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Witness: J.C. Martin

Application of SAN DIEGO GAS & ELECTRIC COMPANY (U 902 E) For Approval of its Electric Vehicle-Grid Integration Pilot Program.	))))	Application No. 14-04-014 (Filed April 11, 2014)

REVISED PREPARED DIRECT TESTIMONY OF

J.C. MARTIN

CHAPTER 6

ON BEHALF OF SAN DIEGO GAS & ELECTRIC COMPANY

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

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CHAPTER 6

I. INTRODUCTION

San Diego Gas & Electric Company (SDG&E) proposes a Vehicle-Grid Integration (VGI) Pilot Program with an innovative hourly time-variant rate, to promote efficient grid usage and charging. Measurement and analysis of the impact an electric vehicle (EV) charging rate has on EV charging decisions are critical aspects of the VGI Pilot Program and are discussed in this chapter. The VGI Pilot Rate, described in Cynthia Fang's testimony (Chapter 3), is designed to reflect in prices the dynamic nature of the grid's supply and demand balance for energy and capacity. The VGI Pilot Program will explore the degree to which lower hourly prices encourage EV charging when available energy and capacity resources are more abundant, and higher hourly prices discourage EV charging when these resources are scarcer. Hourly pricing for EV charging is enhanced by the use of enabling technology provided by the VGI Pilot Program's charging infrastructure, described in Randy Schimka's testimony (Chapter 2). This enabling technology provides a flexible and convenient method for customers to meet their EV charging needs, to minimize their EV fuel cost and to promote efficient grid usage. The VGI Pilot Program creates the opportunity to learn more about customers' EV charging behavior when exposed to hourly prices designed to encourage grid-integrated charging.

In line with the Commission's VGI White Paper issued November 22, 2013,[1] my testimony introduces a cost-effectiveness methodology for the Commission's consideration to use in evaluating various VGI solutions, such as those proposed in SDG&E's VGI Pilot Program. The methodology relies on an analytical model developed at my direction by Energy and Environmental Economics (E3), a consulting firm that has conducted economic assessments in support of the Commission's policy development in the area of distributed energy resources including distributed generation, demand response, and energy efficiency. The methodology and model described in my testimony builds upon standard cost-effectiveness tests familiar to the Commission.

Cost-effectiveness methodology is used to model EV charging in SDG&E's service territory under two sets of hypothesized assumptions, including assumptions on SDG&E's VGI Pilot Program. Results are used to infer market level insights into the cost and benefits of deploying EV charging at workplace and multi-unit dwelling (MuD) locations. The model output is illustrative only and is not intended to be predictive. However, results may provide policy makers with insights about various VGI solutions in the SDG&E EV charging market. The results also may provide policy makers with a method to evaluate the benefits of the VGI Pilot Program in general and the VGI Rate in particular.

The Research Plan described in my testimony provides a link between the hypothesized assumptions and realized VGI Pilot Program results available upon completion of the VGI Pilot Program. The Research Plan describes the data to be collected during the VGI Pilot Program deployment and operation (e.g., costs and energy usage at VGI facilities). As customer EV charging data and cost information becomes available through the VGI Pilot

[1] Available at: http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M080/K775/80775679.pdf

Program deployment and operation, observed results will replace hypothesized assumptions in order to more rigorously evaluate the cost-effectiveness of SDG&E's completed VGI Pilot Program.

To illustrate the effect of the hourly time-variant VGI pricing on EV customer charging decisions, two EV charging scenarios are hypothesized with two sets of assumptions. Both scenarios represent a depiction of SDG&E's service territory EV charging market. One scenario includes an EV charger deployment with the VGI Pilot Program including the VGI Rate (SDG&E VGI Rate scenario). The other scenario characterizes a similar EV charger deployment as the VGI Pilot Program, but deployed by a non-utility entity with EV charging priced as a flat fee (Non-utility Flat Fee scenario).

The Non-utility Flat Fee scenario depicts an EV charging environment inspired by today's options for EV customers. The SDG&E VGI Rate scenario utilizes cost inputs described in Chapter 2 and the VGI Rate pricing described in Chapter 3. The Non-utility Flat Fee scenario uses similar EV charging technology installation and cost assumptions as the SDG&E VGI Rate scenario with Flat Fee pricing. The composition of the Flat Fee is further described in section II.B.3.

II. COST EFFECTIVENESS MODELING

The VGI Pilot Program supports state policy and law encouraging efforts which increase the environmentally beneficial use of electricity as transportation fuel, described in the testimony of Lee Krevat (Chapter 1).[2] The VGI Pilot Program goal is to explore ways to improve the utilization of utility grid assets and energy resource availability for the benefit of

[2] Witness Lee Krevat's testimony, Chapter 1.

all customers.[3] The successful implementation of a VGI solution (as SDG&E proposes) is intended to result in increased electricity use and decreased fossil fuel use. The evaluation methodology will quantify the costs and benefits of these impacts.

The cost-benefit methodology described in my testimony employs and adapts similar analytical properties as methodologies currently in use to evaluate Energy Efficiency (EE), Demand Response (DR), and Distributed Generation (DG) programs. EE and DR programs are designed to reduce demand and energy use or shift electricity use to lower cost periods. EE, DR and DG programs are traditionally evaluated based on their incremental costs and benefits of discrete projects.[4]

Discrete project evaluation is less applicable for price-based EV charging programs, due to the unique flexibility of EV charging decisions. An EV customer can choose when (time of day), where (location), how quickly (kW), how long (duration) and how often (frequency) to charge. For an EV customer, EV fuel prices at one location and at one time will influence EV charging not only at that location and time, but also charging at other locations and at other available times. To capture these interrelated location and charging time dynamics, a market level approach (i.e., modeling all customer groups, vehicle types, charging locations, and prices) is required to evaluate load impacts and their corresponding costs and benefits for a price-based EV charging program.

A. Overview

SDG&E hired E3 to develop a VGI Cost-Benefit model leveraging many of E3's existing models already utilized in California energy policy analysis. Under my direction, E3

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[3] Alternative Fuel Vehicle Order Instituting Rulemaking, R.13-11-007.

[4] *See* "California Standard Practice Manual," http://www.cpuc.ca.gov/NR/rdonlyres/004ABF9D-027C-4BE1-9AE1-CE56ADF8DADC/0/CPUC_STANDARD_PRACTICE_MANUAL.pdf (2001).

performed analysis of SDG&E's hypothesized set of market level assumptions characterizing the proposed VGI Pilot Program, including the dynamic time-differentiated VGI Rate for EV charging at workplace and MuD locations. The analysis was conducted in three steps:

(1) Define market scenarios in terms of EV charging locations and pricing.

(2) Estimate aggregate market level load impacts for each scenario for each hour of the day.

(3) Calculate the cost and benefit components associated with each scenario and compile the results for the illustrative cost effectiveness tests.

1. EV Market Scenarios

This analysis models two SDG&E service territory wide EV market scenarios that model EV charging for current and future EVs in the SDG&E service territory. The primary differences between the two market scenarios is <u>who owns</u> the workplace and MuD EV charging technology (SDG&E or a non-utility entity), and <u>what prices</u> are EV customers exposed to at these charging locations (VGI Rate or Flat Fee).

a. SDG&E VGI Rate Scenario

SDG&E-owned VGI charging technology installations at workplace and MuD locations are deployed as described in this Application. EV customers are exposed to dynamic time-variant prices (VGI Rate) while charging EVs at VGI installations. The VGI Rate encourages grid-integrated EV charging based on the dynamic hourly price that reflects grid supply and demand conditions. (VGI Rate modeling is discussed in section II.B.4).

b. Non-utility Flat Fee Scenario

A Non-Utility entity owns charging installations at workplace and MuD EV locations and deploys them under similar assumptions as the SDG&E VGI Rate scenario. EV customers are exposed to Flat Fee prices while charging EVs in these locations. (The Flat Fee is described in section II.B.3).

2. Aggregate Market Level Load Impacts

Aggregate load impacts are estimated for each scenario to determine the hourly load and total usage (kW and kWh) for the entire SDG&E EV market. Aggregate load impacts are used as inputs to the VGI Cost-Benefit model. Customer behavior induced by EV charging prices is a key consideration in determining where and when EV charging occurs. EV charging load impacts are estimated under the assumption that EV customers desire to meet their EV driving requirements at the lowest available EV fuel prices. A cost optimization approach is used to estimate the price-induced EV charging behavior. This approach reflects the cost optimization built into the VGI Pilot Program technology and support system. The VGI system dispenses electricity at the lowest possible price within the EV charging customers' requirements, as explained in Mr. Schimka's testimony. This cost optimization process is discussed in section II.B.

3. VGI Cost-Benefit Model

The VGI Cost-Benefit Model estimates results for cost and benefit components used in the California Standard Practice Manual (standard) cost-effectiveness tests (e.g., as used with EE and DR program evaluations).[5] Aggregate load impacts are an important input to the VGI Model because several of the cost-benefit test components use hourly energy values as the basis for valuation. Once each test component is estimated, the standard cost-effectiveness tests are calculated, specifically: the Ratepayer Impact Measure (RIM), the

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[5] *See* "California Standard Practice Manual, *available at* http://www.cpuc.ca.gov/NR/rdonlyres/004ABF9D-027C-4BE1-9AE1-CE56ADF8DADC/0/CPUC_STANDARD_PRACTICE_MANUAL.pdf (2001).

Participant Cost Test (PCT), the Total Resource Cost (TRC), and the Societal Cost Test (SCT). Table 6-1 lists the test components and their relationship to the cost-effectiveness tests used in this analysis. The gray cells in table 6-1 indicate that a test component is not applicable to a particular cost-effectiveness test. Test Components for the cost-effectiveness tests are discussed in detail in section II.D below.

Table 6-1

VGI Pilot Program Cost-Effectiveness Tests

Test Components		Cost-Effectiveness Tests			
		RIM	**PCT**	**TRC**	**SCT**
EV Customer Costs & Benefits	Incremental Vehicle Cost		Cost	Cost	Cost
	Gasoline Savings		Benefit	Benefit	Benefit
	Utility Bills	Benefit	Cost		
	Flat Rate Fees		Cost		
	Federal Tax Credits		Benefit	Benefit	Benefit
	State Rebates		Benefit		
EV Charger Cost	Utility Assets (VGI Rate scenario only)	Cost		Cost	Cost
	Commercial Assets (Flat Rate scenario only)			Cost	Cost
	Customer Assets (Both scenarios)		Cost	Cost	Cost
Administrative Costs	Utility Assets (VGI Rate scenario only)	Cost		Cost	Cost
	Commercial Assets (Flat Rate scenario only)			Cost	Cost
Electricity Supply Costs	Energy Cost	Cost		Cost	Cost
	Losses Cost	Cost		Cost	Cost
	Ancillary Services Cost	Cost		Cost	Cost
	Capacity Cost	Cost		Cost	Cost
	T&D Cost	Cost		Cost	Cost
	RPS Cost	Cost		Cost	Cost
Societal Benefits	Avoided Gasoline CO_2				Benefit
	LCFS Benefits				Benefit
	Criteria Pollutants				Benefit

B. Cost Optimization Approach to Estimate EV Charging Load Impacts

EV charging load impacts are necessary to value many of the test components listed in Table 6-1 above. EV charging load impacts are estimated using a cost optimization approach, which models EV charging behavior in response to different pricing signals at different locations subject to EV mileage requirements and vehicle characteristics. The following sections describe the inputs used in the cost optimization process and a description of the approach. The section concludes with a description of how the aggregate EV charging load impacts are estimated.

1. EV Customer Groups, Mileage Requirements and Characteristics

The cost optimization process, developed for the purposes of evaluating the VGI Pilot Program, considers five groups of EV customers presented in Table 6-2. The EV customer groups are defined by their residential location (either Single Family (SF) or MuD) and by the availability of workplace EV charging (Unavailable, Preexisting, or New). Each EV customer group has available charging locations, prices and Zero Emission Miles (ZEM)[6] driving requirements. ZEM is the number of miles traveled using electricity as transportation fuel.

Available EV charging locations and prices are defined for each EV customer group depending on the day of the week and time of day. During day hours on weekdays, EV charging is assumed to be available at the workplace location (if available in the group), and during night hours EV charging is assumed to be available at the residence location (either SF or MuD). Weekend EV charging is assumed to occur exclusively at the residential location.

[6] Zero Emission Miles (ZEM) are also known as electric Vehicle Miles Traveled (eVMT).

Table 6-2

EV Customer Groups: Zero Emission Mile Requirements, EV Charging Locations and Prices							
EV Customer Groups			ZEM Required [2]	EV Charging Locations and Prices			
						Available Prices	
Group [1]	Residence Type	Workplace Charging Access		Charging Locations	Available Hours[3]	Non-Utility Flat Fee scenario	SDG&E VGI Rate Scenario
1	SF	Preexisting	With Workplace Charging Weekday	Workplace	Day	Flat Fee	Flat Fee
				Residence	Night	Residential Rates	Residential Rates
			Weekend	Residence	All	Residential Rates	Residential Rates
2	SF	Unavailable	Without Workplace Charging Weekday	Workplace	Day	N/A	N/A
				Residence	Night	Residential Rates	Residential Rates
			Weekend	Residence	All	Residential Rates	Residential Rates
3	SF	New	With Workplace Charging Weekday	Workplace	Day	Flat Fee	VGI Rate
				Residence	Night	Residential Rates	Residential Rates
			Weekend	Residence	All	Residential Rates	Residential Rates
4	MuD	Preexisting	With Workplace Charging Weekday	Workplace	Day	Flat Fee	Flat Fee
				Residence	Night	Flat Fee	VGI Rate
			Weekend	Residence	All	Flat Fee	VGI Rate
5	MuD	Unavailable	Without Workplace Charging Weekday	Workplace	Day	N/A	N/A
				Residence	Night	Flat Fee	VGI Rate
			Weekend	Residence	All	Flat Fee	VGI Rate

[1] A Driver group with MuD and with new Workplace charging is not analyzed due to small size.

[2] Zero Emission Miles (ZEM) traveled for Driver Groups with Workplace charging is "Base+" which is greater than ZEM for groups without Workplace charging "Base". Workplace charging is assumed to provide additional EV charging for additional ZEM.

[3] Day hours are 8 AM to 5 PM , Night hours are 6 PM to 7 AM.

The mix of prices available at residence and workplace locations are different for each EV customer group. Prices for all SF residential EV charging are assumed to be under residential utility rates, (described in section II.B.2). Prices for all preexisting workplace EV charging locations are assumed to be the Flat Fee, (described in section II.B.3). Customer groups without workplace charging only have the option for EV charging at their residence.

The mix of prices differs for the two scenarios in three EV Charging Groups. Group 3 (SF residential charging and new workplace charging) has different prices available at the workplace location (Flat Fee in the Non-utility Flat Fee scenario and VGI Rate in the SDG&E VGI Rate scenario). Groups 4 and 5 have different prices at their MuD residence EV charging location (Flat Fee in the Non-utility Flat Fee scenario and VGI Rate in the SDG&E VGI Rate scenario). Details on the Flat Fee are described in section II.B.3. Details on the VGI Rate are described in section II.B.4.

In addition to prices available at charging locations, each EV customer group has required ZEM. Required ZEM is the number of electric miles needed by the EV customer each day. Required ZEM mileage for each EV customer group is dependent on the availability of workplace charging. Availability of workplace charging is assumed to provide additional EV charging for additional weekday ZEM driving. Required ZEM is defined as "Without Workplace Charging" for EV customer groups without access to workplace charging, and defined as "With Workplace Charging" for groups with access to workplace charging. Weekend required ZEM is not influenced by workplace EV charging, because weekend charging is assumed to occur at the residence only. The number of ZEM electric miles required is specific to the type of EV, as listed in Table 6-3.

Table 6-3

EV Zero Emission Mileage Requirements and Characteristics						
	ZEM Required					
EV Type	Without Workplace Charging Weekday	With Workplace Charging Weekday	Weekend	Battery Capacity (miles)	Watt Hours per Mile	EV Departure Min. SOC Required
BEV	30.8	31.9	26.2	66	350	30%
PHEV-10	10.0	20.0	10.0	10	350	30%
PHEV-20	20.0	31.9	20.0	20	350	30%
PHEV-40	31.9	31.9	27.2	40	350	30%
BEV = Battery Electric Vehicle w/ less than 100 mile range.						
PHEV-10 = Plug-in Hybrid Electric Vehicle w/ 10 mile EV range.						
PHEV-20 = Plug-in Hybrid Electric Vehicle w/ 20 mile EV range.						
PHEV-40 = Plug-in Hybrid Electric Vehicle w/ 40 mile EV range.						
ZEM = Zero Emission Miles. 31.9 miles is assumed maximum daily vehicles miles						
SOC = battery's State of Change.						

Table 6-3 lists required ZEM and EV characteristics for each EV type. The four EV types include a Battery Electric Vehicle (BEV) (an all-electric vehicle) and three Plug-in Hybrid Vehicles (PHEV) with different maximum EV ranges. "Watt Hours per Mile" is used to convert the ZEM requirements from miles into kWh requirements for the cost optimization process. Battery capacity for each EV type represents the maximum ZEM ranges available when fully charged. EV departure minimum state of charge (SOC) is an additional constraint used by the cost optimization process.

Single Family residential EV chargers are included in the analysis but are not locations for VGI Pilot Program installations. Assumptions are made on the type of EV charger that an EV customer uses at their SF residence. The type of charger in a SF residence is determined by the EV-type battery capacity. A BEV and PHEV-40 is assumed to have a Level 2 (L2) SF charger, and a PHEV-10 and PHEV-20 is assumed to have a Level 1 (L1) SF charger. L1 chargers are assumed to have a 1.6 kW average charging capacity, and L2 chargers a 3.5 kW average charging capacity.

Workplace and MuD EV charging is assumed to be 50% L1 and 50% L2 chargers, as reflected in Mr. Schimka's testimony. The charger capacity assumption influences the quantity of kWhs consumed at a particular location for a particular hour.

2. Residential Rates

Prices for SF residential EV charging are assumed to be a mixture of residential rates available to SDG&E's EV customers. The residential rates considered are Schedule EV-TOU-2 and Schedule DR. The EV-TOU-2 rate is a whole house EV rate, which has different prices for each time-of-use period.[7] EV-TOU-2 prices used in this analysis are $0.3133/kWh On-Peak, $0.1940/kWh Off-Peak, and $0.1648/kWh Super Off-Peak for summer months, and $0.2051/kWh On-Peak, $0.1968/kWh Off-Peak, and $0.1673/kWh Super Off-Peak for winter months. The DR rate is the default residential rate, which has inverted tier prices with four price tiers determined by total consumption.[8] The DR price used in this analysis is assumed to be $0.2949/kWh for summer months, and $0.2833/kWh for winter months. These DR prices are weighted averages of the DR rate tiers. Fifty percent of all SF residential EV charging is assumed to occur under the DR rate and 50% under EV-TOU-2.

3. Flat Fee (For Non-Utility EV Charging)

The Flat Fee is intended as a generalized price for non-utility EV charging. The observed price for non-utility EV charging in the SDG&E service territory is generally either free,

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[7] For details on SDG&E's Schedule EV-TOU-2 *see*: https://www.sdge.com/sites/default/files/regulatory/Schedules%20EV%20&%20EV-TOU-2%20Apr2014.pdf

[8] For details on SDG&E's Schedule DR *see*: https://www.sdge.com/sites/default/files/regulatory/Schedule%20DR%20Apr2014.pdf

priced by the hour, or priced as a subscription for limited to unlimited charging access. The Flat Fee is derived from an assumed average non-utility EV charging cost of $1.25 per EV charging hour. This cost is translated to a flat $0.36/kWh price by assuming that non-utility EV chargers dispense electricity at an average rate of 3.5 kW per connected hour.

4. VGI Rate

A central component to SDG&E's proposed VGI Pilot Program is the VGI Rate: a dynamic hourly electricity price that incorporates California Independent System Operator (CAISO) wholesale electricity prices and Critical Peak Pricing (CPP) for the California electricity system and for SDG&E distribution circuits. The VGI Rate is calculated in the cost-benefit model as described in Ms. Fang's testimony with three exceptions to accommodate price modeling limitations. The three modeling exceptions are:

a. CAISO Day-Ahead Hourly Price

CAISO day-ahead hourly price and CAISO Day-of adjustment are estimated using the hourly incremental costs of energy described in section II.D.2.

b. VGI Commodity Critical Peak Pricing Hourly Adder

The VGI Commodity Critical Peak Pricing (C-CPP) Hourly Adder is applied to the top 150 statewide gross load forecast hours as a proxy for SDG&E top system hours. The Statewide gross load forecast is used instead of SDG&E's system load in order to remain consistent with the DER Avoided Cost methodology.

c. Distribution Critical Peak Hourly Adder

The Distribution Critical Peak Pricing (D-CPP) Hourly Adder is applied to the top 200 statewide gross load forecast hours, as a proxy for SDG&E circuit data. Modeling VGI prices for each SDG&E circuit is beyond the capabilities of the cost-benefit model.

5. Cost Optimization Approach

The EV cost optimization approach uses information for each EV Customer Group (see Table 6-2) and each EV Type. This information is used to determine total electricity needed for required ZEM and is used to distribute shares of the total electricity to available charging locations and prices. The cost optimization process distributes the shares of total electricity to produce the lowest EV fueling cost.

This cost optimization approach evaluates charging costs over a three-day period (a seventy-two-hour period starting at midnight). Only the second day results are retained for load impact purposes, in order to limit the impact of a 50% SOC assumption used for the first hour of the three-day period. The third day is included, because evening EV charging on the second day may be influenced by the third day's available prices and required ZEM. Weekend charging assumes that an EV has sufficient time to charge from the initial 50% SOC to 100% SOC before weekend driving occurs. The cost optimization approach prioritizes EV charging to the earliest hours, when prices are in effect over multiple consecutive hours (such as the Flat Rate and SF residential rates). The result of this process is hourly load shapes for each EV Driver Group location and each EV Type for every hour of the year.[9] The final step in estimating the load impacts for the entire EV market is to aggregate the charging load shapes to the EV population.

C. Aggregate EV Charging Impacts

As discussed above, EV charging load impacts are estimated using a cost optimization process to determine hourly kWh charging for the EV Customer Group locations and for each

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[9] These hourly load shapes are an input to the Utility Bill and Commercial Charging Fees, as shown in section II.D.1.

EV Type. These group load shapes are allocated to the EV population forecast to create aggregate charging load shapes for the EV market in SDG&E's service territory, under the two scenarios. Load shapes are a key input to several components of the standard cost tests discussed below.

1. Allocation of EV Customer Groups to Population Forecast

Each driver group is allocated to the EV Population forecast based on several factors. The factors include the assumption that 46% of all current EV drivers have access to workplace charging today.[10] The proportion of EV charging in use at workplace and MuD also are a factor in the allocation, as is the installation schedule for the workplace and MuD chargers. Table 6-4 shows the allocations over time.

Table 6-4

Allocation EV Population Forecast to EV Customer Groups

EV Customer Groups			Portion of EV Population Forecast Applied to EV Customer Group														
Group	Residence Type	Workplace Charging Access	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
1	SF	Preexisting	46.0%	45.5%	44.3%	42.1%	40.5%	41.4%	42.3%	43.0%	43.7%	44.1%	44.5%	44.7%	44.9%	45.1%	45.2%
2	SF	Unavailable	54.0%	52.9%	50.2%	44.7%	39.6%	41.9%	44.2%	46.1%	47.9%	49.1%	50.0%	50.7%	51.2%	51.5%	51.8%
3	SF	New	0.0%	1.0%	3.2%	7.2%	10.0%	8.3%	6.8%	5.5%	4.2%	3.4%	2.8%	2.3%	2.0%	1.7%	1.5%
4	MuD	Preexisting	0.0%	0.3%	1.0%	2.8%	4.6%	3.8%	3.1%	2.5%	1.9%	1.6%	1.3%	1.1%	0.9%	0.8%	0.7%
5	MuD	Unavailable	0.0%	0.3%	1.2%	3.2%	5.4%	4.5%	3.7%	3.0%	2.3%	1.8%	1.5%	1.2%	1.1%	0.9%	0.8%
Total			100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Portion of vehicles with access to the VGI Rate (Groups 3, 4 & 5)			0.0%	1.6%	5.4%	13.2%	19.9%	16.7%	13.5%	10.9%	8.5%	6.7%	5.5%	4.6%	3.9%	3.4%	3.0%

2. EV Population Forecast

The EV population forecast is used to aggregate the EV customer groups to the entire EV market in SDG&E's service territory. The EV population forecast is based on the EV adoption forecast forthcoming from the California Electrification Transportation Coalition (CalETC), and is shown in Table 6-5. An additional 3,300 EVs are added to the CalETC

[10] This assumption is based on survey results from the California Center for Sustainable Energy (CCSE) February 2014 Report and Infographic, available at http://energycenter.org/clean-vehicle-rebate-project/vehicle-owner-survey/feb-2014-survey.

forecast to create an EV forecast (Table 6-5), in recognition that a workplace and MuD charging project of the size proposed in this application will result in additional EV adoption by drivers. SDG&E assumes on average 6 incremental EV adoptions per VGI site installation – higher for MuD and lower for workplace.[11]

The EV forecast projects an EV population below the 2025 target for zero-emission vehicle in the Governor's executive order to help bring 1.5 million zero-emission vehicles onto California's roads.[12] SDG&E's EV forecast projects 119,526 EVs in SDG&E's service territory in 2025, which represents a California-wide projection of approximately 1.3 million EVs. SDG&E's share of the California EV market is assumed to be 9.43%.

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[11] EV adoption due to the presence of workplace and MuD charging is a hypothesis to be tested by SDG&E's VGI Pilot Program. Appendix B to Mr. Schimka's Testimony reveals that 67% (40 out of 57 of respondents) indicated that the presence of workplace charging influenced their EV buying decision.

[12] *See* Governor Brown's Executive Order (March 23, 2012), http://gov.ca.gov/news.php?id=17463.

Table 6-5

Cumulative EV Population Forecast										
	SDG&E's Share of CalETC PEV Forecast[1]				EV Additions [2]	EV Forecast used in Scenarios[3]				
Year	BEV	PHEV-10	PHEV-20	PHEV-40		BEV	PHEV-10	PHEV-20	PHEV-40	Total
2014	3,591	1,159	1,159	2,318	-	3,591	1,159	1,159	2,318	8,227
2015	4,933	1,793	1,793	3,585	300	5,008	1,868	1,868	3,660	12,403
2016	6,298	2,434	2,434	4,869	900	6,523	2,659	2,659	5,094	16,936
2017	7,687	3,084	3,084	6,169	2,100	8,212	3,609	3,609	6,694	22,124
2018	9,100	3,797	3,797	7,595	3,300	9,925	4,622	4,622	8,420	27,589
2019	11,027	4,670	4,670	9,341	3,300	11,852	5,495	5,495	10,166	33,008
2020	13,869	5,860	5,860	11,721	3,300	14,694	6,685	6,685	12,546	40,611
2021	17,577	7,341	7,341	14,681	3,300	18,402	8,166	8,166	15,506	50,240
2022	22,533	9,771	9,771	19,543	3,300	23,358	10,596	10,596	20,368	64,918
2023	28,144	12,512	12,512	25,024	3,300	28,969	13,337	13,337	25,849	81,492
2024	34,201	15,583	15,583	31,166	3,300	35,026	16,408	16,408	31,991	99,834
2025	40,366	18,965	18,965	37,930	3,300	41,191	19,790	19,790	38,755	119,526
2026	46,638	22,770	22,770	45,541	3,300	47,463	23,595	23,595	46,366	141,019
2027	52,567	26,592	26,592	53,183	3,300	53,392	27,417	27,417	54,008	162,233
2028	58,542	30,256	30,256	60,512	3,300	59,367	31,081	31,081	61,337	182,866
2029	63,836	33,762	33,762	67,523	3,300	64,661	34,587	34,587	68,348	202,183
2030	69,232	37,316	37,316	74,632	3,300	70,057	38,141	38,141	75,457	221,796

[1] Source: Forthcoming "California Transportation Electrification Assessment - Final Draft Phase 1 Report", Table 8, CalETC - prepared by ICF International. SDG&E's share is assumed to be 9.43%.

[2] EV Additions are vehicles purchased due to a Workplace and MUD charging program, these vehicles are distributed in equal proportions across the four EV Types to create the VGI forecast.

[3] This EV Forecast is used in both the Non-utility Flat Fee scenario and SDG&E VGI Rate scenario.

The EV forecast is used in both the SDG&E VGI Rate scenario and the Non-utility Flat Fee scenario. After the group load shapes are allocated to the EV population forecast, the resulting aggregate charging load shapes for the EV market in SDG&E's service territory are available as inputs for some of the Cost Effectiveness test components (see Section II.D).

This section describes the cost optimization process to estimate EV charging load impacts, for the Flat Rate and the SDG&E VGI Rate scenarios. Assumptions on vehicle miles and charging requirements and constraints are described. The prices used in the optimization process are described, including SF residential rates, the Flat Rate, and the VGI Rate. The approach to estimate the VGI Rate hourly price estimates are also described. The cost optimization approach uses these assumptions, requirements, constraints and prices to estimate hourly EV charging load shapes for the EV Customer Groups and EV Types in both scenarios (Flat Fee and VGI Rate) These load shapes are aggregated to the SDG&E service territory EV population in order to derive the EV Charging Load Impacts.

D. Cost-Effectiveness Test Components

This section describes the methods used to calculate the Test Components used in the standard Cost-Effectiveness Tests. Table 6-1 shows which Test Components are used in each of the Cost-Effectiveness Tests.

1. EV Customer Costs and Benefits

Several test components are costs paid or benefits received by the EV customer. These costs and benefits include Incremental Vehicle Cost, Utility Bills, Commercial Charging Fee, Gasoline Savings, Federal Tax Credits and State Rebates. Each of these components is discussed in this section.

a. Incremental Vehicle Cost

Incremental vehicle cost is the cost premium for a customer who purchases an EV relative to an otherwise comparable internal combustion engine (ICE) vehicle. Table 6-6 lists the cost above a comparable ICE vehicle. This cost premium is assumed to decrease over time by 10% per year.[13]

[Remainder of page intentionally left blank]

[13] *See* ICF International and E3, California Transportation Electrification Assessment (Draft Phase 1 Report), March 14, 2014.

Table 6-6

EV Cost Premium and Comparable MPG		
EV Type	MPG of Comparable ICE Vehicle	Cost Above Comparable ICE Vehicle[1]
BEV	31	$16,380
PHEV-10	29	$5,717
PHEV-20	28	$11,434
PHEV-40	27	$15,206
[1]Internal Combustion Engine (ICE). Pre-tax Incremental cost of EV relative to ICE vehicle ($2013) is assumed to decrease over time by 10% per year.		

b. Gasoline Savings

Gasoline Savings is an avoided cost for EV drivers, since they do not need to purchase fossil fuels for ZEM driving. Gasoline Savings is estimated by multiplying estimated gallons of gasoline displaced by electric fuel by a gasoline price of $4.318 per gallon in 2014 and increases over time.[14] The gallons of gasoline displaced are estimated by multiplying the annual ZEM requirements for each EV type by the miles per gallon (MPG) of the comparable ICE vehicle (See Table 6-6). The MPG for comparable ICE vehicles increases over time to reflect improving fuel economy requirements.

c. Utility Bills & Flat Rate Fees

Utility Bills are costs paid by the EV customer to SDG&E for charging an EV under an applicable retail rate. Utility Bills and Flat Fees are estimated using load shape shares

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[14] Source: CEC, "Transportation Fuel Price And Demand Forecasts: Inputs And Methods For The 2009 Integrated Energy Policy Report" CEC-600-2009-001-SD (2009) http://www.energy.ca.gov/2009publications/CEC-600-2009-001/CEC-600-2009-001-SD.PDF

(*see* table 4, retail gasoline and diesel price forecasts, the mid-point of the High and Low values are used) associated with the applicable rate. Applicable SDG&E Residential Rates (EV-TOU-2 and DR) are applied to load shape shares from locations using Residential Rates.[15]

Flat Fee price is applied to load shape shares from locations using the Commercial Charging Fee. These Flat Fee load shapes are used to calculate Utility Bills for these locations. At Flat Fee locations, the EV customer pays the Flat Fee price, and another entity pays the Utility Bill for the electricity used for EV charging. The entity paying the Utility Bill at the Flat Fee locations may be the Utility customer at that site or may be the non-utility EV charging facility owner. The Utility Bills at these Flat Fee locations are assumed to be on SDG&E's Schedule AL-TOU. The rates for the AL-TOU bill are summarized in Table 6-7.

Table 6-7

Commercial AL-TOU Rate
Values Used For VGI Utility Bill Estimates

	Energy ($/kWh)			Demand ($/kW)	
Season	**On-Peak**	**Semi-Peak**	**Off-Peak**	**On-Peak**	**Non-Coincident**
Summer	$0.12399	$0.09895	$0.07371	$ 16.66	$ 19.96
Winter	$0.11857	$0.10764	$0.08082	$ 6.49	$ 19.96

See: https://www.sdge.com/sites/default/files/regulatory/Schedule%20AL-TOU%20%28secondary%20voltage%29%20Rates%20Effective%204-1-14.pdf

EV charging load shape shares are estimated during the cost optimization process and are inputs to the estimation process (*see* section II.C.2).

d. Federal Tax Credit

The federal tax credit is a one-time tax credit available to an EV Customer who purchases a new EV. The credit amount is dependent on the battery capacity of the EV. The BEV credit is $7,500, the PHEV-40 credit is $7,500, the PHEV-20 credit is $4,000 and the

[15] *See* Table 6-2 where Pricing Scenario is Residential Rates or VGI Rate or Flat Rate Fee.

PHEV-10 credit is $2,500. This credit is reduced over time for future EV purchases.[16] The federal tax credit is assumed to expire after 2023.

e. State Rebate

The state rebate is a one-time payment to an EV Customer who purchases or leases a new EV. The rebate is dependent on the battery capacity of the EV. The BEV rebate is $2,500, and the rebate for all PHEVs is $1,500. This rebate is reduced over time for future EV leases or purchases.

2. Electricity Supply Costs

Estimated hourly incremental Electricity Supply Costs ($/kWh) are modeled hourly using the E3 Distributed Energy Resources (DER) Avoided Cost methodology.[17] The Electricity Supply Costs are a consolidation of individual cost components similar to those estimated in the DER Avoided Cost model (i.e., Energy, Losses, Ancillary Services, Emissions, Capacity, T&D, RPS) with some VGI-specific variations; each component's methodology and VGI-specific variations are described as follows.

a. Energy Cost

Hourly incremental energy price estimates are developed using the E3 Renewable Energy Flexibility (REFLEX) model[18] and the E3 Renewables Portfolio Standard (RPS) model.[19] Using these models, E3 developed a California statewide dispatchable resource

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[16] *See* ICF International, California Transportation Electrification Assessment (Final Draft Phase 1 Report), June, 2014, p.78.

[17] *See* E3's Distributed Energy Resources Avoided Cost Model (July 24, 2012): https://www.ethree.com/documents/DERAvoidedCostModel_v3_9_2011_v4d.xlsm

[18] *See* E3's "Investigating a Higher Renewables Portfolio Standard in California" (2014): http://www.ethree.com/documents/E3_Final_RPS_Report_2014_01_06_with_appendices.pdf.

[19] *See* E3's 33% RPS Calculator with Output Module: https://www.ethree.com/documents/LTPP/Model%20w%20OutputModule%20-%202007.zip.

supply stack, which ranks generators by variable energy cost. The cost of carbon dioxide (CO_2) emissions is embedded in the energy cost. The resource stack is used to correlate statewide net load and marginal energy price. E3 uses a gross load forecast, with two renewable penetration levels: 33% and 40%.[20] The 33% renewable penetration level represents the 33% RPS goal for the California utilities and the 40% level represents the 33% RPS plus future renewable and distributed photovoltaic installations.[21] The 40% renewables level is used for Energy Costs reported in the illustrative results (Section IV). The 33% renewables level is reported in the illustrative results as a sensitivity analysis.

Statewide hourly net load data (statewide gross load forecast[22] minus renewable generation) are created for eight representative day types described below. The end results are marginal hourly energy prices in dollars per kWh for each hour for each of the eight day types. The eight day types are weighted to represent a 365-day year. Table 6-8 describes the eight day types selected to reflect combinations of gross load conditions (high or low) and renewable generation conditions (high or low). Each day type was assigned a weight, such that the eight day types can be combined to represent a full year. This energy price component replaces the DER model's energy price.

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[20] *See* E3's "Renewable Energy Flexibility (REFLEX) Results California ISO Webinar" (December 9, 2013), http://www.caiso.com/Documents/RenewableEnergyFlexibilityResults-Final_2013.pdf

[21] *See* SDG&E's current Net Energy Metering enrollments and enrollment MW cap: http://www.sdge.com/clean-energy/net-energy-metering/overview-nem-cap.

[22] *See* "California Energy Demand 2014 - 2024 Final Forecast, Volume 1: Statewide Electricity Demand, End-User Natural Gas Demand, and Energy Efficiency" - Final Staff Report. CEC-200-2013-004-SF-V1 (December 2013), http://www.energy.ca.gov/2013publications/CEC-200-2013-004/CEC-200-2013-004-SF-V1.pdf.

Table 6-8

REFLEX Model Day Types						
Day Type	**Descriptive Month**	**Day of Week**	**Load Level**	**Renewable Availability**	**Days Per Year**	**% Weight**
1	March	Weekday	Low	High	37	10.1%
2	March	Weekend	Low	High	30	8.2%
3	July	Weekday	High	High	26	7.1%
4	September	Weekday	High	Low	24	6.6%
5	September	Weekend	High	Low	1	0.3%
6	August	Weekday	High	High	57	15.6%
7	November	Weekend	Low	Low	73	20.0%
8	December	Weekday	Low	Low	117	32.1%
					365	100.0%

b. Losses

In addition to energy prices, incremental energy losses are estimated.[23] Losses are calculated from the DER avoided cost model using SDG&E's time of use-specific transmission and distribution loss factors. Losses are applied as a fraction of the incremental energy price. This approach reflects that EV loads at the meter require a larger amount of central station generation (and corresponding carbon emissions) due to energy losses.

c. Ancillary services costs

Incremental ancillary service (such as scheduling, dispatch, reactive power, voltage control, loss compensation, load following, system protection, and energy imbalance) are the same as in the DER avoided cost model; ancillary services cost was assumed to be 1% of hourly energy cost.

[23] Losses are caused by electrical resistance; resistance increases with electric load.

e. System Capacity Costs

Annual system capacity values are derived from the DER avoided cost model. The annual values are allocated to individual hours using the methodology applied in the DER avoided cost model, which assigns incremental system capacity values to the top 250 hours of net load over the course of the year. As in the DER avoided cost model, a planning reserve margin of 15% is included. The Resource Balance Year is adjusted from 2017 to 2014 to reflect the fact that SDG&E is currently authorized to procure additional generation capacity.[24]

f. T&D Capacity Costs

In the DER avoided cost model, annual transmission and distribution (T&D) deferral values are allocated to specific hours based on climate-zone specific temperatures. Hourly allocation factors from that model represent California climate zone 7, as defined by the California Energy Commission.[25] Climate zone 7 is the best match to SDG&E's service territory.

g. RPS Cost

The incremental RPS factor is applied to hourly incremental Energy Cost to reflect the additional renewable resources that must be purchased by the utility as a result of load increases, under a 33% and a 40% renewables level considered in the analysis. These RPS factor estimates are taken directly from the DER avoided cost model.

[24] *See* D.14-03-004, pp. 2 and 4.

[25] *See* http://www.energy.ca.gov/maps/renewable/Building_Climate_Zones.pdf.

h. Total Electricity Supply Cost Estimates

The incremental hourly Electricity Supply Cost estimates are the sum of each of the hourly components described previously. Hourly Electricity Supply Cost estimates were developed for each of the eight representative day types. As described, each day type was assigned a weight such that the eight days combined to result in a year of hourly Electricity Supply Costs and extrapolated into the future using the E3 NEM Avoided Cost Model methodology. This estimate is used as the Electricity Supply Cost ($/kWh) component of the standard cost test. Examples of the estimated hourly Electricity Supply Cost estimates for two day types are illustrated in Figures 6-1 and 6-2.

Figure 6-1
REFLEX Day Type: March Weekend - Low Load - High Renewables
(40% Renewables)

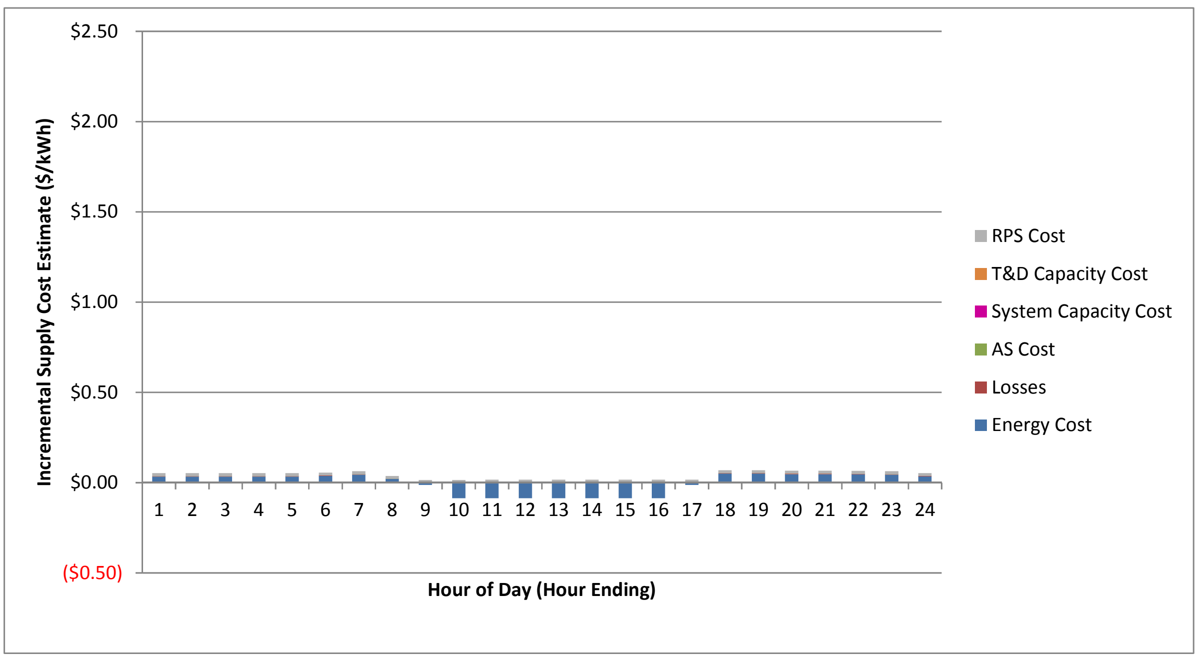
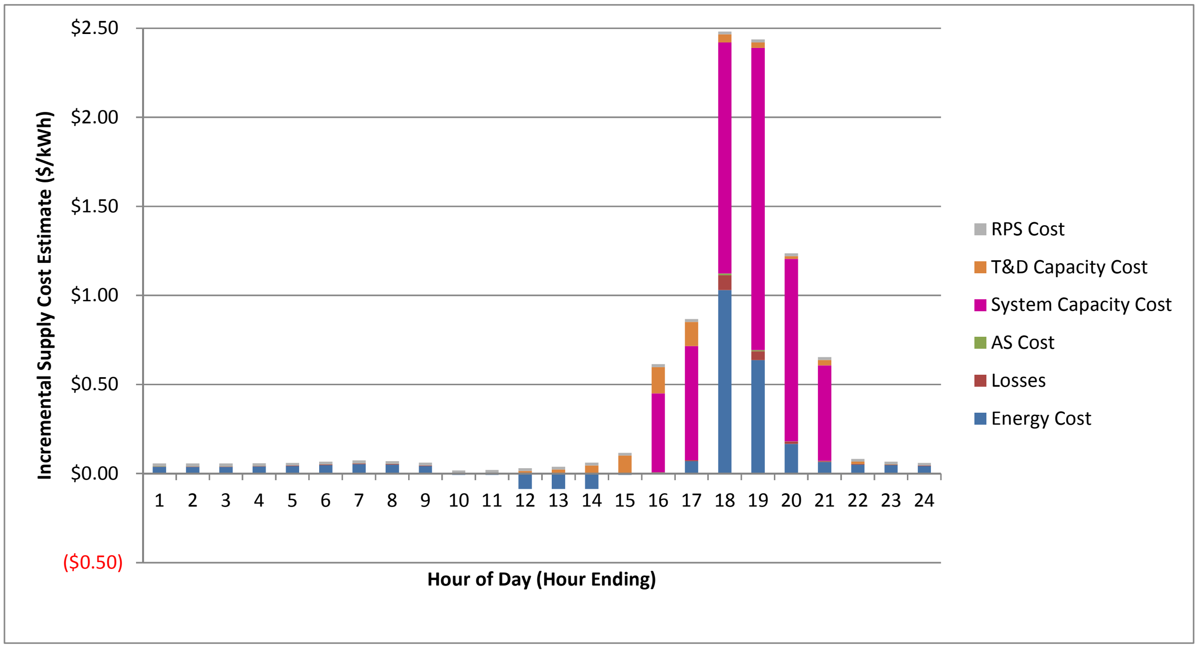


Figure 6-2.
REFLEX Day Type: Sept. Weekday - High Load -Low Renewables (40% Renewables)



3. EV Charging Equipment Costs and Administrative Costs

Charging Equipment costs and Administrative costs for the SDG&E VGI Rate scenario are the VGI Pilot Program costs described in Mr. Schimka's testimony and quantified in Mr. Atun's testimony. Table 6-9 defines which costs in Mr. Schimka's testimony are applicable to Charging Equipment costs and which are applicable to Administrative costs. Table 6-9 also indicates which costs are applicable to the Non-utility Flat Fee scenario. VGI Billing costs are excluded from the Non-utility Flat Fee scenario (see shaded cost components in Table 6-9). Franchise Fees and Uncollectables (FF&U) are removed from the Non-utility Flat Fee scenario cost estimates since FF&U do not apply to a non-utility owner EV charger.

Table 6-9

VGI Pilot Program Costs Standard Cost Test Treatment by Market Expansion Scenario				
Mr. Schimka's Testimony Cost Components		Cost Test Treatment		
			Used in	
Chapt. 2 Reference	Descriptive Summary	Cost Test Component	VGI Rate scenario	Flat Rate scenario
5.C.1	Engineering Design and Permitting	EV Charger	Yes	Yes
5.C.2	New Electric Service: Electrical Installation	EV Charger	Yes	Yes
5.C.2	New Electric Service: Transformer Installation	EV Charger	Yes	Yes
5.C.3	EVSE Installation	EV Charger	Yes	Yes
5.C.4	Access Control Equipment Installation	EV Charger	Yes	Yes
5.D.1	VGI Billing System Integration - Software	EV Charger	Yes	No
5.D.1	VGI Billing System Integration - Hardware	EV Charger	Yes	No
5.D.2	VGI Phone and Web Applications	EV Charger	Yes	No
6.A.a	Replacement costs - EVSE Equipment	EV Charger	Yes	Yes
6.A.b	Replacement costs - Access Control Equipment	EV Charger	Yes	Yes
6.A.c	Replacement costs - ADA Costs	EV Charger	Yes	Yes
6.B.a	Access Control Equipment Installation	EV Charger	Yes	Yes
6.C.5	ADA, Parking Modifications and Signage	EV Charger	Yes	Yes
6.C.a	Customer Engagement - internal labor	Administrative	Yes	Yes
6.C.b	Customer Engagement - contract labor	Administrative	Yes	Yes
6.C.c	Customer Engagement - contract labor (yr. 3&4)	Administrative	Yes	Yes
6.D.a	Customer Engagement Materials - events & web content	Administrative	Yes	Yes
6.D.b	Customer Engagement Materials - marketing materials	Administrative	Yes	Yes
6.E.a	Billing System Integration - first 2 years	Administrative	Yes	No
6.E.b	Billing System Integration - first 4 years	Administrative	Yes	No
6.F.a	Customer Support and Billing Integration Services	Administrative	Yes	No
6.G.a	Rates/Distribution Circuit Modeling	Administrative	Yes	No
6.H.a	Evaluation of VGI Program & Load Impacts	Administrative	Yes	Yes

Charging Equipment costs at SF residences (included in both scenarios) are assumed to be dependent on the type of EV. BEVs and PHEV-40 are assumed to have L2 SF residence chargers at a cost of $1,500 per EV, and PHEV-10 and PHEV-20 are assumed to have the L1 cord set provided with the EV at no incremental cost.

Pre-existing workplace charging equipment cost is estimated at $1,500 per EV charger. The number of preexisting workplace charging units is estimated at 0.2 per EV in service.[26] Pre-existing workplace charging equipment is assumed to be the same for both scenarios (SDG&E VGI Rate scenario and Non-utility Flat Fee scenario).

4. Societal Benefits

SDG&E includes three sets of societal benefits for use in the Societal Cost Test. These societal benefits are Avoided Gasoline $CO_{2,}$ Low Carbon Fuel Standard (LCFS) Credits, and Criteria Pollutants. Mr. Krevat's testimony describes how California law and policy promotes these beneficial measures in the public interest.[27] In theory, Avoided Gasoline CO_2 and Low Carbon Fuel Standard (LCFS) Credits benefits are also EV Customer Benefits, but since these markets are so new and the future market value attributable to them is not well understood, and uncertainty to whom the benefits will ultimately accrue, they are considered Societal Benefits in this analysis.

a. Avoided Gasoline CO_2

Avoided Gasoline CO_2 is the value of avoided CO_2 similar to the value of Gasoline Savings. Avoided Gasoline CO_2 value is estimated using the gasoline gallon estimate in the Gasoline Savings (discussed above) multiplied by the Carbon Cost included in Electricity Supply Costs.

b. LCFS Benefits

LCFS Benefits, per the California Air Resources Board (CARB), are the value of LCFS credits earned and sold by a utility related to selling electricity as a transportation fuel. LCFS Benefits are estimated based on the ZEM associated kWhrs.

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[26] ICF International and E3, California Transportation Electrification Assessment (Draft Phase 1 Report), March 14, 2014.

[27] *See* Utilities Code: § 740.8. "Interests" Of Ratepayers.

c. Criteria Pollutants

Criteria Pollutants include Greenhouse Gases (GHG), Nitrous Oxides (NOx), Particulate Matter (PM) and Volatile Organic Chemicals (VOC).[28] These criteria pollutants are avoided when gasoline is displaced by electric fuel. Results from the forthcoming CalETC report are used to estimate these criteria pollutant benefits based on the calculated Gasoline Savings (see section II.D.1)

III. COST EFFECTIVENESS TESTS

The illustrative results presented include standard costs test. Each cost test is designed to answer a key policy question relating to the EV market development. Table 6-10 describes the key questions answered for each of the Cost-Benefit Tests.[29] The cost tests are: Ratepayer Impact Measure (RIM), Participant Cost Test (PCT), Total Resource Cost (TRC), and Societal Cost Test (SCT). These tests are intended to quantify the costs and benefits of SDG&E market level EV adoption and charging. These tests are performed for both the SDG&E VGI Rate scenario and the Non-utility Flat Fee scenario.

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[28] ICF International and E3, California Transportation Electrification Assessment (Draft Phase 1 Report), March 14, 2014.

[29] *See* "Understanding Cost-Effectiveness of Energy Efficiency Programs: Best Practices, Technical Methods, and Emerging Issues for Policy-Makers" (2008) Table 2.2, available at http://www.epa.gov/cleanenergy/documents/suca/cost-effectiveness.pdf.

Table 6-10

Cost -Benefit Tests - Key Questions Answered		
Cost Test	**Acronym**	**Key Question Answered**
Ratepayer Impact Measure	RIM	Will utility rates increase?
Participant Cost Test	PCT	Will the participants benefit over the measure life?
Total Resource Cost	TRC	Will the total costs of energy in the utility service territory decrease?
Societal Cost Test	SCT	Is the utility, state, or nation better off as a whole?

IV. ILLUSTRATIVE COST EFFECTIVENESS

The illustrative results from the cost effectiveness model for the two scenarios analyzed are summarized below. Illustrative results are presented at the total SDG&E service territory market level for EV charging, for both scenarios as well as relative to each other. Illustrative results are reported at the 40% renewables level, and sensitivity analysis also provides results at the 33% renewables level.[30] Relative results highlight the net benefit or net costs of the SDG&E VGI Rate scenario compared to the Non-utility Flat Fee scenario (*see* section II.A.1 above for descriptions of the two scenarios).

Results are reported as the Net Present Value (NPV) for costs and benefits between 2015 and 2028. NPV discount rate is 6.76%, representing SDG&E's after tax weighted average cost of capital. Tax rates are assumed to be 35% Federal and 8.84% State. Arguably, a societal discount rate could be used for the SCT, however for simplicity the SDG&E WACC is used.

[30] *See* section II.D.2.a for discussion on the two RPS levels.

The illustrative results in Table 6-11 show that both scenarios provide market level net benefits in all four cost-effectiveness tests. The SDG&E VGI Rate scenario estimated net benefits, ranging from $127.7 million NPV benefits for the Rate Payer Impact test to $387.3 million NPV benefits for the Societal Cost Test. The Table 6-11 illustrative results are market level net benefits for the entire SDG&E service territory EV population. These illustrative results indicate that the SDG&E service territory EV market is beneficial to SDG&E ratepayers (RIM), EV customers (PCT), and the SDG&E service territory region in general (TRC and SCT).

In relative terms, the SDG&E VGI Rate scenario provides the SDG&E service territory region an estimated $9.6 million NPV impact greater than the Non-utility Flat Fee scenario for both the TRC test and the SCT. The SDG&E VGI Rate scenario provides SDG&E's EV customers an estimated $18.2 million more NPV impact in the PCT, compared to the Non-utility Flat Fee scenario. The RIM test is positive for both the VGI Rate and Non-utility Flat Fee scenario, showing that incremental revenues from utility bills exceed the market level electric supply costs to serve EV charging, as well as, charger costs and administration costs. However, the SDG&E VGI Rate scenario has an estimated $63.7 million less NPV impact for ratepayers than the Non-utility Flat Fee scenario in the RIM test.

The RIM test result is mainly due to the fact that VGI charger infrastructure is owned by SDG&E and Administrative cost incurred by SDG&E are a cost to ratepayers and therefore are included in the RIM test. The Non-utility Flat Fee scenario charger infrastructure and administrative costs provided by a non-utility entity (third party) are absorbed by the non-utility owners of the equipment, as opposed to ratepayers, and therefore not included in the RIM test result.

If the Non-utility Flat Fee scenario were funded by ratepayers (directly or indirectly), then the non-utility entity's costs should be included the RIM test. The non-utility entity (third party) costs are estimated at $72.0 million NPV, for charger infrastructure and administrative costs. Adding $72.0 million NPV to the Non-utility Flat Fee scenario RIM would result in a positive SDG&E VGI Rate net impact of approximately $8.3 million NPV (versus the negative VGI Net Impact of $63.7 million NPV report in Table 6-11).

Table 6-11

Cost Effectiveness Tests - Illustrative Results (NPV $ Millions)

	Cost Effectiveness Test			
Scenario	**RIM**	**PCT**	**TRC**	**SCT**
SDG&E VGI Rate	$127.7	$172.3	$193.4	$387.3
Non-utility Flat Fee	$191.4	$154.1	$183.8	$377.7
VGI Net Impact	($63.7)	$18.2	$9.6	$9.6
VGI % of Flat	67%	112%	105%	103%

Illustrative detail results are provided in Table 6-12. Table 6-12 provides illustrative detailed cost and benefit results for each test component, by cost effectiveness test and scenario. The table also summarizes the total costs and total benefits for each cost-effectiveness test, as well as the Cost/Benefit (C/B) Ratio. A C/B Ratio greater than 1.0 indicates that total estimated benefits are greater than total estimated costs.

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Table 6-12

Cost Effectiveness Tests - Illustrative Detailed Results
(NPV $ Millions)

Test Component		SDG&E VGI Rate Scenario RIM	SDG&E VGI Rate Scenario PCT	SDG&E VGI Rate Scenario TRC	SDG&E VGI Rate Scenario SCT	Non-utility Flat Fee Scenario RIM	Non-utility Flat Fee Scenario PCT	Non-utility Flat Fee Scenario TRC	Non-utility Flat Fee Scenario SCT
EV Customer Costs & Benefits	Incremental Vehicle Cost		($538.8)	($538.8)	($538.8)		($538.8)	($538.8)	($538.8)
	Utility Bills	$493.4	($479.8)			$494.8	($471.0)		
	Commercial Charging Fees		($35.8)				($62.9)		
	Gasoline Savings		$961.3	$961.3	$961.3		$961.3	$961.3	$961.3
	Federal Tax Credits		$300.1	$300.1	$300.1		$300.1	$300.1	$300.1
	State Tax Credits		$91.1				$91.1		
EV Charger & Admin Costs	Utility Charger and Admin Costs	($79.1)		($79.1)	($79.1)				
	Third Party Charger and Admin Costs			($37.7)	($37.7)			($109.7)	($109.7)
	Customer Charger Costs		($125.9)	($125.9)	($125.9)		($125.9)	($125.9)	($125.9)
Electric Supply Costs		($286.6)		($286.6)	($286.6)	($303.4)		($303.4)	($303.4)
Societal Benefits	Avoided Gasoline CO_2				$50.3				$50.3
	LCFS Benefit				$100.1				$100.1
	Criteria Pollutant Benefit				$43.5				$43.5
Grand Total		$127.7	$172.3	$193.4	$387.3	$191.4	$154.1	$183.8	$377.7
Total Costs		$365.7	$1,180.2	$1,068.0	$1,068.0	$303.4	$1,198.5	$1,077.7	$1,077.7
Total Benefits		$493.4	$1,352.6	$1,261.5	$1,455.3	$494.8	$1,352.6	$1,261.5	$1,455.3
C/B Ratio		1.35	1.15	1.18	1.36	1.63	1.13	1.17	1.35

Table 6-13 provides a sensitivity table of the estimated net TRC for the SDG&E VGI Rate scenario, relative to the Non-utility Flat Fee scenario. The sensitivity is for two analysis components, Renewables Penetration and Pilot Charger Utilization. Renewables Penetration is the level of renewables generation included in the energy cost model estimates (*see* section II.D.2.a). Renewable Penetration sensitivities are 33% and 40%. Pilot Charging Utilization is the number of EVs that utilize the EV charging equipment at workplace and MuD locations on a given day. The Pilot Charging Utilization used in the two scenarios and included in the results is one EV charged at each workplace and MuD charger each day (base case). The sensitively analysis considers Pilot Charging Utilization of 1, 1.5 and 2 EV(s) charging per day. The sensitivity analysis shows even at the 33% Renewables Penetration and Pilot Charger Utilization of 1, the SDG&E VGI Rate scenario has an estimated $0.4 million NPV benefits greater than the Non-utility Flat Fee scenario.

Table 6-13

Net TRC Cost Effectiveness - Illustrative Sensitivity (SDG&E VGI Rate scenario - Non-utility Flat Fee scenario) (NPV $ Millions)			
Renewables Penetration	Pilot Charger Utilization (EVs per Charger per Day)		
	1	1.5	2
33%	$0.4	$0.8	$1.1
40%	$9.6	$11.9	$13.1

Table 6-14 provides cost component details for the Electricity Supply Costs. The table shows that the SDG&E VGI Rate scenario results have lower estimated Electricity Supply Costs for all components. The SDG&E VGI Rate scenario has lower estimated Energy Costs by over $12 million NPV, has lower estimated Capacity Cost by $3.2 million NPV, and has lower estimated T&D Costs by $0.8 million NPV, than the Non-utility Flat Fee scenario. Total Electric Supply Costs for the Non-utility Flat Fee scenario is an estimated $16.7 million NPV higher than the SDG&E VGI Rate scenario.

Table 6-14

Electricity Supply Costs - Illustrative Component (NPV $ Millions)		
	Scenario	
Cost Components	SDG&E VGI Rate	Non-Utility Flat Fee
Energy Cost	$174.3	$186.2
Losses	$13.6	$14.4
A/S Cost	$1.8	$1.9
Capacity Cost	$35.9	$39.1
T&D Cost	$14.7	$15.5
RPS Cost	$46.3	$46.3
Total Elec. Supply Costs	$286.6	$303.4

Table 6-15 provides illustrative Electricity Supply Costs sensitivity results for the SDG&E VGI Rate scenario relative to the Non-utility Flat Fee scenario. The sensitivities considered in Table 6-15 are the same as Table 6-13 (Renewables Penetration and Pilot Charger Utilization). Results show that the estimated Electric Supply costs for the SDG&E VGI Rate scenario are less than the Non-utility Flat Fee scenario by $7.5 to $20.2 million NPV over the sensitivity ranges.

Table 6-15

Electricity Supply Costs - Illustrative Sensitivity Analysis
(SDG&E VGI Rate scenario - Non-utility Flat Fee scenario)
(NPV $ Millions)

Renewables Penetration	Pilot Charger Utilization (EVs per Charger per Day)		
	1	1.5	2
33%	$ (7.5)	$ (7.9)	$ (8.2)
40%	$ (16.7)	$ (19.0)	$ (20.2)

V. RESEARCH PLAN – DATA COLLECTION AND ANALYSIS

The Research Plan described below provides a link between the hypothesized assumptions described in section I and results illustrated in section IV. The realized VGI Pilot Program results will be available upon completion of the VGI Pilot Program. As customer EV charging data and cost information becomes available through the VGI Pilot Program deployment and operation, observed results will replace hypothesized assumptions used above in order to more rigorously evaluate the cost-effectiveness of SDG&E's completed VGI Pilot Program. Data collection will begin the first year of the pilot (2015), load impact analysis and reporting will begin after two years of implementation (2017), and a cost-effectiveness analysis 18 months after the final VGI facility is installed (2019).

SDG&E will perform a cost-effectiveness analysis eighteen months after the last VGI facility is installed and operational, using the data gathered during the VGI Pilot Program. SDG&E will report the results of the analysis to the Commission and interested parties. This time frame allows six months for SDG&E to analyze at least one year's data for each VGI facility. The following data collection and analysis is planned for the VGI Pilot Program:

- Actual VGI installation costs (total and average per site);
- Actual VGI operating costs (over the fleet of VGI facilities);
- Charging load profiles (from the VGI facility metered data for MUD and workplace locations, in aggregate and by circuit);
- Estimated percentage of EV purchases related to the VGI Pilot Program (gathered through surveys of EV customers using the VGI facilities);
- Estimated VGI Pilot program-related increases in ZEV miles traveled per EV (gathered through surveys of EV customers using the VGI facilities);
- EV customer input on the VGI mobile and web applications, the VGI rate and overall convenience and ease of use of the VGI facility (gathered through surveys of EV customers using the VGI facilities);
- VGI kWh usage by price, over time (gathered through the SDG&E VGI billing data);
- Where available, EV related kWh usage at home will be reviewed with VGI kWh usage at workplace VGI facilities (gathered through the SDG&E VGI billing data); and
- Where possible, determine whether EV-TOU or EV-TOU2 adoption has increased as a result of the VGI Pilot.

SDG&E intends to conduct measurement and evaluation studies on the VGI Pilot Program. If, after two years of implementation, the extent to which the VGI Pilot Program produces load impacts, load impact studies will be conducted according the Load Impact Protocols that were adopted in D-08-04-051. These protocols provided rules that specified required output data that must be included in all measurement and evaluation reports. For example, these protocols require that every load impact measurement and evaluation report include hourly ex-post load impact results for each event day for the entire program, as well as on average per customer. In addition, each load impact report is required to contain a 10-year hourly forecast of expected future load impacts for 24 different temperature scenarios. D-08-04-051 further required that every demand response activity be evaluated every year and that the load impact reports be filed with the CPUC on April 1st of each year.[31] The decision specified that the load impact protocols applied to all demand response activities, which includes both demand response programs and dynamic rates.

VI. CONCLUSION

Illustrative results presented in my testimony indicate that the EV charging market in SDG&E's service territory with the VGI Pilot Program provides net benefits. The illustrative results indicate that the SDG&E service territory EV market with the VGI Pilot Program is beneficial to SDG&E ratepayers, EV customers, and the SDG&E service territory region in general.

This concludes my direct testimony.

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[31] CPP and dynamic rates are considered Demand Response activities.

VII. STATEMENT OF QUALIFICATIONS

My name is John C. Martin. My business address is 8306 Century Park Court, San Diego, California 92123. I am employed by San Diego Gas & Electric Company as Project Manager in Clean Transportation.

I have over 21 years of energy industry experience. My current duties involve project management to support SDG&E's electric transportation efforts, including EV rates, market participant support and implementing a pilot using third party EV submetering with utility subtractive billing. Prior duties focus on costs and benefits associated with the capabilities of Smart Metering and Home Area Networks, and conservation based information feedback. This work draws upon my broad experience in the electricity and oil industry.

My prior electricity work experience includes demand response program and tariff development, electricity trading and scheduling, demand side management program evaluation and load research of customer energy use. My duties also utilize my experience in the oil trading, refining and marketing industries.

My electric vehicle driving experience began in 1997. I currently lease a PHEV-20, as of January 2013. I actively charge my vehicle at home, at my workplace, and at commercial facilities. I am a member of an electric car sharing service.

My education is in the general area of resource economics. I graduated from Cornell University in 1988 with a master's degree in agricultural economics. My Bachelor of Science degree was granted by Purdue University in 1984 in business and farm management. I have previously testified before the California Public Utilities Commission in the SDG&E AMI and the SoCalGas AMI proceedings.

APPENDIX A

GLOSSARY OF ACRONYMS AND DEFINED TERMS

ACRONYM	TERM
BEV	Battery electric vehicle
Cal ETC	California Electrification Transportation Coalition
Charging Fee	Commercial charging fee
Day/Night Hours	For purposes of the study, day hours are 8 AM to 5 PM, and night hours are 6 PM to 7 AM
DER	Distributed energy resources
DG	Distributed generation
DR	Demand responses
E3	Energy and Environmental Economics (consulting firm)
EE	Energy efficiency
EV	Electric vehicle
ICE	Internal combustion engine
LCFS	Low carbon fuel standard credits
MuD	Multi-unit dwelling
O&M	Operations and maintenance
PAC	Program administrator cost
PCT	Participant cost test
PEV	Plug-in electric vehicles
PHEV	Plug-in hybrid electric vehicles
PHEV-10	Plug-in hybrid electric vehicle with 10 mile EV range
PHEV-20	Plug-in hybrid electric vehicle with 20 mile EV range
PHEV-40	Plug-in hybrid electric vehicle with 40 mile EV range

REFLEX	Renewable energy flexibility model
RIM	Ratepayer impact measure
RPS	Renewable portfolio standard
RTP	Real-time pricing
SCT	Societal cost-test
SF	Single family
SOC	State of charge
T&D	Transmission and distribution
TRC	Total resource cost-test
VGI	Vehicle-grid integration
VGI Rate	Dynamic time-variant prices
ZEM	Zero emission miles

A.14-04-014 - SDG&E Vehicle to Grid Integration Pilot Program ("VGI") Testimony Revision[1] Log

Witness	Page	Origional Version Location	Revision Item
JC Martin	*Passim*	*Passim*	Replaced "VGI Rate scenario" with "SDG&E VGI Rate scenario" for clarity.
JC Martin	*Passim*	*Passim*	Replaced "Flat Rate scenario" with "Non-utility Flat Fee scenario" for clarity.
JC Martin	*Passim*	*Passim*	Replaced "Flat Rate" and "flat rate" with "Flat Fee" and "flat fee" for clarity.
JC Martin	JCM-4	Line 17	Deleted "level" for clarity.
JC Martin	JCM-10	Table JCM 6-2	Replaced "VGI Rate scenario" with "SDG&E VGI Rate scenario" for clarity.
JC Martin	JCM-10	Table JCM 6-2	Replaced "Flat Rate scenario" with "Non-utility Flat Fee scenario" for clarity.
JC Martin	JCM-10	Table JCM 6-2	Replaced "Base" ZEM Requirement with "Without Workplace Charging" for clarity.
JC Martin	JCM-10	Table JCM 6-2	Replaced "Base+" ZEM Requirement with "With Workplace Charging" for clarity.
JC Martin	JCM-11	Line 18	Replaced "Base" ZEM Requirement with "Without Workplace Charging" for clarity.
JC Martin	JCM-11	Line 19	Replaced "Base+" ZEM Requirement with "With Workplace Charging" for clarity.
JC Martin	JCM-12	Table JCM 6-3, BEV Battery Capacity	Updated BEV Battery Capacity to reflect refined assumptions.
JC Martin	JCM-12	Footnotes	Deleted non-relevant footnotes.
JC Martin	JCM-13	Line 3	Inserted "charger" after "Level 1 (L1) SF" for clarity.
JC Martin	JCM-13	Lines 13-16	Updated the EV-TOU-2 and DR rate values for consistency with Witness Fang's revised VGI Rate.
JC Martin	JCM-13	Footnotes 7 & 8	Updated references for the EV-TOU-2 and DR rates for consistency with Witness Fang's revised VGI Rate.
JC Martin	JCM-14	Lines 13 & 14	Corrected "two" with "three".
JC Martin	JCM-15	Line 8	Inserted "is" before "used to" for clarity.
JC Martin	JCM-15	Line 11	Replaced "prices" with "charging costs" for precision.
JC Martin	JCM-16	Line 5	Replaced "Driver" with "Customer" for clarity.
JC Martin	JCM-17	Table 6-4	Updated for refined assumptions on allocation of EV Customer Groups to Population Forecast.
JC Martin	JCM-17	Table 6-4	Updated table heading descriptions to remove "VGI" and for clarity.
JC Martin	JCM-17	Table 6-4	Added a table row to indicate "The porportion of vehicles with access to the VGI Rate" for clarity.
JC Martin	JCM-17	Line 7	Corrected table number from "Table 6-6" to Table 6-5".
JC Martin	JCM-17	Lines 8-12	Updated to reflect refined assumptions on additional EV adoptions associated with VGI Pilot implementation.

[1]Revisions to April 11, 2014 Submission

A.14-04-014 - SDG&E Vehicle to Grid Integration Pilot Program ("VGI") Testimony Revision[1] Log

Witness	Page	Origional Version Location	Revision Item
JC Martin	JCM-17	Lines 13 & 15	Removed "VGI" from "VGI EV Forecast", for clarity.
JC Martin	JCM-18	Table 6-5	Updated VGI EV Forecast to reflect refined assumptions on allocation of EV Additions.
JC Martin	JCM-18	Table 6-5	Removed "VGI" from "VGI EV Forecast", for clarity.
JC Martin	JCM-18	Table 6-5, Footnote 2	Updated description to reflect equal proportion allocation of EV Additions.
JC Martin	JCM-19	Line 2	Replaced "trips" with "miles", for clarity.
JC Martin	JCM-20	Table 6-6, Cost Above Comparable ICE Vehicle	Corrected to reflect refined assumptions.
JC Martin	JCM-20	Line 9	Added "in 2014 and increases over time" after "gallon", for clarity.
JC Martin	JCM-21	Table 6-7	Updated the AL-TOU rate values for consistency with Witness Fang's revised VGI Rate.
JC Martin	JCM-22	Lines 4 & 5	Corrected Federal Tax credit assumptions for EV Types.
JC Martin	JCM-22	Line 5	Added sentence "The federal tax credit is assumed to expire after 2023.", for clarity.
JC Martin	JCM-22	Footnote 16	Updated citation for more recent ICF report draft.
JC Martin	JCM-32	Lines 3, 10, 12 & 16	Updated values to reflect update to Table 6-11.
JC Martin	JCM-33	Lines 3 - 6	Updated values to reflect update to Table 6-11.
JC Martin	JCM-33	Table 6-11	Updated for revised VGI Rate and refined assumptions.
JC Martin	JCM-34	Table 6-12	Updated for revised VGI Rate and refined assumptions.
JC Martin	JCM-34	Lines 12 & 13	Removed "base case" and after "Pilot Charger Utilization" added "of 1"
JC Martin	JCM-34	Line 13	Updated values to reflect update to Table 6-13.
JC Martin	JCM-35	Lines 5-8	Updated values to reflect update to Table 6-14.
JC Martin	JCM-35	Table 6-13	Updated for revised VGI Rate and refined assumptions.
JC Martin	JCM-35	Table 6-14	Updated for revised VGI Rate and refined assumptions.
JC Martin	JCM-36	Line 5	Updated values to reflect update to Table 6-15.
JC Martin	JCM-36	Table 6-15	Updated for revised VGI Rate and refined assumptions.

[1]Revisions to April 11, 2014 Submission