Energy+Environmental Economics

UC Davis West Village CSI Grant:

E3 Subtasks in Target Area 2

CPUC Update
February 14, 2012

E3 Project Overview Under CSI Grant Target Area 2

- **E3 Team was selected to support the single-family home portion of the UC Davis West Village development**
  - lead development of zero net energy business models
  - regulatory strategies
- **Project Goals**
  - Achieve ZNE at no higher cost to the developer and no higher cost to the owner
  - Integrate multiple renewable resources
  - Facilitate decision making and understanding with broad stakeholder group including UCD staff, Carmel Partners, and CSI Grant Administrator

E3 Project Timeline

Event	Date
+ Project Start	June 1st 2011
+ Design Charrette	June 22nd 2011
+ Data / EE packages Done	August 1st 2011
+ Final Analysis Complete	Sept 1st 2011

+ Project was completed close to on time. Final results were presented on Sept. 8th to UCD, CSI Grant Administrator, Carmel Partners
+ Outstanding deliverable is the final report. Outline has been provided and included in CPR materials.

Project Team

Energy and Environmental Economics, Inc.

- **Snuller Price, Partner**
  - Principal-in-Charge
  - Lead Regulatory Liaison
- **Michele Chait, Sr. Consultant**
  - Project Manager
  - Lead Financial Planner

Davis Energy Group

- **Bill Dakin, PE, Engineering Mgr.**
  - Lead Planner – Energy Efficiency
- **Marc Hoeschele, PE, Engineering Mgr.**
  - Lead Planner – Energy Efficiency
- **Alea German, Staff Engineer**
  - Engineer - Energy Efficiency

Clean Power Research

- **Tom Hoff, PhD, President**
  - Lead Planner – PV Systems
- **Benjamin Norris, PE**
  - Senior Consultant – PV Systems

Analytical Approach

CPR

PV System Data

- 8760 Solar PV Output
- Net usage PG&E electric bills for West Village and Purple Line
- System Cost

DEG

Energy Efficiency

- EE Measure Packages
- Measure Cost & Incentives
- 8760 net gas and electric usage for West Village and Purple Line

E3

Financial Pro Forma

- Business & Regulatory Models
- Financing & Payback Analysis

- Storage
- EV
- Fuel Cell
- Biogas

+ One Excel-based economic model

- Incorporates all data developed by the team
- Fosters continuity of context, alignment of assumptions and business model scenarios
- Facilitates comprehensive solutions to the energy needs of the West Village
- Avoids duplication of modeling effort, helping to deliver services cost-effectively

Achieving ZNE at No Higher Cost to Developer

Capital Cost in Developer Scope Net of Incentives	≤	Purple Line Home Measure Cost

- **Solar PV at no higher cost to developer is achieved because it is not in developer scope**
- **EEMs must be in developer scope**
  - Lack of entities providing cost-effective financing of EEMs in the residential sector
  - UC Davis financing of EE faces prevailing wage issue
- **Gross measure costs incur additional 15% developer overhead charge, then incentives are netted**

Achieving ZNE at no higher cost to owner

NPV of Purple Line Energy Bills
- PG&E retail natural gas
- PG&E retail electricity
- Gasoline

>=

NPV Cost of ZNE at West Village
- PV, EE, EV capital & operating
- Incentives
- Biogas
- Over-/Under-generation

+ **Achieving ZNE from owner perspective takes into account total savings/(costs) compared to Purple Line**
  - Electricity
  - Natural Gas
  - Electric vehicles (not active in base case)
+ **Technological, cost, & regulatory change are accommodated in future cost projections**

Scope of Modeling

- **Single-family home usage**
  - Energy efficiency measure packages
  - PEV
- **Generation**
  - Solar PV output
  - Biodigester
  - Fuel cell
- **Regulatory scenarios**
  - Base case and regulatory change
- **Additional technology**
  - Storage, smart grid

The amount of energy efficiency in the homes directly affects other aspects of the project

Zero-net energy Business model

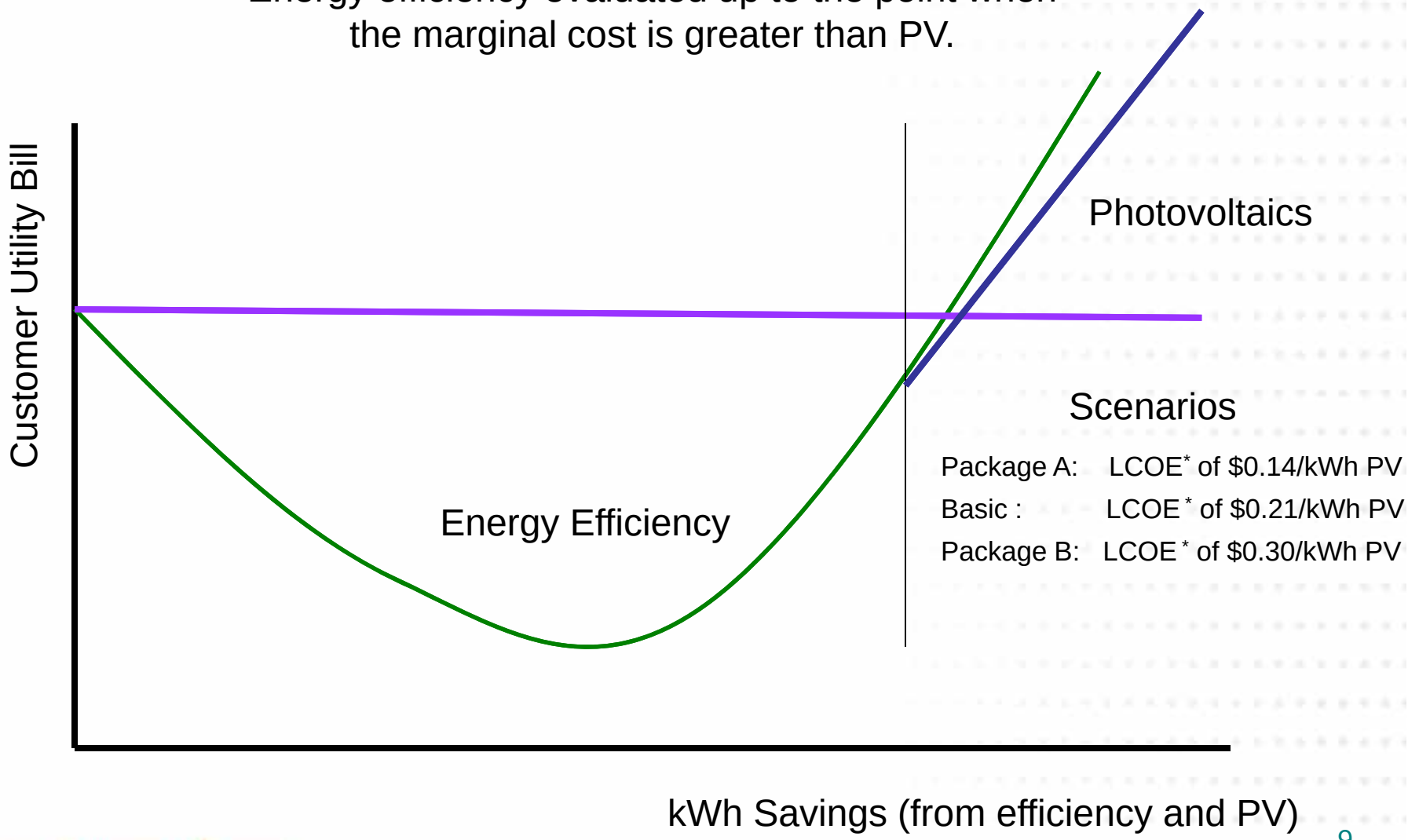
Site vs. Source Energy Use

	Base Case (Title-24 + 15%)	Basic Performance Package - Gas/Electric	Basic Performance Package - All Electric
Annual kWh	10,546	9,214	16,535
Annual Therms	746	505	0
Source Energy (MMBtu) 2.46 factor = 13 kWh/therm	170	133	139
Site Energy (MMBtu) 1 factor = 29.3 kWh/therm	117	87	56
kWh of PV (13 kWh/therm) (Source)	20,233	15,772	16,535
kWh of PV (29.3 kWh/therm) (Site)	34,414	25,372	16,535

- **All-electric scenario requires approximately 16,535 kWh**
- **Gas/electric scenario requires**
  - 15,772 kWh of PV generation (= 9,214 kWh for electric + 6,558 kWh for gas), or
  - 9,214 kWh of PV generation with 505 therms of biogas
- **If we use the site energy conversion factor, we under-value the energy produced on-site (25,372 kWh site vs. 15,772 kWh source)**
- **Note usage includes carriage house but does not include PEVs**

Economics of EE and PV

Energy efficiency evaluated up to the point when the marginal cost is greater than PV.



Revised Proposed Package

BUILDING ENVELOPE:	
Walls (Exterior)	2x6 16” o.c. R-21 batt (no exterior insulation)
Roof (Attic)	R-49 blown insulation. Attic Radiant Barrier
Roofing Products	Cool Roof Shingles
Glazing U-Factor/ SHGC	Average U ≤ 0.32 / SHGC ≤ 0.23
House Infiltration	Tight: SLA ≤ 1.8
HVAC:	
Equipment Sizing	ACCA Manual J & D sizing
Cooling	15 SEER / 12.5 EER
Heating	High Efficiency Gas Furnace (92% AFUE)
Ducts	Ducts in Conditioned Space
Fresh Air Ventilation	Per ASHRAE 62.2, mandatory August 2010
WATER HEATING:	
Type / Energy Factor	Tankless Gas Water Heater / 0.82 EF
Hot Water Distribution	PEX, engineered design; locate water heater close to uses
Solar Water Heating	None
3RD PARTY TESTING / VERIFICATION:	
Envelope Integrity	Quality Insulation Inspection / Verification
Duct Tightness / Location	Tight Duct Testing: < 6% Leakage
Envelope Tightness	Tight Envelope (Blower Door Test)
Cooling System	Refrigerant Charge / EER Verification
LIGHTING / APPLIANCES:	
High Efficacy Lighting	100% fluorescent for hard-wired fixtures. Assume 80% hardwired lighting. Lighting controls / Vacancy sensors.
Energy Star Appliances	Dishwasher

Advanced EEM Packages

	Package A	Package B
BUILDING ENVELOPE:		
Walls / Ceilings	Advanced Framing, 2x6, 24" o.c.	Advanced Framing, 2x6, 24" o.c. **+ 1" exterior foam insulation & 5/8" drywall**
Windows	Reduced glazing per revised design	Reduced glazing per revised design (22% of floor area)
HVAC:		
Heating	Combined Hydronic w/ Condensing Tankless WH	Combined Hydronic w/ Condensing Tankless WH
Distribution	Return air paths for bedrooms	Return air paths for bedrooms
Ventilation Cooling		**Whole House Fan**
Studios	Ductless mini-split heat pump	Ductless mini-split heat pump
WATER HEATING:		
Type / Energy Factor	Condensing Tankless Water Heater / 0.96 EF	Condensing Tankless Water Heater / 0.96 EF
Solar Water Heating	None	None
3RD PARTY TESTING / VERIFICATION:		
HVAC System	System Airflow / Fan Watt Draw Testing	System Airflow / Fan Watt Draw Testing
LIGHTING / APPLIANCES:		
High Efficacy Lighting	Same as base package	Same as base package
Energy Star Appliances	Clothes washer, Refrigerator	Clothes washer, Refrigerator

Package Incremental Costs

- Incremental Costs for the Three Packages
  - Incremental cost compared to Title 24 + 15%
  - Costs include 60% of studio

Package	Incremental Cost	Net Incremental Cost (after incentives)
Basic Performance	$ 4,993	$ 1,831
Advanced – A	$ 6,372	$ 2,554
Advanced - B	$ 11,924	$ 7,883

Rooftop PV – 2012 Installation

System Design	
System Cost per Watt (DC) (ALL IN)	$7.42
System Size (DC) (kpW)	6.4
Initial debt service reserve funding	$797
Project Finance Upfront Fees	$242
Total System Cost	$48,455

Performance Inputs	
DC to AC Derate Factor	1.00
System Size (AC)(kWp)	6.4
Annual Net AC Capacity Factor	18.4%
Year 1 Annual Output (kWh)	10,285
Degradation Factor	0.70%
System lifetime (in Years) = PPA Term	25

Other	
O&M Costs ($/kW)	$30.00
O&M Costs Escalator (%/yr)	0.00%
Inverter replacement cost ($/W)	$0.46
Inverter replacement time (in Years)	10
Inverter replacement cost	$2,917
Levelized (10yr) inverter replacement c	$403
Insurance Expense ($/kW)	29.67
Insurance Escalator (%/yr)	0.00%

Tax Assumptions	
Federal Tax Rate	35.00%
State Tax Rate	8.84%
Effective Tax Rate	40.75%

Federal Tax Credit	
System Cost Eligible for Tax Credit	$47,658
Tax Credit Rate	30%
Tax Credit Amount	$14,297

Tax Savings through Depreciation	
System Cost Eligible forTax Credit	$47,658
Basis Reduction for ITC	50%
Federal Tax Depreciation Basis	$40,509
State Tax Depreciation Basis	$32,395
MACRS Term	5

State Rebate	NSHP
PBI	**NO**
Rebate Amount ($/kWh)	$0.0000
NSHP - Upfront	**YES**
2011 Rebate Amount Per Watt AC	$2.35
Total Upfront Rebate Amount ($)	$15,021

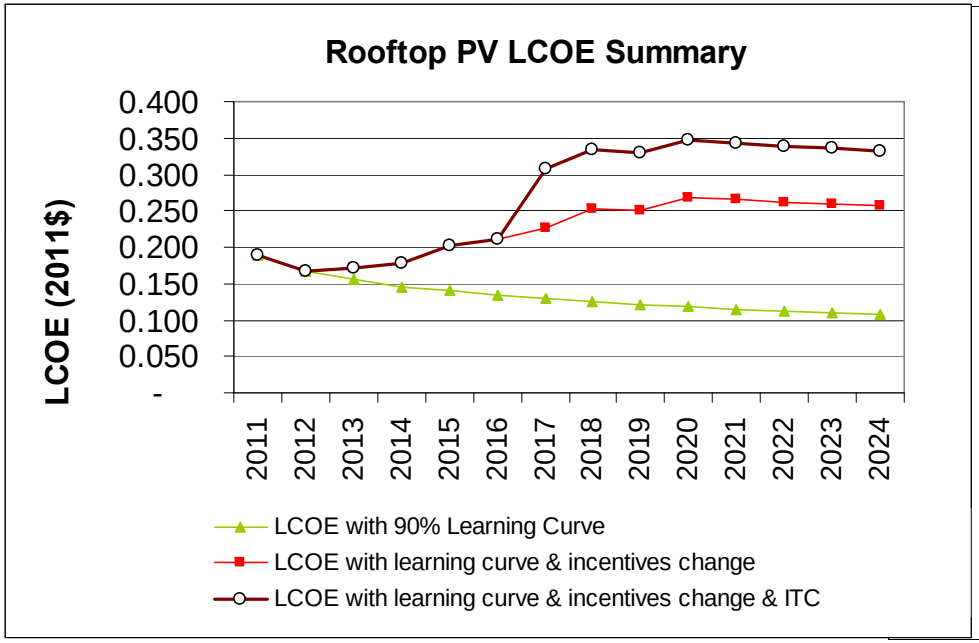
Financing	
% Financed w/ equity	66%
% Financed w/ debt	34%
Real Debt Interest rate	5.4%
Debt period in years	15
Target DSCR	1.40
Real Cost of Equity	8.01%
Real WACC	6.37%
Months in DSRF	6
Real Interest Rate on DSRF	1.0%
LCOE Escalation Rate	0.00%
Project Finance Upfront Fees	1.5%
Equity Amount	$31,980
Debt Amount	$16,475

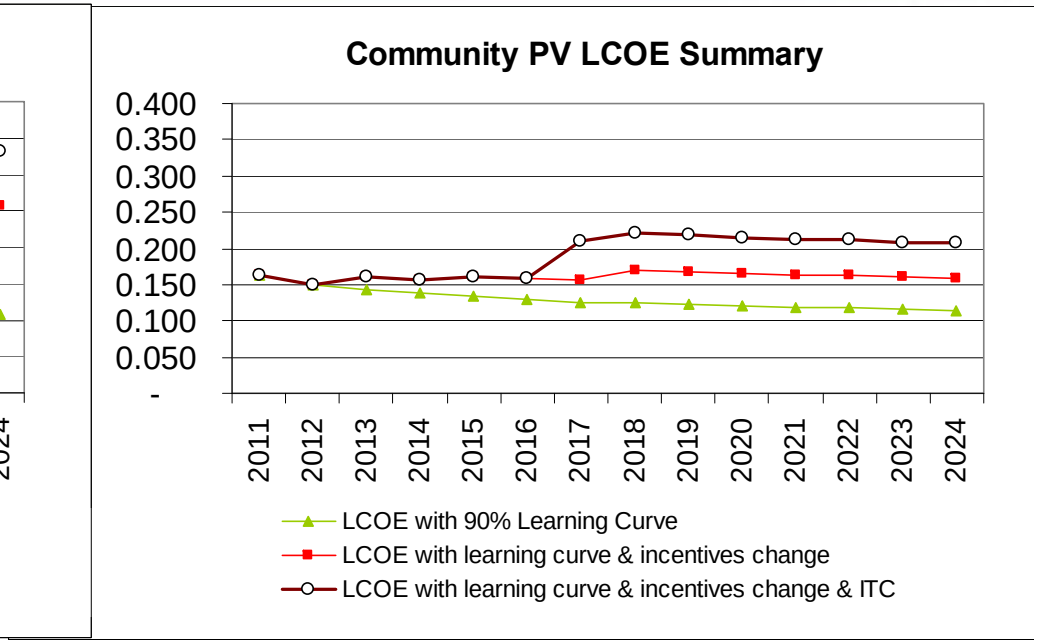
Output	
Real Levelized Cost of Generatic	**$0.1884**
NPV	$0.000

+ Note these are real levelized LCOEs specific to this analysis

- Real cost of capital
- No cost escalation

Changes in LCOE Over Time



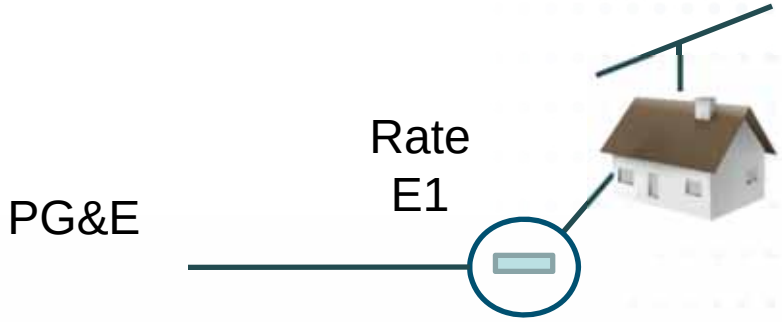


+ **Brown lines show final LCOE trajectory after taking into consideration learning curve, changes in incentive levels, and ITC stepdown**
  - In rooftop scenario, learning curve improvements largely offset NSHP incentive declines
  - In community scenario, learning curve improvements are greater than CSI incentive declines, and eventually also nearly offset ITC stepdown
  - Community PV LCOE excludes trench & security costs

Biogas Procurement

- **Conservative estimate of $2/therm**
  - Out-of-state roughly $1.65/therm compared to in-state at roughly $1.30/therm, including transportation
- **Out-of-state supplies: Shell Energy North America**
  - Priced higher, in part due to higher transportation costs
  - Convenient for purchase of small and phased quantities as demand grows or until campus facility is operational in 10-15 years
- **In-state supplies: RealEnergy, SMUD**
  - Could purchase entire biogas project output and re-sell excess biogas to another party during phase-in with SMUD as potential off-taker
  - Project's connection West Village would be a tangible example of ZNE goals
- **Upcoming CPUC decision on biogas rule changes**
  - Possibility of more restrictive rules on out-of-state biogas may limit out-of-state options
  - Possibility of less restrictive rules on in-state biogas may make working with PG&E for biogas easier and cheaper

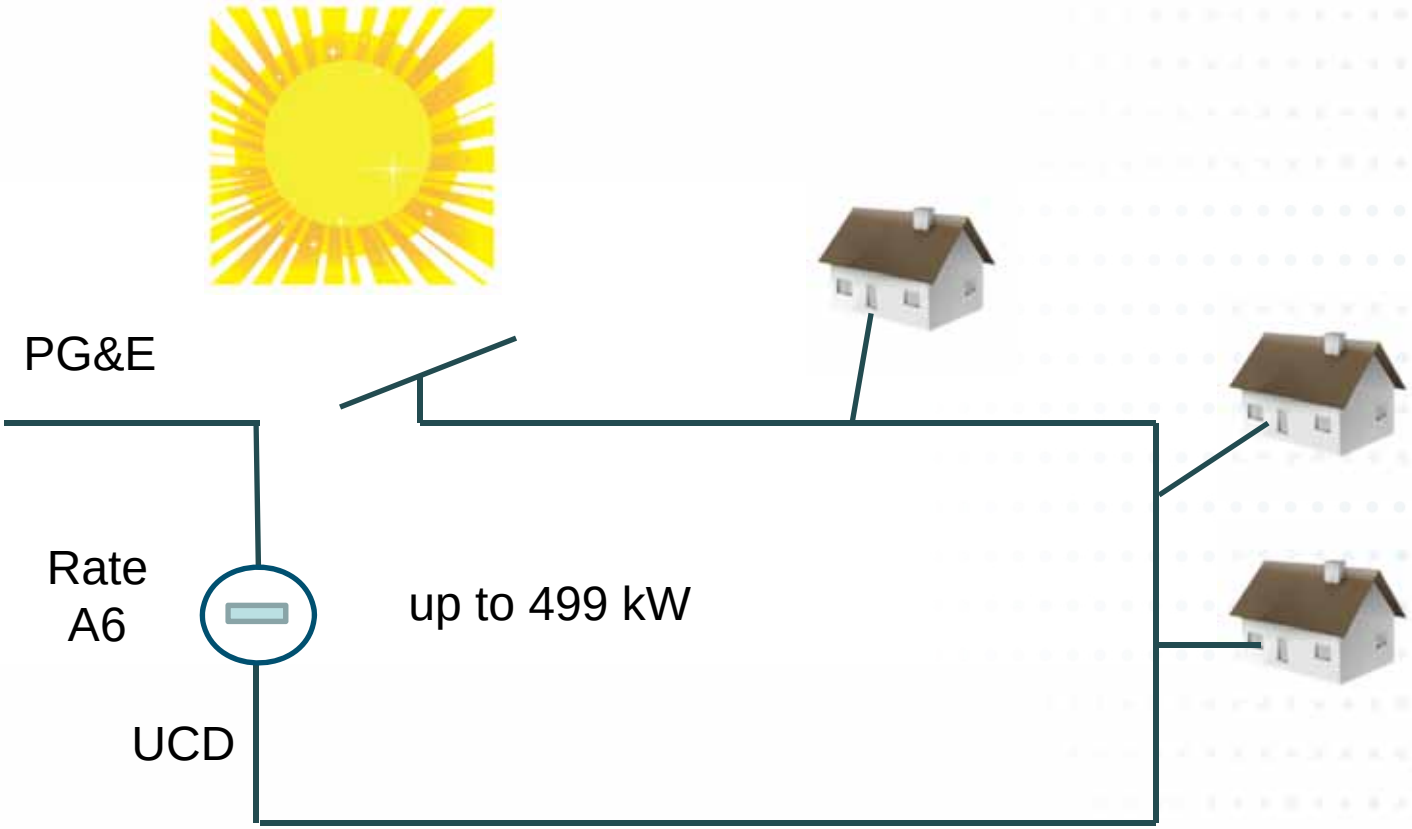
Residential Rooftop PV + NEM Business Model Diagram



Business Model: Single Family Home

- **PV system installed on roof of each single-family home**
- **NSHP $2.35 per watt incentive**
- **PV sized to achieve first year annual home usage**
  - Assumes home owner behavior doesn't change over time
  - 0.7% annual degradation of PV output
- **Generation shortfall procured at PG&E retail rate + REC ($0.05 / kWh) (total of ~ $0.19 per kWh)**

UCD Loop + NEM Business Model Diagram



Business Model: UCD Loop with NEM

- **Net usage behind the meter is billed per PG&E rate schedule A-6**
  - A-6 serves customers 200 kW to 499 kW
  - All PV kWh are eligible for CSI incentive under this business model
  - If necessary, larger peak load would be billed at E-19 which serves customers 500 KW to 1 MW, but is significantly more costly
  - A-6 solar pilot program increases demand limit for A-6 to 1000 kW, for up to 20 program MW (now fully subscribed)
- **Two ~ 500 kW community-scale PV systems constructed on recreation fields or other areas**
  - Peak load of 343 houses with off-peak charging of EVs is approximately 1MW
    - Therefore, two loops peak at 500kW
- **About 1.7 MW of PV required with Proposed EEMs**
  - 14 total acres required (assuming approximately 8 acres of land per MW)
    - 14 total acres are available for community-scale PV, 7 acres on recreation fields (one loop may fit on rec fields)

Business Model Overview: Current Regulatory Environment

Potential PV Business Models	Regulatory Model	Incentive	PG&E Rate	Status
Rooftop PV	NEM	NSHP	Residential	√
UCD Loop	BCT	CSI	Small commercial TOU	X
UCD Loop + In one or two phases	NEM	CSI	Small commercial TOU	√

- **+ UCD Loop + BCT (bill credit transfer program) was eliminated from consideration because it was not economic**
  - Credits only generation portion of rate (excluding delivery charges) and CSI incentive is only available for net usage

Business Model Overview: Current Regulatory Environment

Potential PV Business Models	Regulatory Model	Incentive	PG&E Rate	Status
Delayed Loop + Initial home development with Rooftop PV + UCD Loop sized for remaining development later	NEM	NSHP initially None later (CSI likely expired)	Initial homes residential Small commercial TOU for later homes	√
Delayed Roof + Initial home development with Loop PV + Rooftop PV for remaining development later	NEM	CSI initially Small or None later (NSHP largely expired)	Small commercial TOU for homes Later homes residential	X

- **Delayed Roof scenario does not make economic sense**
  - Doesn't take advantage of higher initial NSHP for rooftop PV, then builds after NSHP is reduced

Business Model Overview: Regulatory Change

Potential PV Business Models	Regulatory Model	Incentive	PG&E Rate	Status
PV Development: + Generation facility – not necessarily at West Village, no joint trench cost	Virtual Net Metering	CSI	Residential (Tiered or Tiered TOU)	√
Aggregated NSHP: + UCD Loop	NEM	NSHP	PG&E small commercial TOU Rate	√

+ These scenarios are not currently possible
+ They have been analyzed as regulatory change models

Overview of Business Models

Scenarios

- **Rooftop - PPA**
- **Two Loops, 2013 COD**
  - PPA or UCD + Tax Equity financing
- **Two Loops, COD 2013 & 2015 or 2018**
  - PPA or UCD + Tax Equity financing
- **Rooftop then Delayed 2017 Loop**
  - PPA or UCD + Tax Equity financing

Sensitivities

- **Home construction rate**
  - 30 homes/yr
  - 60 homes/yr
  - 100 homes/yr
- **Learning curve**
  - 75%
  - 90%
- **EVs**
- **Carriage House**

Summary of Analysis

Homes Per Yr	Learning Curve	Business Model	NPV
30	75% learning curve	Rooftop or	0.9
		Rooftop + Delayed Loop	1.3
	90% learning curve	Rooftop + Delayed Loop	-0.3
60	75% learning curve	Rooftop	1.8
	90% learning curve	Rooftop + Delayed Loop	-0.1
100	75% learning curve	Rooftop	2.5
	90% learning curve	Rooftop	0.6

Learning curve is the rate of price decline with a doubling of installed capacity, 75% is much faster than 90%. Historical rate has been around 80%.

NPV in millions of dollars ($) measures savings/(cost)of West Village homes over Title 24 Purple Line homes

Pros & Cons
Rooftop vs. UCD Loop

ROOFTOP PV SCENARIO

+ **Pros**
  - Most economic business model
  - Straightforward to implement
+ **Cons**
  - Does not directly promote community solar goal
  - Rooftop space on homes may be limited
    - Fire codes

UCD LOOP SCENARIO

+ **Pros**
  - Supports community solar goals
+ **Cons**
  - Rule 18 billing issues
  - Maintenance of trench
  - Cost of trench
  - Security at PV location
  - Land requirements

Roadmap

- **Pursue agreement with developer to build homes with EEM package A**
- **Pursue rooftop with NSHP through 2014, then evaluate whether to proceed with delayed loop**
  - PG&E trench for half of the development
  - if ~ 170 homes projected to be built by end of 2017, then build UCD loop for second half of development
  - If ~ 300 homes by end of 2017, then continue with rooftop PV and PG&E trench

Further Research for West Village

- **Model a 'hybrid' strategy with approximately 80% rooftop system and the remainder community scale without the loop**
  - Requires modeling community PPA and REC purchase
- **Develop a behavioral energy efficiency plan to reinforce the energy efficiency message and make low use sustainable in West Village**
- **Develop a 'lab house' funding and research plan that can showcase technology, provide an opportunity for student research, and information to the community**
- **Inclusion of Electric Vehicles**
- **'Triggers' for Fuel Cells and Energy Storage**

What if we add electric vehicles?

Home Constr Rate	EEM Package	Learning Curve	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA
30	Adv A	75%	2.1	3.0
30	Adv A	90%	(1.2)	1.0
60	Adv A	75%	3.4	3.6
60	Adv A	90%	0.6	1.3
100	Adv A	75%	4.2	3.7
100	Adv A	90%	1.8	1.4

- **There are many potential future EV scenarios:**
  - **Low, Medium, High penetration rates**
  - **Mix of owner types: Soccer Mom & Commuter**
  - **Controlled & uncontrolled charging patterns**
- **This scenario reflects medium penetration, controlled charging, 35% soccer mom / 65% commuter**
- **Business models that should be pursued in each case do not change, but NPVs increase**

Strategies for energy savings from behavior changes

Information and Behavior-Based Energy Efficiency Strategies

Education and Outreach provides consumers with energy efficiency information independent of their own energy use.

Feedback provides consumers with specific and personalized information about their energy use.

Indirect Feedback provides energy use information after some time interval has passed.

Direct Feedback provides energy use information in real-time.

Behavior-based Approaches & Energy Feedback

Community focus engages with customers through their community affiliation, often by creating a sense of team effort towards a common goal

Peer/comparative focus compares household energy use information against "peers" or other households with similar characteristics.

Household focus provides information about a specific home's energy use, often with custom efficiency advice & disaggregated data

Maintaining Community Zero Energy Goals

- Need to provide feedback to occupants
  - In-house displays – real-time energy use feedback
  - Provide tools to control “leaking” energy use
- Limit owner-provided energy hogs
  - Appliances
  - Electronics (TV’s, set-top boxes)
  - Lighting
- How to engage the community?
  - Education – seminars, workshops (engage university community)
  - Community events, contests
  - Additional fees for excessive use
  - Continued / ongoing community feedback

Fuel Cell

+ Fuel Cell (i.e., Bloom Energy)

- Can run on biogas
- Could be located within the community
- Learning curve with a progress ratio of 82%
- Limited flexibility in output, but high capacity factor
- Useful life of 10 years
- SGIP incentive ($4.50/watt) expires at the end of 2015
- ITC assumed to decline to 10% in 2017

	2011	2012	2013	2014	2015	2016	2017	2018
Timing Impacts on SGIP								
SGIP expiration	$4.50	$4.50	$4.50	$4.50	$4.50	-	-	-
Impact on LCOE	-	-	-	-	-	$0.08591	-	-
Investment Tax Credit								
ITC Assumption	30%	30%	30%	30%	30%	30%	10%	10%
Impact on LCOE	-	-	-	-	-	-	$0.03629	-

Fuel Cell – 2012 Installation

System Design	
System Cost per Watt ($/W)	$8.59
System Size (kWp)	1.0
Initial debt service reserve funding	$0.00
Project Finance Upfront Fees	$0.00
Total System Cost	$8,592

Performance Inputs	
Initial efficiency	0.50
System Size (kWp)	1.0
Annual Net AC Capacity Factor	90.0%
Year 1 Annual Output (kWh)	7,884
Efficiency Degradation Factor	2.01%
System lifetime (in Years) = PPA T	10

Other	
Input Levelized O&M costs ($/kWh	$0.03
O&M Costs Escalator (%/yr)	0.00%
Departing Load Charges ($/kWh)	$0.01527
Departing Load Charges Escalatc	0.00%
Initial fuel price ($/therm)	$2.00
Fuel Price Escalator (%/yr)	0.00%
Insurance Expense ($/kW)	$34.37
Insurance Escalator (%/yr)	0.00%

Tax Assumptions	
Federal Tax Rate	35.00%
State Tax Rate	8.84%
Effective Tax Rate	40.75%

Federal Tax Credit	
Total System Cost	$8,592
Tax Credit Rate	$0.30
Tax Credit Amount	$2,578

Tax Savings through Depreciation	
Full Basis Amount	$8,592
Basis Reduction	15%
Federal Tax Depreciation Basis	$7,303
State Tax Depreciation Basis	$4,092
MACRS Term	5

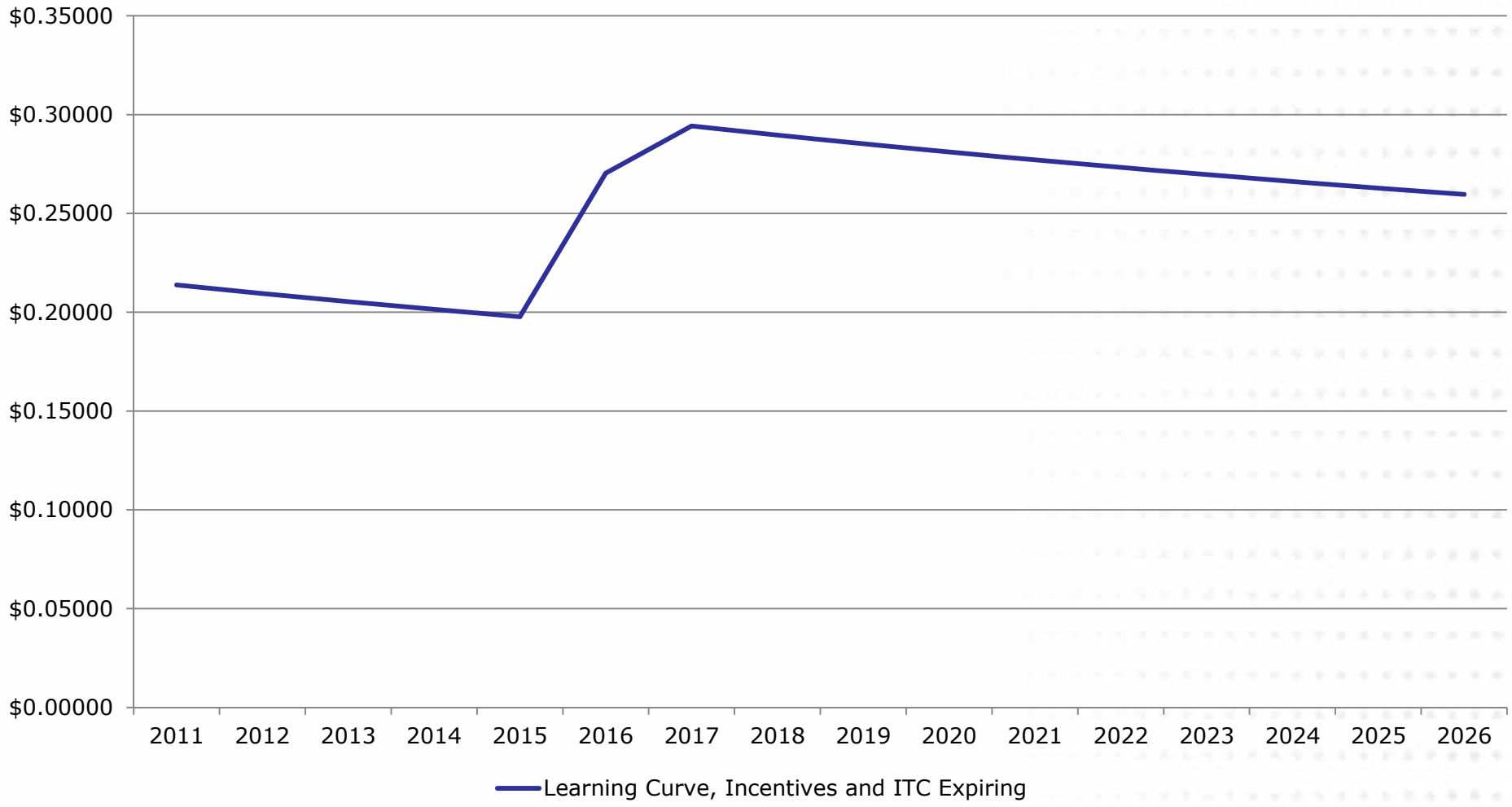
State Rebate	
PBI	**NO**
Rebate Amount ($/kWh)	$0.0000
SGIP - Upfront	**YES**
Rebate Amount Per Watt	$4.50
Total Upfront Rebate Amount ($)	$4,500

Financing	
% Financed w/ equity	62%
% Financed w/ debt	38%
Real Debt Interest rate	2.94%
Debt period in years	10
DSCR	1.40
Cost of Equity	9.17%
Real WACC	6.37%
Interest Rate on DSRF	0.5%
PPA Escalator	0.00%
Equity Amount	$5,356
Debt Amount	$3,236

Output	
Levelized Cost of Generation ($/kWh	**$0.2095**

- **Departing load charge assumption**
- **Requires renewable biogas on-site to qualify for SGIP ($2/watt reduction) and ITC.**

Fuel Cell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Learning Curve, Incentives and ITC Expiring

Storage – Uses Evaluated

- **Advanced Electrical Storage (AES) potential uses:**
  - Arbitrage time-of-use retail rates
    - Encompasses household value of reduced on-peak usage and flattened load profile
  - Backup power during grid emergencies or interruptions
    - Backup for on-site generation loss is provided by the grid
- **Other AES uses do not benefit households directly**
  - Community-level load following resource
    - Grid interconnection provides this service
  - Optimizing availability and utilization of PV and/or fuel cell
    - Grid interconnection provides this service
    - Value of optimization is to PG&E, diffuse value to households
  - Smooth out intermittent resource output and improve grid reliability and performance
    - Value is to PG&E, diffuse value to households

Storage – Benefits Calculation

+ Arbitrage of retail rates

- Modeled systems charge during off-peak and discharge to meet peak hour demand, saving the difference in prices
- Modeled storage for 8760 hours of the year based on PV with household load shape
- Rates
  - Community system modeled with A-6 tariff, which has no demand charges
  - Rooftop PV system modeled for households with E-6, also no demand charges
- EV's do not impact arbitrage benefit streams
  - EV charging increases demand, but homes remain ZNE
  - Rates do not have demand charges, so EV's do not alter economics

Storage – Rate Arbitrage Benefits

Community PV with A-6 tariff

1000 kW Industrial Lead-Acid				
Usable Energy Storage	NPV of Benefits	System Cost	System Life (Years)	Net NPV
4000 kWh	$1,576,698	$1,700,000	10	($140,405)
6000 kWh	$2,475,678	$2,550,000	10	($99,977)
1000 kW Nas				
4000 kWh	$1,095,752	$1,776,000	20	($547,871)
6000 kWh	$1,744,494	$2,664,000	20	($720,941)

Rooftop PV Systems with E-6 Tariff

1 kW Li-Ion				
Usable Energy Storage	NPV of Benefits	System Cost	System Life (Years)	Net NPV
4 kWh	$738	$3,852	10	($2,986)
6 kWh	$1,085	$5,778	10	($4,502)
1 kW Lead-Acid				
4 kWh	$609	$1,700	10	($1,034)
6 kWh	$956	$2,550	10	($1,510)
8 kWh	$1,157	$3,400	10	($2,131)
10 kWh	$1,225	$4,250	10	($2,884)

Storage – Benefits Calculation

- **Backup power eliminating or shortening outages**
  - Avoided cost of outage derived from System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) for PG&E
  - SAIDI and SAIFI imply a distribution of outage lengths. Storage can eliminate or reduce the duration of these outages avoiding the cost of an outage
- **Analysis only considers arbitrage of retail rates**
  - Each use requires dedicated storage capacity
  - Benefits of avoiding outages on the order of 3% of benefits from rate arbitrage

Economic Take Away Points

- **We can meet the goals of no higher cost to developer and to the owner with current subsidies**
  - Very small incremental cost to developer that can likely be passed through to the customer
  - Faster deployment helps as incentives decline (NSHP, ITC)
- **Significant energy efficiency is possible in new construction at modest incremental cost**
  - LED incentives are currently not sufficient to encourage adoption
  - Behavior improvement through customer feedback is difficult to model and needs further research
- **Natural gas use with biogas offset is the most efficient path to ZNE**
- **Electric vehicles increase lifecycle benefits significantly**
- **Difficult to make fuel cells and storage economic today, even with the state and federal subsidies**

Regulatory Take Away Points

- **Current policies do not promote the least societal cost system which is ground mounted PV**
  - This is because community scale PV systems require a complicated loop system and uncertain regulatory process to offset retail electricity costs rather than wholesale
- **CAHP program limit of one dwelling per property discourages density of new construction**
- **NEM provides the best current business model**
  - Bill Credit Transfer program pays only the generation component and has other limitations (# of accounts, CSI incentive capped at net usage)

Further Research Needed

- **Sustainable business models for PV in California**
  - NEM has significant cross-subsidies and is rapidly approaching the 5% legislative cap
  - SDG&E's grid charge was denied
  - Project would develop alternative regulatory models to encourage least cost systems with less cross subsidy than NEM
- **Evaluate incentive EV rate design and ability to sub-meter**
  - Important to encourage electric vehicles
- **Residential financing of energy efficiency for new construction and retrofits is critical for ZNE**

Energy+Environmental Economics

Thank you!
Break before in-depth model section

Overview of Modeling Approach

Establishing Purple Line Base Case

- **Assume Purple Line home acts to minimize its bills**
  - Purple Line home separately meters the carriage house
    - E-1 rate for main home
    - EL-1 (CARE) rate for carriage house
  - Real levelized electric rate for this configuration is $0.164 / kWh
  - $1,493 real levelized annual bill per home
- **If purple line is not metered separately**
  - $0.261 / kWh for E-1/EL-1
  - $0.278 / kWh for E-6/EL-6
- **For today's presentation, Purple Line assumed to be Title 24, reflecting savings versus generic California home**
  - $0.163 / kWh if Title 24 + 15%
  - $1,423 annual per home if Title 24 + 15%
- **Purple Line natural gas rates G-1, GL-1 (CARE)**

Establishing the West Village Base Case

- **Similarly, assume West Village home owners act to minimize their electric bills**
  - Carriage house separately metered
  - Electric vehicle is submetered
  - Under rooftop scenarios, the following net usage scenario yields the lowest bills:
    - E-1 rate for main home
    - EL-1 (CARE) rate for carriage house
    - E-9 for the electric vehicle
  - For Loop scenarios, A-6 rates yield lower net usage bills than E-19

Accommodating Various Home Floor Plans

- **To achieve budget and schedule objectives, multiple floor plans were accommodated in the following way:**
  - DEG detailed calculations for base case floor plan (described previously)
  - Electric and gas usage multipliers applied to adjust usage for floor plans that are larger or smaller than the base case
  - Today's results assume 100 each of small, base & large homes, and 43 extra large homes.

Gas - small home usage multiplier	0.850
Gas - large home usage multiplier	1.090
Gas - extra large home usage multiplier	1.230
Electricity - small home usage multiplier	0.843
Electricity - large home usage multiplier	1.057
Electricity - extra large home usage multiplier	1.169

Metering Configuration Scenarios for Rooftop Solar Configuration

- **Base Case = (H, EV) (CH)**
  - EV submetered with home on rate E-9 (additional meter cost of $450)
    - Home on PG&E residential schedule, carriage house on EL-1 (CARE)
    - EV on E9
  - Carriage unit metered separately on CARE schedule
- **The following scenarios are all more expensive than the Base Case:**
  - (H, CH, EV)
    - E6 rate is tiered
    - Under AltA EE package, large and extra large home PV systems exceed 7.5 kW eligibility for NSHP, but small & base case homes would qualify
  - (H) (CH) (EV)
    - PV to supply separately metered EV would receive CSI incentive instead of NSHP
  - (H, EV) (CH)
    - Increases tiered E1 usage
  - (H, CH) (EV)
    - Increases cost of E1 tiered rates, EV receives CSI
    - Note this configuration is profitable if Purple Line also meters carriage house with home (but this is cheating)

Solar PV Modeling Process

- **CPR determined solar PV capital costs & capacity factors**
- **CPR determined 8760 PV generation profile**
  - Community
  - Rooftop
- **E3 compiled 180 net usage scenarios incorporating home size, EE package, carriage house & EV scenarios**
- **CPR generated net usage bills**
  - Rooftop: E-1, E-6, EL-1, EL-6, E-9
  - Community: A-6, E-19

PV System Characteristics

- **Conservative price estimates**
- **Rooftop PV**
  - 18.4% capacity factor
  - $7,418 per kW capital cost (AC)
    - Median cost of all systems in CSI Database with the following filters: Residential sector, installed, sized within 20% of kW size target, and "First Incentive Claim Request Review Date" occurred in 2011. There were 1,674 candidate systems, and the median value was $7,400 per kW.
- **Community Scale**
  - 21.5% capacity factor
  - $5,138 per kW capital cost (AC)
    - Median cost of all systems in CSI database with the following filters: Commercial sector, installed, sized between 800 kW and 1200 kW CEC-PTC (i.e., within 20% of 1 MW target), where the "First Incentive Claim Request Review Date" occurred in 2011. There were 10 candidate systems and the median value was $5,200 per kW.

Rooftop PV – 2012 Installation

System Design	
System Cost per Watt (DC) (ALL IN)	$7.42
System Size (DC) (kpW)	6.4
Initial debt service reserve funding	$797
Project Finance Upfront Fees	$242
Total System Cost	$48,455

Performance Inputs	
DC to AC Derate Factor	1.00
System Size (AC)(kWp)	6.4
Annual Net AC Capacity Factor	18.4%
Year 1 Annual Output (kWh)	10,285
Degradation Factor	0.70%
System lifetime (in Years) = PPA Term	25

Other	
O&M Costs ($/kW)	$30.00
O&M Costs Escalator (%/yr)	0.00%
Inverter replacement cost ($/W)	$0.46
Inverter replacement time (in Years)	10
Inverter replacement cost	$2,917
Levelized (10yr) inverter replacement c	$403
Insurance Expense ($/kW)	29.67
Insurance Escalator (%/yr)	0.00%

Tax Assumptions	
Federal Tax Rate	35.00%
State Tax Rate	8.84%
Effective Tax Rate	40.75%

Federal Tax Credit	
System Cost Eligible for Tax Credit	$47,658
Tax Credit Rate	30%
Tax Credit Amount	$14,297

Tax Savings through Depreciation	
System Cost Eligible forTax Credit	$47,658
Basis Reduction for ITC	50%
Federal Tax Depreciation Basis	$40,509
State Tax Depreciation Basis	$32,395
MACRS Term	5

State Rebate	NSHP
PBI	**NO**
Rebate Amount ($/kWh)	$0.0000
NSHP - Upfront	**YES**
2011 Rebate Amount Per Watt AC	$2.35
Total Upfront Rebate Amount ($)	$15,021

Financing	
% Financed w/ equity	66%
% Financed w/ debt	34%
Real Debt Interest rate	5.4%
Debt period in years	15
Target DSCR	1.40
Real Cost of Equity	8.01%
Real WACC	6.37%
Months in DSRF	6
Real Interest Rate on DSRF	1.0%
LCOE Escalation Rate	0.00%
Project Finance Upfront Fees	1.5%
Equity Amount	$31,980
Debt Amount	$16,475

Output	
Real Levelized Cost of Generatic	**$0.1884**
NPV	$0.000

+ Note these are real levelized LCOEs specific to this analysis

- Real cost of capital
- No cost escalation

Community PV – 2012 Installation

System Design	
System Cost per Watt (DC) (ALL IN)	$5.14
System Size (DC) (kpW)	5.5
Initial debt service reserve funding	$516
Project Finance Upfront Fees	$157
Total System Cost	$28,886

Performance Inputs	
DC to AC Derate Factor	1.00
System Size (AC)(kWp)	5.5
Annual Net AC Capacity Factor	21.5%
Year 1 Annual Output (kWh)	10,319
Degradation Factor	0.70%
System lifetime (in Years) = PPA Term	25

Other	
O&M Costs ($/kW)	$25.00
O&M Costs Escalator (%/yr)	0.00%
Inverter replacement cost ($/W)	$0.46
Inverter replacement time (in Years)	10
Inverter replacement cost	$2,506
Levelized (10yr) inverter replacement cos	$346
Insurance Expense ($/kW)	$20.55
Insurance Escalator (%/yr)	0.00%
Land Cost (annual $)	$ 44

Tax Assumptions	
Federal Tax Rate	35.00%
State Tax Rate	8.84%
Effective Tax Rate	40.75%

Federal Tax Credit	
System Cost Eligible for Tax Credit	$28,369
Tax Credit Rate	30%
Tax Credit Amount	$8,511

Tax Savings through Depreciation	
System Cost Eligible forTax Credit	$28,369
Basis Reduction for ITC	50%
Federal Tax Depreciation Basis	$24,114
State Tax Depreciation Basis	$28,213
MACRS Term	5

State Rebate	CSI
PBI	**YES**
2011 Rebate Amount ($/kWh)	$0.0900
NSHP - Upfront	**NO**
2011 Rebate Amount Per Watt AC	$0.00
Total Upfront Rebate Amount ($)	$0

Financing	
% Financed w/ equity	63%
% Financed w/ debt	37%
Real Debt Interest rate	5.4%
Debt period in years	15
Target DSCR	1.40
Real Cost of Equity	8.24%
Real WACC	6.37%
Months in DSRF	6
Real Interest Rate on DSRF	1.0%
LCOE Escalation Rate	0.00%
Project Finance Upfront Fees	1.5%
Equity Amount	$18,198
Debt Amount	$10,688

Output	
Real Levelized Cost of Generati	**$0.1626**
NPV	$0.000

+ Note these are real levelized LCOEs specific to this analysis

- Real cost of capital
- No cost escalation

Construction Timing & Incentives

COD for $0.09 CSI Incentive

30% ITC steps down to 10%

Scenario	Rate	2011	2012	2013	2014	2015	2016	2017	2018	2019	202
Downside Case	30 houses/year	-	10	40	70	100	130	160	190	220	25(
Base Case	60 houses/year	-	20	80	140	200	260	320	343	343	34:
Upside Case	100 houses/year	-	33	133	233	333	343	343	343	343	34:

18 mos

36 mos

Last CSI Payout

Last NSHP Payout

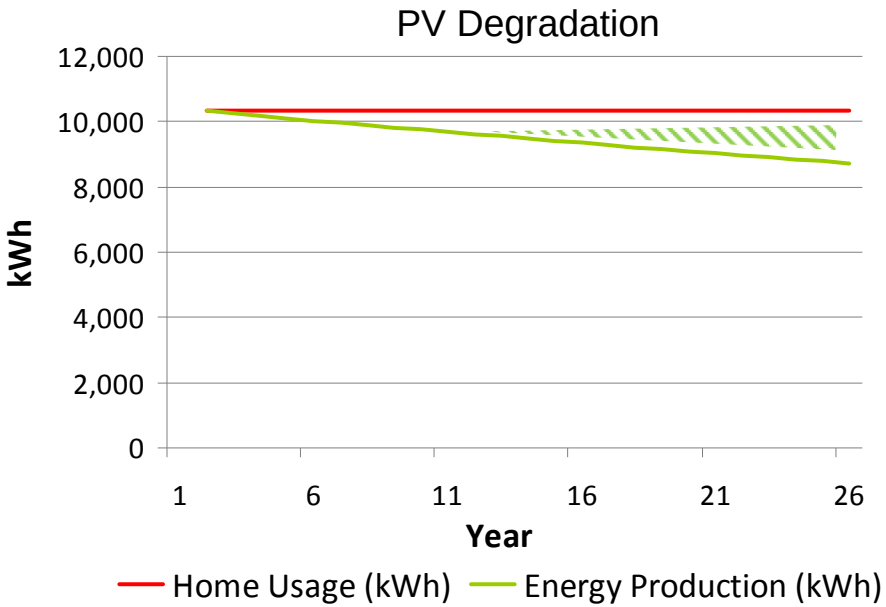
NSHP, CSI, ITC & Learning Curves: Changes Over Time

		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Solar PV Learning Curve	Source - CSI model 8/18/2011											
$/kW Capital Cost Decline - from 2011	75%	0.818	0.715	0.646	0.595	0.556	0.525	0.498	0.476	0.457	0.440	0.425
$/kW Capital Cost Decline - from 2011	80%	0.856	0.771	0.712	0.669	0.634	0.606	0.583	0.562	0.545	0.529	0.515
$/kW Capital Cost Decline - from 2011	85%	0.893	0.827	0.781	0.746	0.718	0.695	0.675	0.658	0.642	0.629	0.617
$/kW Capital Cost Decline - from 2011	90%	0.929	0.884	0.852	0.827	0.807	0.790	0.775	0.762	0.751	0.740	0.731
Active Learning Curve	90%	0.929	0.884	0.852	0.827	0.807	0.790	0.775	0.762	0.751	0.740	0.731
Timing Impacts on CSI												
CSI Incentive Decline Schedule		$ 0.09	$ 0.05	$ 0.05	$ 0.03	$ 0.03	$ 0.03	$ -	$ -	$ -	$ -	$ -
Impact on LCOE		-	0.019	0.019	0.028	0.028	0.028	0.042	0.042	0.042	0.042	0.042
Timing Impacts on NSHP												
NSHP Incentive Level		$ 2.35	$ 2.10	$ 1.85	$ 1.35	$ 1.10	$ 0.85	$ 0.35	$ 0.35	$ -	$ -	$ -
Impact on LCOE		-	0.016	0.031	0.063	0.078	0.094	0.125	0.125	0.147	0.147	0.147
Investment Tax Credit												
ITC Assumption		30%	30%	30%	30%	30%	10%	10%	10%	10%	10%	10%
Impact on LCOE - Rooftop (before learning curve)		-	-	-	-	-	0.104	0.104	0.104	0.104	0.104	0.104
Impact on LCOE - Community (before learning curve)		-	-	-	-	-	0.067	0.067	0.067	0.067	0.067	0.067

- **NSHP, CSI and ITC will step down over time**
  - Last CSI payout in 2017
  - Last NSHP payout in 2019
- **The table above shows the assumptions used to generate today's results**

Sources of Generation Requirement Uncertainties

- Uncertain future generation requirements stem from several sources:
  - Home owner behavior and future plug loads may increase or decrease usage at West Village
  - Future electric vehicle needs
  - PV degradation will decrease generation to some degree, but the magnitude is not known with certainty
- A future solution may be required to supplement production in later years
- Today's results assume 0.7% annual PV degradation



20,000 kWh per home may need to be replaced over 25 years

Up to 15% shortfall by year 25

Potential Supply Sources if Usage is Greater than Projected

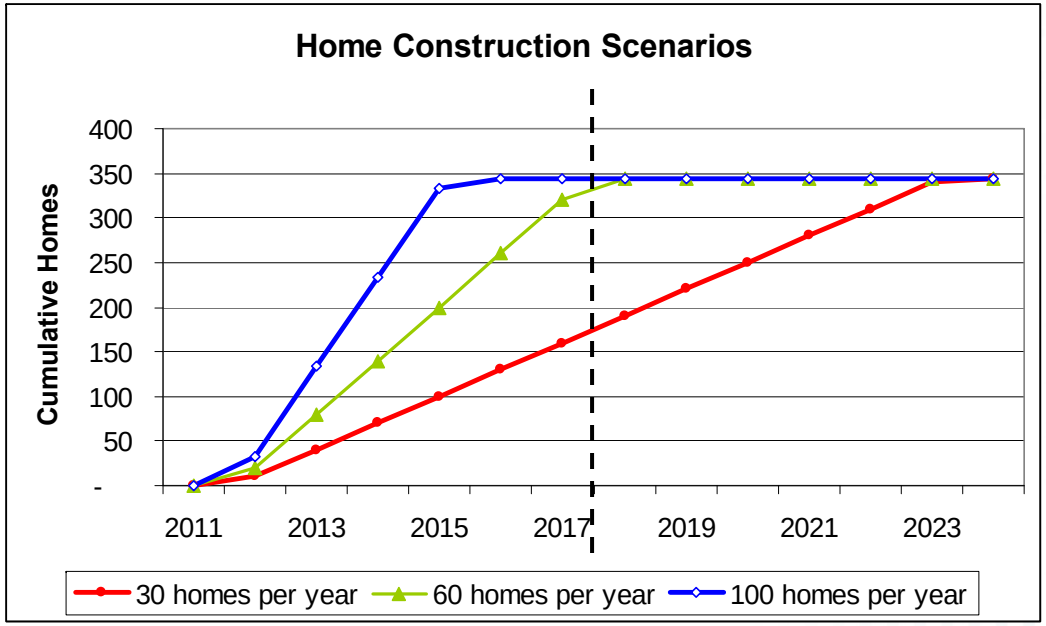
+ Size PV to generate first year kWh

- If future generation is less than year 1 production, generation will be required to replace the shortfall
- Future fuel cell
  - Costly, but demonstrates multiple renewable sources and could be located on-site in the loop configuration
- Install additional PV in the future
  - Does not demonstrate multiple resources
- PG&E retail rate + RECs (~ $0.19 per kWh)
  - Not on-site generation
- PG&E retail rate without RECs
  - Not renewable

Potential Energy Sale Solutions When System is Over-sized

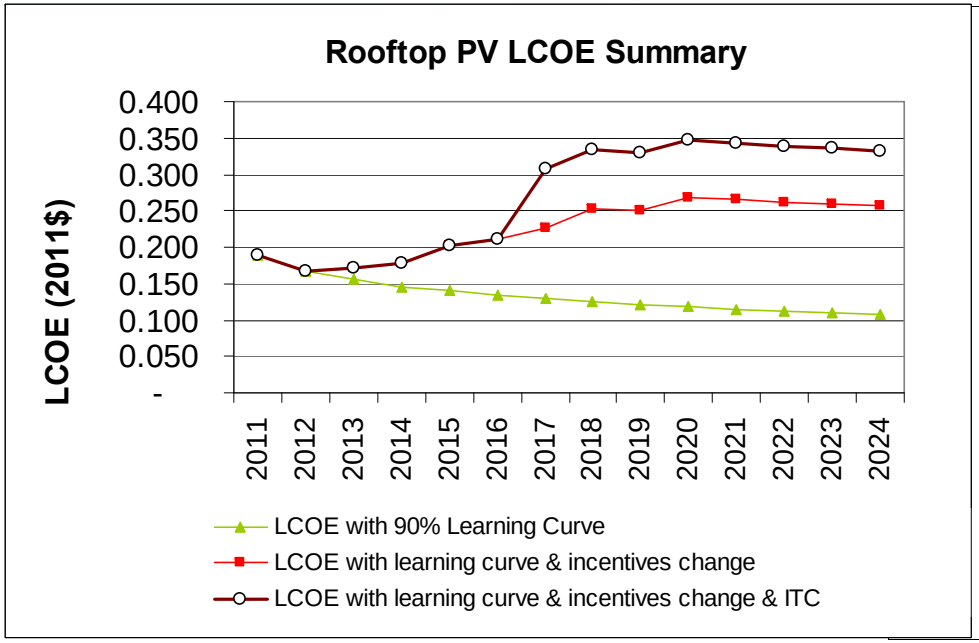
- **Size PV to generate lifetime kWh usage (over-sized in early years, under-sized in later years)**
  - Net surplus compensation = approx. $0.04 / kWh
  - In community loop scenario, short-term small renewable generator PPA with PG&E (PG&E Schedule E-SRG)
    - MPR * 1.2 TOD factor = $0.12/kWh
  - PPA with UCD
    - Price and ownership of RECs would have to be negotiated

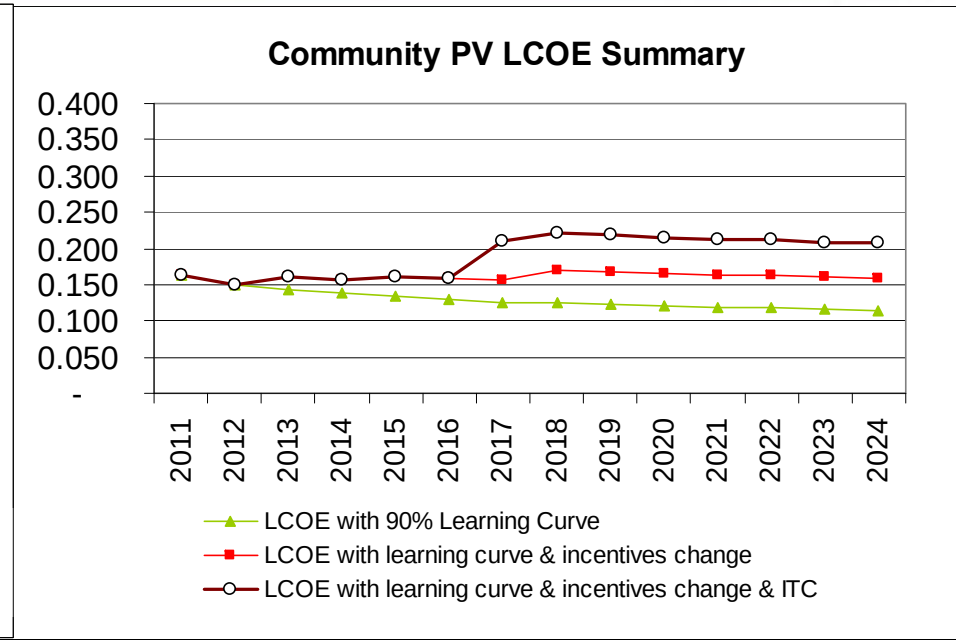
Construction Scenarios



- **Scenarios: 30, 60, or 100 homes per year constructed**
- **If construction rate is 60 homes per year, construction is completed in 2018**
- **If 30 homes per year are constructed, by the end of 2017, 160 homes have been constructed (~50%)**

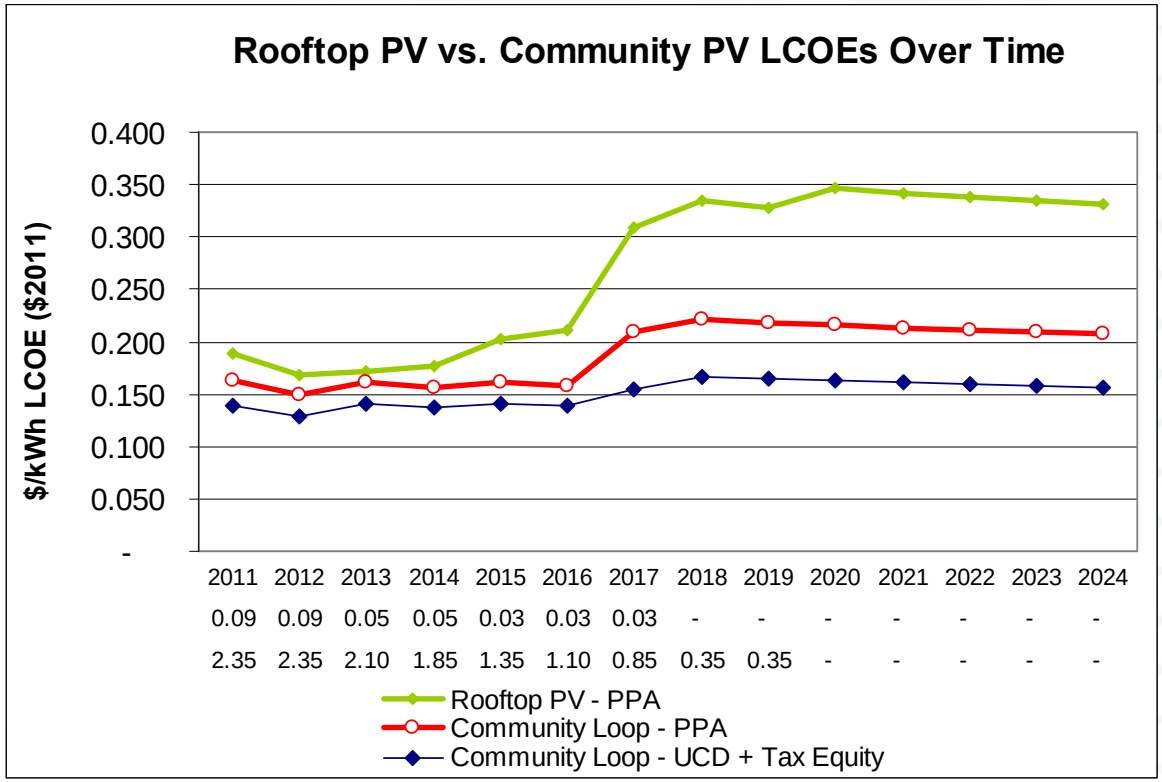
Changes in LCOE Over Time





- **Brown lines show final LCOE trajectory after taking into consideration learning curve, changes in incentive levels, and ITC stepdown**
  - In rooftop scenario, learning curve improvements largely offset NSHP incentive declines
  - In community scenario, learning curve improvements are greater than CSI incentive declines, and eventually also nearly offset ITC stepdown
  - Community PV LCOE excludes trench & security costs

90% Learning Curve LCOEs



- **Results take into account learning curves & declining incentive values over time**
- **With rooftop PV installations, homeowners purchasing in different years will pay different prices for solar PV**
- **Rooftop PV is impacted to a greater degree as incentives roll off**

Gas & Electric Retail Rate & Gasoline Escalation

Year			2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Real PG&E Rate Escalation Scenarios													
PG&E GHG thru 2020, 1.5% after			0.0232	0.0232	0.0232	0.0232	0.0232	0.0232	0.0232	0.0232	0.0232	0.015	0.015
Compound Real Rate Escalation			1.02	1.05	1.07	1.10	1.12	1.15	1.17	1.20	1.23	1.25	1.27
Gasoline Price Forecast ($/Gallon)													
source: EIA Annual Energy Outlook 2011													
Federal Gasoline Tax	$	0.184											
California Gasoline Tax	$	0.505											
Federal Gasoline Tax			$ 0.69	$ 0.69	$ 0.69	$ 0.69	$ 0.69	$ 0.69	$ 0.69	$ 0.69	$ 0.69	$ 0.69	$ 0.69
Real $/Gallon 2011$	$	2.44	$ 2.80	$ 2.91	$ 3.03	$ 3.15	$ 3.20	$ 3.24	$ 3.29	$ 3.34	$ 3.38	$ 3.41	$ 3.43
Real $/Gallon 2011$ - after gasoline taxes	$	-	$ 3.48	$ 3.60	$ 3.72	$ 3.84	$ 3.88	$ 3.93	$ 3.98	$ 4.03	$ 4.07	$ 4.10	$ 4.12
Residential Natural Gas Price Forecast													
source: EIA Annual Energy Outlook 2011													
Compound Real Price Escalation			0.97	0.95	0.92	0.89	0.91	0.92	0.94	0.95	0.96	0.98	1.00

+ **The above table shows real escalation assumptions used to generate today's results**
  - PG&E retail gas and electric rates
  - Gasoline

Electric Vehicles at no higher cost to owner and developer

West Village Costs
- Incremental EV and infrastructure costs, net of incentives
- Cost of PV kWh

≤

Purple Line Costs
- Gasoline Costs

+ **Electric vehicle infrastructure assumed not included in developer scope**
  - Meter $800
    - $450 if EV is submetered
  - 220 kV charger $1,500
+ **All purple line cars assumed to use gasoline**

Electric Vehicle Modeling

- **No EVs have been assumed in the base case economics**
- **$12,200 average incremental cost of vehicle, plus learning curve**
- **Incentives**
  - Federal tax credit $7,500 available until ~ 2020
    - Expires when 200,000 EVs from each manufacturer have been produced
  - $2,500 California incentive available until ~ 2015
- **West Village EVs use PV generation (not PG&E retail)**
  - "Soccer Mom" 4,702 kWh per year + ~ 12 gallons of gasoline
  - "Commuter" 3,910 kWh per year + ~ 12 gallons of gasoline
- **2 vehicles per household, 35% soccer mom, 65% commuter**
- **Controlled and uncontrolled charging scenarios – assumed controlled**

Additional Modeling Assumptions

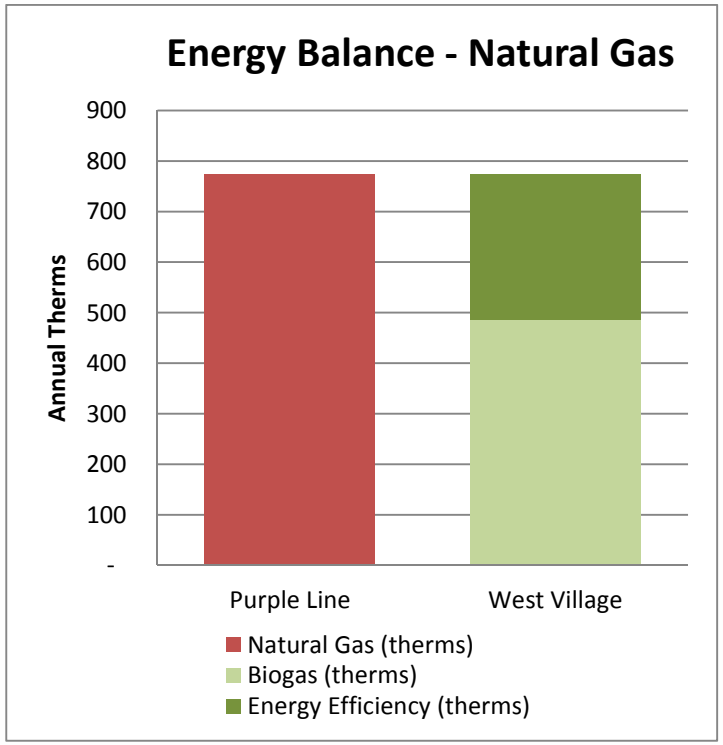
- **100% of carriage units are rentals**
- **Costs modeled in real 2011$**
  - Real discount rates
  - Real electric rate, natural gas, gasoline price escalation
- **25-year economic life of PV panels**
  - Model term through 2043
- **EEM costs & incentive levels assumed fixed for construction period (excluding CAHP with defined expiry)**

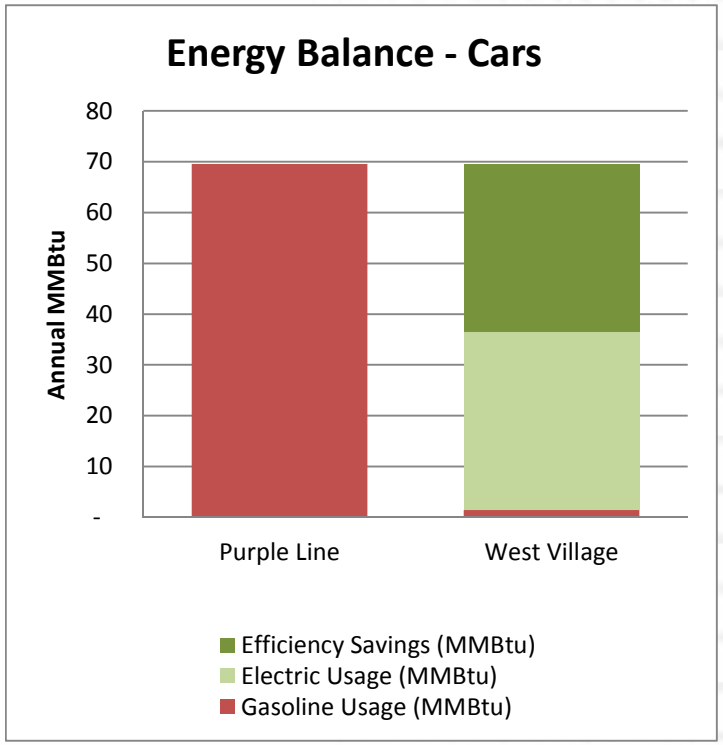
Results:
Current Regulatory Environment

Results Metrics

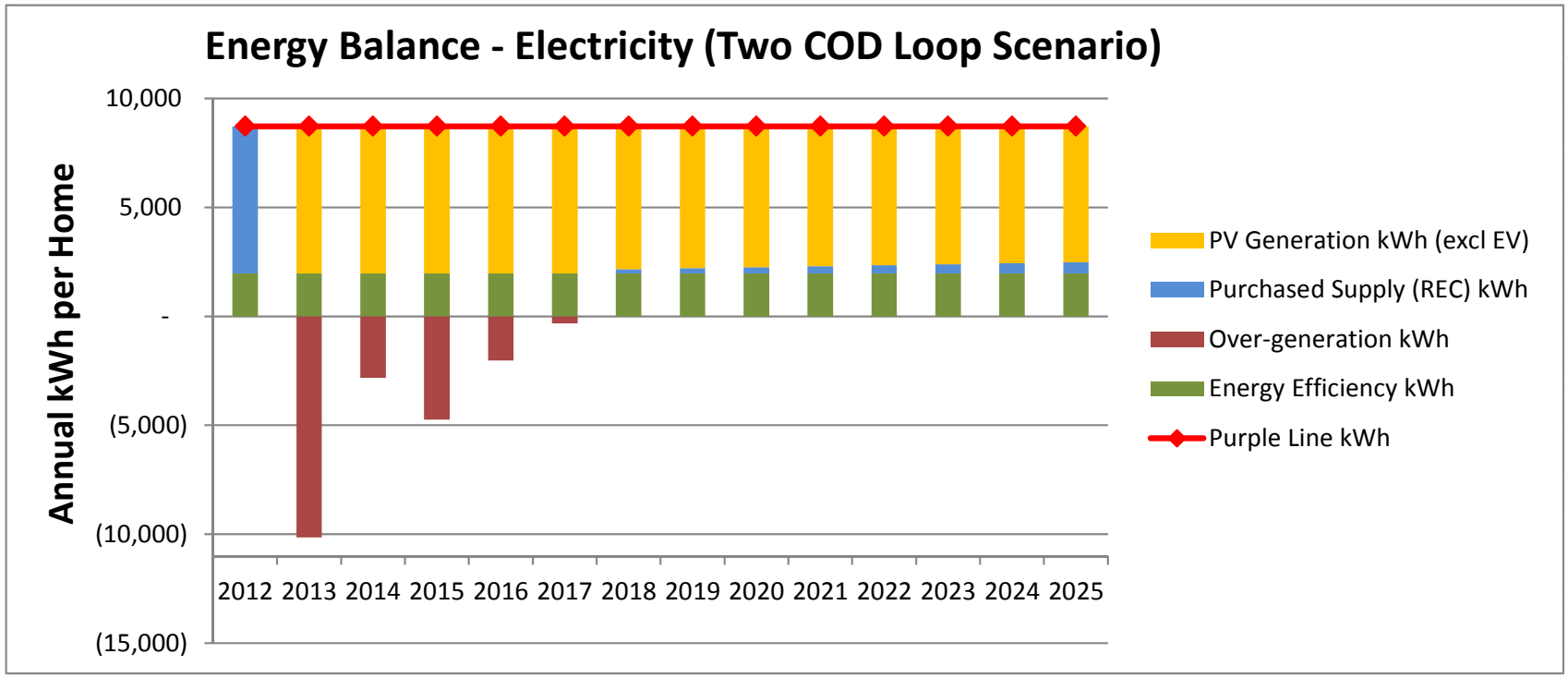
- **Results measured in real 2011$ NPV of difference between Purple Line home and West Village Home**
  - Total West Village may be more/(less) economic than Purple Line
    - Contribution from energy efficiency
    - Contribution from electricity usage
    - Contribution from gas usage (natural gas, biogas)
    - Contribution from vehicles
- **NPV discount rate is home owner real cost of capital**
  - 3.4% real = (1+5.5% nominal)/(1.02) -1
- **Trench cost assumptions:**
  - $1 million per loop

Energy Balance – Gas & Gasoline





Energy Balance - Electricity



The above example assumes 60 homes per year construction, and Loops constructed in 2013 and 2015.

Overview of Business Models

Scenarios

- **Rooftop - PPA**
- **Two Loops, 2013 COD**
  - PPA or UCD + Tax Equity financing
- **Two Loops, COD 2013 & 2015 or 2018**
  - PPA or UCD + Tax Equity financing
- **Rooftop then Delayed 2017 Loop**
  - PPA or UCD + Tax Equity financing

Sensitivities

- **Home construction rate**
  - 30 homes/yr
  - 60 homes/yr
  - 100 homes/yr
- **Learning curve**
  - 75%
  - 90%
- **Carriage unit**
- **Electric vehicles**

Results: 30 Homes/Yr & 90% Learning

Home Constr Rate	EEM Package	Learning Curve	Two Loops 2013 COD PPA	Two Loops COD 2013 & 2015 (60) or 2018 (30) PPA	Two Loops 2013 COD UCD + Tax Equity	Two Loops COD 2013 & 2015 (60) or 2018 (30) UCD + Tax Equity	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA	Rooftop + Delayed 2017 Loop UCD + Tax Equity
30	Proposed	90%	(0.5)	(0.6)	0.3	0.6	(2.5)	0.0	0.4
30	Adv A	90%	0.3	0.2	1.0	1.3	(1.7)	0.7	1.1
30	Adv B	90%	(0.6)	(0.7)	0.1	0.4	(2.5)	(0.1)	0.2
Trench Cost Assumption:			**2.0**	**2.0**	**2.0**	**2.0**	**-**	**1.0**	**1.0**

Configuration			Amount West Village More/(Less) Profitable Than Purple Line ($ millions) After Adjusting for Joint Trench Costs						
30	Proposed	90%	(2.5)	(2.6)	(1.7)	(1.4)	(2.5)	(1.0)	(0.6)
30	Adv A	90%	(1.7)	(1.8)	(1.0)	(0.7)	(1.7)	(0.3)	0.1
30	Adv B	90%	(2.6)	(2.7)	(1.9)	(1.6)	(2.5)	(1.1)	(0.8)

- **No scenarios are economic under a slow construction rate & 90% learning curve scenario**
  - In this case, rooftop + delayed loop appears to be the best strategy
- **Results are after trench costs**

Trench costs include security & administrative costs associated with loop scenario, as well as joint trench cost.
Prevailing wage adder has been included in UCD scenario economics.

Results: 30 Homes/Yr & 75% Learning

Home Constr Rate	EEM Package	Learning Curve	Two Loops 2013 COD PPA	Two Loops COD 2013 & 2015 (60) or 2018 (30) PPA	Two Loops 2013 COD UCD + Tax Equity	Two Loops COD 2013 & 2015 (60) or 2018 (30) UCD + Tax Equity	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA	Rooftop + Delayed 2017 Loop UCD + Tax Equity
30	Proposed	75%	0.2	0.7	0.9	1.6	0.2	1.6	1.9
30	Adv A	75%	0.9	1.3	1.5	2.2	0.9	2.3	2.5
30	Adv B	75%	0.0	0.4	0.7	1.3	-	1.3	1.6
Trench Cost Assumption:			**2.0**	**2.0**	**2.0**	**2.0**	**-**	**1.0**	**1.0**

Configuration			Amount West Village More/(Less) Profitable Than Purple Line ($ millions) After Adjusting for Joint Trench Costs						
30	Proposed	75%	(1.8)	(1.3)	(1.1)	(0.4)	0.2	0.6	0.9
30	Adv A	75%	(1.1)	(0.7)	(0.5)	0.2	0.9	1.3	1.5
30	Adv B	75%	(2.0)	(1.6)	(1.3)	(0.7)	-	0.3	0.6

+ **Rooftop & Rooftop + Delayed Loop scenarios are economic under a slow construction rate & 75% learning curve scenario**
  - In this case, rooftop + delayed loop appears to be the best strategy, however an all-rooftop strategy would provide the least risk.

Results: 60 Homes/Yr & 90% Learning

Home Constr Rate	EEM Package	Learning Curve	Two Loops 2013 COD PPA	Two Loops COD 2013 & 2015 (60) or 2018 (30) PPA	Two Loops 2013 COD UCD + Tax Equity	Two Loops COD 2013 & 2015 (60) or 2018 (30) UCD + Tax Equity	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA	Rooftop + Delayed 2017 Loop UCD + Tax Equity
60	Proposed	90%	0.0	0.2	0.8	1.0	(1.3)	0.0	0.2
60	Adv A	90%	0.8	0.9	1.5	1.7	(0.5)	0.8	0.9
60	Adv B	90%	(0.2)	(0.0)	0.5	0.7	(1.4)	0.0	(0.1)
Trench Cost Assumption:			**2.0**	**2.0**	**2.0**	**2.0**	**-**	**1.0**	**1.0**

Configuration			Amount West Village More/(Less) Profitable Than Purple Line ($ millions) After Adjusting for Joint Trench Costs						
60	Proposed	90%	(2.0)	(1.8)	(1.2)	(1.0)	(1.3)	(1.0)	(0.8)
60	Adv A	90%	(1.2)	(1.1)	(0.5)	(0.3)	(0.5)	(0.2)	(0.1)
60	Adv B	90%	(2.2)	(2.0)	(1.5)	(1.3)	(1.4)	(1.0)	(1.1)

- **No scenarios are economic under a medium construction rate & 90% learning curve scenario**
  - In this case, rooftop + delayed loop appears to be the best strategy

Results:
60 Homes/Yr & 75% Learning

Home Constr Rate	EEM Package	Learning Curve	Two Loops 2013 COD PPA	Two Loops COD 2013 & 2015 (60) or 2018 (30) PPA	Two Loops 2013 COD UCD + Tax Equity	Two Loops COD 2013 & 2015 (60) or 2018 (30) UCD + Tax Equity	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA	Rooftop + Delayed 2017 Loop UCD + Tax Equity
60	Proposed	75%	0.7	1.8	1.4	1.7	1.0	1.9	2.0
60	Adv A	75%	1.4	1.8	2.1	2.4	1.8	2.5	2.6
60	Adv B	75%	0.4	0.8	1.0	1.3	0.8	1.9	1.6
Trench Cost Assumption:			**2.0**	**2.0**	**2.0**	**2.0**	**-**	**1.0**	**1.0**

Configuration			Amount West Village More/(Less) Profitable Than Purple Line ($ millions) After Adjusting for Joint Trench Costs						
60	Proposed	75%	(1.3)	(0.2)	(0.6)	(0.3)	1.0	0.9	1.0
60	Adv A	75%	(0.6)	(0.2)	0.1	0.4	1.8	1.5	1.6
60	Adv B	75%	(1.6)	(1.2)	(1.0)	(0.7)	0.8	0.9	0.6

- **Rooftop or Rooftop + Delayed Loop scenarios are economic under a medium construction rate & 75% learning curve scenario**
  - Rooftop is less risky and results in higher projected NPV

Results:
100 Homes/Yr & 90% Learning

Home Constr Rate	EEM Package	Learning Curve	Two Loops 2013 COD PPA	Two Loops COD 2013 & 2015 (60) or 2018 (30) PPA	Two Loops 2013 COD UCD + Tax Equity	Two Loops COD 2013 & 2015 (60) or 2018 (30) UCD + Tax Equity	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA	Rooftop + Delayed 2017 Loop UCD + Tax Equity
100	Proposed	90%	0.3	n/a	1.1	n/a	(0.2)	0.2	0.0
100	Adv A	90%	1.0	n/a	1.8	n/a	0.6	0.8	0.8
100	Adv B	90%	(0.0)	n/a	0.4	n/a	(0.4)	(0.3)	0.2
Trench Cost Assumption:			**2.0**	**2.0**	**2.0**	**2.0**	**-**	**1.0**	**1.0**

Configuration			Amount West Village More/(Less) Profitable Than Purple Line ($ millions) After Adjusting for Joint Trench Costs						
100	Proposed	90%	(1.7)	n/a	(0.9)	n/a	(0.2)	(0.8)	(1.0)
100	Adv A	90%	(1.0)	n/a	(0.2)	n/a	0.6	(0.2)	(0.2)
100	Adv B	90%	(2.0)	n/a	(1.6)	n/a	(0.4)	(1.3)	(0.8)

- **Under a fast construction rate & 90% learning curve scenario, only the Rooftop + Adv A EEM scenario is economic**

Results:
100 Homes/Yr & 75% Learning

Home Constr Rate	EEM Package	Learning Curve	Two Loops 2013 COD PPA	Two Loops COD 2013 & 2015 (60) or 2018 (30) PPA	Two Loops 2013 COD UCD + Tax Equity	Two Loops COD 2013 & 2015 (60) or 2018 (30) UCD + Tax Equity	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA	Rooftop + Delayed 2017 Loop UCD + Tax Equity
100	Proposed	75%	0.9	n/a	1.6	n/a	1.8	2.0	2.0
100	Adv A	75%	1.6	n/a	2.2	n/a	2.5	2.7	2.7
100	Adv B	75%	0.6	n/a	1.2	n/a	1.4	1.6	1.6
Trench Cost Assumption:			**2.0**	**2.0**	**2.0**	**2.0**	**-**	**1.0**	**1.0**

Configuration			Amount West Village More/(Less) Profitable Than Purple Line ($ millions) After Adjusting for Joint Trench Costs						
100	Proposed	75%	(1.1)	n/a	(0.4)	n/a	1.8	1.0	1.0
100	Adv A	75%	(0.4)	n/a	0.2	n/a	2.5	1.7	1.7
100	Adv B	75%	(1.4)	n/a	(0.8)	n/a	1.4	0.6	0.6

- **Under a 75% learning curve and fast construction scenario, rooftop PV is the most economic scenario under the assumed trench costs**

Summary: 90% Learning Curve + Various Home Construction Rates

Home Constr Rate	EEM Package	Learning Curve	Two Loops 2013 COD PPA	Two Loops COD 2013 & 2015 (60) or 2018 (30) PPA	Two Loops 2013 COD UCD + Tax Equity	Two Loops COD 2013 & 2015 (60) or 2018 (30) UCD + Tax Equity	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA	Rooftop + Delayed 2017 Loop UCD + Tax Equity
30	Proposed	90%	(2.5)	(2.6)	(1.7)	(1.4)	(2.5)	(1.0)	(0.6)
30	Adv A	90%	(1.7)	(1.8)	(1.0)	(0.7)	(1.7)	(0.3)	0.1
30	Adv B	90%	(2.6)	(2.7)	(1.9)	(1.6)	(2.5)	(1.1)	(0.8)
60	Proposed	90%	(2.0)	(1.8)	(1.2)	(1.0)	(1.3)	(1.0)	(0.8)
60	Adv A	90%	(1.2)	(1.1)	(0.5)	(0.3)	(0.5)	(0.2)	(0.1)
60	Adv B	90%	(2.2)	(2.0)	(1.5)	(1.3)	(1.4)	(1.0)	(1.1)
100	Proposed	90%	(1.7)	n/a	(0.9)	n/a	(0.2)	(0.8)	(1.0)
100	Adv A	90%	(1.0)	n/a	(0.2)	n/a	0.6	(0.2)	(0.2)
100	Adv B	90%	(2.0)	n/a	(1.6)	n/a	(0.4)	(1.3)	(0.8)

- Adv A package is always the most economic
- Under a 90% learning curve scenario, the economics are difficult
  - Rooftop with Adv A EEMs is only economic in 100 homes/yr case; balance of cases are un-economic after assumed trench costs

Summary: 75% Learning Curve + Various Home Construction Rates

Home Constr Rate	EEM Package	Learning Curve	Two Loops 2013 COD PPA	Two Loops COD 2013 & 2015 (60) or 2018 (30) PPA	Two Loops 2013 COD UCD + Tax Equity	Two Loops COD 2013 & 2015 (60) or 2018 (30) UCD + Tax Equity	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA	Rooftop + Delayed 2017 Loop UCD + Tax Equity
30	Proposed	75%	(1.8)	(1.3)	(1.1)	(0.4)	0.2	0.6	0.9
30	Adv A	75%	(1.1)	(0.7)	(0.5)	0.2	0.9	1.3	1.5
30	Adv B	75%	(2.0)	(1.6)	(1.3)	(0.7)	-	0.3	0.6
60	Proposed	75%	(1.3)	(0.2)	(0.6)	(0.3)	1.0	0.9	1.0
60	Adv A	75%	(0.6)	(0.2)	0.1	0.4	1.8	1.5	1.6
60	Adv B	75%	(1.6)	(1.2)	(1.0)	(0.7)	0.8	0.9	0.6
100	Proposed	75%	(1.1)	n/a	(0.4)	n/a	1.8	1.0	1.0
100	Adv A	75%	(0.4)	n/a	0.2	n/a	2.5	1.7	1.7
100	Adv B	75%	(1.4)	n/a	(0.8)	n/a	1.4	0.6	0.6

- **Adv A package is always the most economic**
- **Rooftop PV is always economic**
- **Rooftop + Delayed Loop is also economic**
  - **Where it falls versus all rooftop scenario depends on trench costs**
- **Balance of loop scenarios are not economic under assumed trench cost.**

Summary of Analysis

Homes Per Yr	Learning Curve	Business Model	NPV
30	75% learning curve	Rooftop or	0.9
		Rooftop + Delayed Loop	1.3
	90% learning curve	Rooftop + Delayed Loop	-0.3
60	75% learning curve	Rooftop	1.8
	90% learning curve	Rooftop + Delayed Loop	-0.1
100	75% learning curve	Rooftop	2.5
	90% learning curve	Rooftop	0.6

What PV generation strategy should be employed?

+ Should a different PV business model other than rooftop PV be pursued?

- In certain scenarios:
  - 30 homes per year, likely want to pursue rooftop then loop post-2017
  - 60 homes per year, rooftop is viable and is more certain under a 90% learning curve, but under a 75% learning curve, depending on joint trench costs, delayed loop may be more profitable
  - 100 homes per year likely want to pursue rooftop only
- In all cases, start with rooftop PV first

What Level of Energy Efficiency

- **Adv A is the most economic package across all PV price scenarios**
  - Should be re-evaluated if EEM incentive levels or component costs change materially
- **Should a different EE path be pursued depending upon future PV prices?**
  - No, Adv A appears to be the best in all scenarios

What if we add electric vehicles?

Home Constr Rate	EEM Package	Learning Curve	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA
30	Adv A	75%	2.1	3.0
30	Adv A	90%	(1.2)	1.0
60	Adv A	75%	3.4	3.6
60	Adv A	90%	0.6	1.3
100	Adv A	75%	4.2	3.7
100	Adv A	90%	1.8	1.4

- **There are many potential future EV scenarios:**
  - **Low, Medium, High penetration rates**
  - **Mix of owner types: Soccer Mom & Commuter**
  - **Controlled & uncontrolled charging patterns**
- **This scenario reflects medium penetration, controlled charging, 35% soccer mom / 65% commuter**
- **Results: business models that should be pursued do not change, but NPVs increase**

What if electric rates are different than projected?

Low Rate Escalation (0.5% after 2020)

Home Constr Rate	EEM Package	Learning Curve	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA
30	Adv A	75%	0.4	0.8
30	Adv A	90%	(2.2)	(0.7)
60	Adv A	75%	1.4	1.1
60	Adv A	90%	(0.9)	(0.6)
100	Adv A	75%	2.2	1.3
100	Adv A	90%	0.3	(0.6)

High Rate Escalation (2.2% after 2020)

Home Constr Rate	EEM Package	Learning Curve	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA
30	Adv A	75%	1.3	1.7
30	Adv A	90%	(1.3)	0.1
60	Adv A	75%	2.1	2.0
60	Adv A	90%	(0.1)	0.1
100	Adv A	75%	2.8	2.0
100	Adv A	90%	0.9	0.1

- **Business models that should be pursued do not change, but NPVs change**
- **Approximately $1 million spread between scenarios**

What if we don't build carriage units?

Home Constr Rate	EEM Package	Learning Curve	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA
30	Adv A	75%	2.1	2.1
30	Adv A	90%	0.2	1.0
60	Adv A	75%	2.9	2.5
60	Adv A	90%	1.2	1.2
100	Adv A	75%	3.5	2.7
100	Adv A	90%	2.1	1.3

+ **Business models that should be pursued do not change, but NPVs increase**
  - West Village Carriage House electricity bill is greater than Purple Line carriage house electricity bill (CARE)
  - No incentives for energy efficiency for carriage units
  - Results above assume no electric vehicles

Conclusions

- **Starting with rooftop always provides the best economics**
  - In slow construction case, jump to loop for second half of development
  - In medium construction case with 90% learning curve, jump to loop for second half of development
  - Otherwise, rooftop is likely the best option
    - Least regulatory risk and uncertainty
- **UCD financing may improve loop economics further, but needs refinement**

Results:
Regulatory Change Scenarios

Regulatory Change Scenario #1: Virtual Net Metering

- **Construct community-scale system with CSI incentive**
- **Bill credits at residential (vs. A-6) rates**
- **Improves economics by approximately $1.8 million**
  - Net usage bills increase by ~ $200k NPV
  - Trench costs savings $2 million
- **No Rule 18 issues**
- **PG&E will not support virtual net metering**

Regulatory Change Scenario #2: Aggregated NSHP

- **Construct community Loop with A-6 bill credits and "Aggregated NSHP" incentives**
- **Economics are improved by $3 to $7 million under this scenario, depending on NSHP level at installation**
- **There are several challenges involved in implementing the "Aggregated NSHP" model**
  - Getting CEC to allow aggregated NSHP incentives
    - hard, but perhaps conceivable
  - Getting CEC to apply NSHP to a commercial customer
    - Hard, but perhaps conceivable

Regulatory Change Strategy Recommendations

- **"Aggregated NSHP" is worth pursuing, without investing a great deal of effort.**
- **Attempting to change virtual net metering is not recommended.**
- **Other unlikely regulatory change:**
  - Increased compensation for surplus generation (4 cents)
- **Additional regulatory changes that could be helpful:**
  - Energy efficiency incentives
    - To help measures become economic (i.e., LED lighting)
    - More than 1 building per property eligible for utility energy efficiency incentives
  - Regulatory issues around biogas in pipelines