	0%	0%	0%	0%	-5%	-17%	-28%	-37%	-44%	-52%
	-40%	0%	0%	0%	0%	-7%	-19%	-30%	-39%	-47%	-53%	-59%
	-50%	0%	0%	0%	0%	-12%	-24%	-34%	-43%	-50%	-56%	-62%
	-60%	0%	0%	0%	-1%	-14%	-26%	-35%	-44%	-51%	-58%	-63%
	-70%	0%	0%	0%	-1%	-15%	-26%	-36%	-45%	-52%	-58%	-64%
	-80%	0%	0%	0%	-1%	-15%	-27%	-36%	-45%	-52%	-58%	-64%
	-90%	0%	0%	0%	-2%	-16%	-28%	-37%	-46%	-53%	-59%	-64%

SCE:

Tables 40, 41

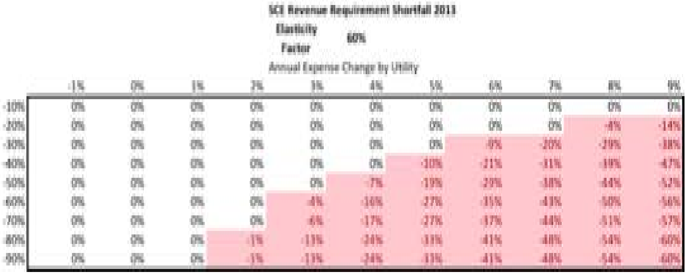


		Percentage Elast. Predicted Usage Decline	Residential Percentage Cust. Who leave	Grid Bill vs. Alt Difference
Elasticity Factor	0.6	20%	6%	79%
		50%	9%	197%
		75%	18%	295%
		>75%	27%	



		Percentage Elast. Predicted Usage Decline	Commercial and Agricultural Percentage Cust. Who leave	Grid Bill vs. Alt Difference
Elasticity Factor	0.6	20%	6%	15%
		50%	12%	37%
		75%	24%	55%
		>75%	48%	

Table 42



SCE Revenue Requirement Shortfall 2013

Elasticity Factor 60%

Annual Expense Change by Utility

Annual Change in Cost of Leaving the Grid

	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
-10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
-20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-4%	-14%
-30%	0%	0%	0%	0%	0%	0%	0%	-9%	-20%	-29%	-38%
-40%	0%	0%	0%	0%	0%	0%	-10%	-21%	-31%	-39%	-47%
-50%	0%	0%	0%	0%	0%	-7%	-19%	-29%	-38%	-44%	-52%
-60%	0%	0%	0%	0%	-4%	-16%	-27%	-35%	-43%	-50%	-56%
-70%	0%	0%	0%	0%	-6%	-17%	-27%	-37%	-44%	-51%	-57%
-80%	0%	0%	0%	-1%	-13%	-24%	-33%	-41%	-48%	-54%	-60%
-90%	0%	0%	0%	-1%	-13%	-24%	-33%	-41%	-48%	-54%	-60%

Tables 43, 44

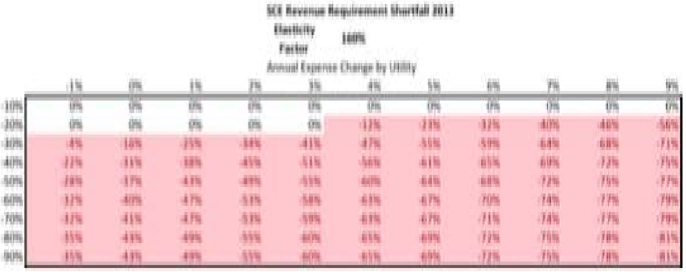
Residential

		Percentage Elast. Predicted Usage Decline	Percentage Cust. Who leave	Grid Bill vs. Alt Difference
Elasticity Factor	1.6	20%	16%	79%
		50%	24%	197%
		75%	48%	295%
		>75%	72%	

Commercial and Agricultural

		Percentage Elast. Predicted Usage Decline	Percentage Cust. Who leave	Grid Bill vs. Alt Difference
Elasticity Factor	1.6	20%	16%	15%
		50%	32%	37%
		75%	64%	55%
		>75%	100%	

Table 45



SCE Revenue Requirement Shortfall 2013

Elasticity Factor 160%

Annual Expense Change by Utility

Annual Change in Cost of Leaving the Grid

	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
-10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
-20%	0%	0%	0%	0%	0%	-12%	-23%	-32%	-40%	-46%	-56%
-30%	-4%	-16%	-25%	-34%	-41%	-47%	-55%	-59%	-64%	-68%	-71%
-40%	-22%	-31%	-38%	-45%	-51%	-56%	-61%	-65%	-69%	-72%	-75%
-50%	-28%	-37%	-43%	-49%	-55%	-60%	-64%	-68%	-72%	-75%	-77%
-60%	-32%	-40%	-47%	-53%	-58%	-63%	-67%	-70%	-74%	-77%	-79%
-70%	-32%	-41%	-47%	-53%	-59%	-63%	-67%	-71%	-74%	-77%	-79%
-80%	-35%	-43%	-49%	-55%	-60%	-65%	-69%	-72%	-75%	-78%	-81%
-90%	-35%	-43%	-49%	-55%	-60%	-65%	-69%	-72%	-75%	-78%	-81%

Appendix B – Detailed Model Methodology

- Residential customers in buildings with at least three units cannot leave the grid. These customers are assumed to be the lowest power usage consumers.
- Residential customers would benefit from political limitations on rates that equal on average 4.5% of the customers' median household income. Hawaii Electric Company, the largest electric utility in the State, has faced significant backlash by the Public Utilities Commission in Hawaii. The State is in the process of requiring the utility to implement certain plans to lower customer rates. However, these proceedings are not a straightforward order to lower rates, as the process is complicated by presence of net metering (until recently) and the reliance on petroleum as a fuel source (which is a significant cause of high rates). Accordingly, the case in Hawaii is a reasonable proxy for the limitation on rates, but likely provides a low end example since the cause of the expensive rates is not the same as would apply to PSE&G and SCE. The average annual bill in Hawaii almost $2,300 in 2014, equal to 3.35% of MHI for the State.[xxxiv, xxxv]
- All commercial and agricultural customers can leave the grid.
- Industrial customers cannot leave the grid and have a per customer ceiling on revenue. This restriction results from the energy needs of industrial customers. The ceiling is calculated using industrial customers' share of the RR in 2014 and the previous year's total earned revenue.
- Public lighting customers cannot leave the grid and have a per customer ceiling on revenue. The ceiling is a function of public customers' share of the RR in 2014.
- In RMI's "Grid Defection" report, the Westchester and Los Angeles LCOE represent the off-grid LCOE for PSE&G's and SCE's service areas respectively. Though the solar irradiance in Westchester does not align exactly to that of New Jersey, the difference

should not have a material impact on the analysis due to the magnitude of annual declines in off-grid LCOE in the scenarios. Additionally, while the customer distribution across usage levels for residential and industrial customers includes users whose annual usage (and therefore required system size) varies from RMI's report's assumptions, according to "Tracking the Sun", a report by the Lawrence Berkley National Laboratory[xxxvi], the economies of scale is minimal for residential systems larger than 10 KW. The system sizes assumed by RMI imply that for lower usage groups the off-grid LCOE would not be significantly different. Similar assumptions are made for commercial systems, though the lowest usage groups (with annual usage approaching that of residential systems) were assumed to be equal to residential off-grid costs with a small discount applied varying with size.

- The off-grid LCOE cannot drop below the on-grid cost of power generated for each customer class. The assumption that off-grid power should not fall below on-grid costs makes sense, because in the event of full deregulation and rapid new construction it seems extremely unlikely that off-grid costs could ever fall below the local on-grid costs of power (the deregulation should allow for customers to purchase the actual power supply from the cheapest available provider, while still paying the transmission and distribution charge to PSE&G and SCE).
- The cost of leaving the grid declines according to a L-Curve based on an assumed average decline over 15 years, or until the minimum cost level is reached.
- The distribution of usage among residential consumers is based on property valuations in the case of PSE&G, while the projections for SCE are based on zip-code level usage data provided by SCE. Commercial consumers for PSE&G are based on a distribution of number of employees among establishments, while the projections for SCE (also

applied to Agricultural customers) are based on zip-code level usage data provided by SCE.

- The MHI for each case was the state level figure reported by the US Census Bureau.
- MHI is expected to increase 2% over time. Additionally, the MHI in any given year is adjusted based on the change in customer profile over the time period (the residential customer numbers skew more towards low income over time because the lowest usage/multi-unit individuals cannot leave the grid).
- The cost of grid power for residential and commercial customers was calculated by dividing the total kWh sold by the total cost of power paid by the Utility, and making slight modifications based on average power costs paid in the State as calculated by the US Energy Information Administration. The cost of grid power remains flat on a real basis through 2030, because the analysis focuses on the relative cost of grid power to off-grid power, and does not seek to make detailed projections on the change in grid generation over time.
- For residential customers, the lower usage customers cannot leave the grid until 2 years after the higher usage consumers begin defection.
- Costs associated with property taxes are not included in the calculations.

Process For Calculating Earned Revenues And Customer Behavior Each Year

The iterated process consists of the following:

The total RR was allocated to customer classes based on the base year proportion of costs per customer compared across all classes. Commercial and agricultural customers are assumed to cover all required costs. Next, residential customers are expected to pay costs up to a percentage of median household income for the utility service area. Public (lighting) and industrial customers are assumed to pay their respective allocations of the RR up to their maximum.

Each year the residential, commercial, and agricultural customers view their previous year's electricity bill and compare it to the current cost of leaving the grid. The cost of leaving the grid is annualized and accordingly presumed to be constant over time. The potential percentage savings are calculated for each usage distribution group within each consumer class. The percentage is translated into an expected change in consumption using price elasticities calculated in research performed the National Renewable Energy Laboratory (Regional Differences in the Price-Elasticity of Demand for Energy M.A Bernstein and J. Griffin RAND Corporation Santa Monica, California), and in turn a percentage of "eligible" customers who would leave the grid. This percentage also increases the longer that customers are economically indifferent or incentivized to leave the grid. The equation used is:

$$breakeven\ quantity = distribution\ charge\ \div (off\ grid\ LCOE - on\ grid\ LCOE)$$

Depending on each scenario new customers may also join the grid as a result of population or economic growth, which is based on historical growth (adjusted for grid costs in that year). The new number of customers is pulled into the following year to calculate the new allocation of the RR among consumer classes.

Appendix C - References

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