

# BUILDING A WORLD OF DIFFERENCE

July 17 2013

## SAN DIEGO CUSTOMER-OWNED DISTRIBUTED PHOTOVOLTAIC (PV) IMPACT STUDY

### RESULTS



Clean Power Research®



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# WORKSHOP AGENDA

- Review Project Schedule, Previous Meetings, Study Objectives
- Methodology Updates
- Data Sources and SDG&E Data
- Draft Study Results
- Wrap-Up and Next Steps

# PROJECT SCHEDULE

- November 29, 2012 – Kick-off
- January 14 – Project Re-scoping
- January 25 – Transmission-related services
- February 1 – Distribution-related services
- February 7 – Customer-related services
- March 29 – Methodology Update
- July 10 – Draft Report to Stakeholder Group
- July 17 – Discussion of Results
- July 19 – Comments on Draft Report Due
- July 31 – Final Report



# RECAP OF PREVIOUS MEETINGS

- Series of three webinars in January-February on proposed methodology components, final methodology webinar in March
- Received significant stakeholder feedback during the webinars and in written comments, which was considered in the final study methodology
- All study materials (meeting notes, presentations, stakeholder comments, etc.) are posted on EPIC website at:

[http://www.sandiego.edu/epic/research\\_reports/other.php#NEMStudy](http://www.sandiego.edu/epic/research_reports/other.php#NEMStudy)

# REVISED STUDY OBJECTIVES

## Objectives:

1. Identify the services that utilities provide distributed PV customers (including but not limited to standby, power quality, reliability, import and re-delivery)
2. Identify the services that distributed PV customers provide to the electrical system (including but not limited to locational, energy, capacity, and environmental)
3. Develop a transparent methodology to determine the cost (both positive and negative) for each of the services identified at different levels of penetration; for purposes of this study services should be defined comprehensively to include those with direct costs to the system and to the extent possible those with external, non-energy-related costs (e.g. societal benefits)
4. Determine whether rate structures allow the utility to recover costs they incur for PV customers
5. Understand how future scenarios, including several PV penetration conditions and smart grid infrastructure, affect the results of the analysis

# LIST OF SERVICES AND COSTS INCLUDED IN ANALYSIS

Service	Services Provided by Utility to PV Customer	Services Provided by PV Customer to Utility
Energy	X	X
Resource Adequacy Capacity	X	X
Ancillary Services	X	
RPS Procurement	X	X
Grid Management	X	X
Transmission Capacity	X	X
Transmission O&M	X	
Distribution Station Capacity	X	X
Distribution Line Capacity	X	
Distribution Voltage Regulation and Reactive Supply	X	
Distribution O&M	X	
Interconnection	X	
Metering/Billing/Administration/ Customer Service	X	

# METHODOLOGY UPDATES

# “AVERAGE” VS. “MARGINAL” COSTS

- **Previous approach**
  - Utility costs should be valued based on average costs, and utility avoided costs (distributed PV value) based on marginal costs
- **Final approach**
  - All services valued based on marginal cost of serving the “marginal load” covered by distributed PV generation—allows fair comparison between costs and avoided costs, and uses transparent public data
  - **Services provided by utility to PV customers**
    - Most services valued based on marginal cost to serve all customers (energy, resource adequacy capacity, RPS procurement, grid management, transmission capacity and O&M, distribution line capacity and distribution O&M)
    - For ancillary services, interconnection, metering/billing/admin, and distribution voltage regulation and reactive supply there are marginal costs specific to PV customers
  - **Services provided by PV customers to utility**
    - These services are estimated based on marginal value to the utility



# DISTRIBUTION VOLTAGE REGULATION AND REACTIVE SUPPLY - METHODOLOGY

- **SDG&E provided forecasted circuit-level PV penetration estimates by year for 739 circuits through 2020**
  - B&V assumed circuits with PV penetration >25% would require mitigation to stabilize voltage fluctuations
  - Generic assumptions for typical circuit:
    - Mitigation strategy would be to add Static VAR Compensator (SVC)
    - Approx. cost of \$200/kVAR
  - In each year, assume that SVC is installed on each circuit that reaches 25%+ PV penetration, and amortize cost of each SVC over 30 years
- **This provides a rough cost estimate—a more realistic cost estimate would require detailed circuit-level analyses to determine exact voltage stability problems and most cost-effective mitigation strategy**

# SDG&E DATA REQUESTS

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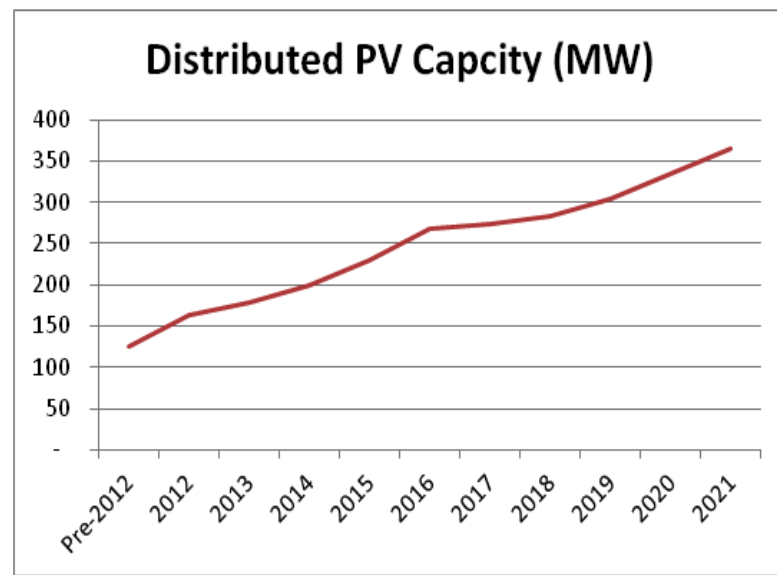
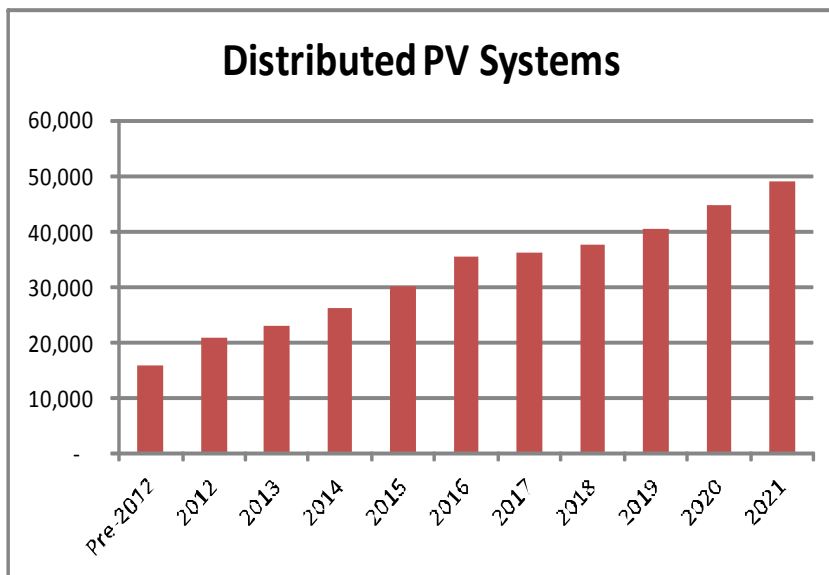
- Initial data request sent to SDG&E on March 4, 2013
- First response received from SDG&E on April 25, 2013
- Additional information received from SDG&E on May 30 and June 12, 2013

Data Item	Information Requested	Information Received
Load Data	SDG&E hourly 2012 retail load values	SDG&E hourly 2012 total load values, 2011 retail load values
Interconnection Costs	2012 costs broken out by function with hourly labor rates and hours spent	2012 costs broken out by program with total annual costs
Metering/Billing/Admin/ Customer Service Costs	2012 costs broken out by function with hourly labor rates and hours spent	Some 2012 costs broken out by function, some total annual costs
PV Growth Forecast	SDG&E forecast of PV installations through 2021	CEC Forecast of PV Installations through 2020
PV Penetration Forecast	SDG&E forecast of PV penetration by circuit through 2021	SDG&E forecast of PV penetration by circuit through 2020
Distributed PV Integration Costs	SDG&E forecast of marginal PV integration costs on distribution system through 2021	None
Transmission Capacity Cost	SDG&E assumed marginal cost of transmission capacity	None

# DRAFT STUDY RESULTS

# FORECAST OF DISTRIBUTED PV INSTALLATIONS AND CAPACITY

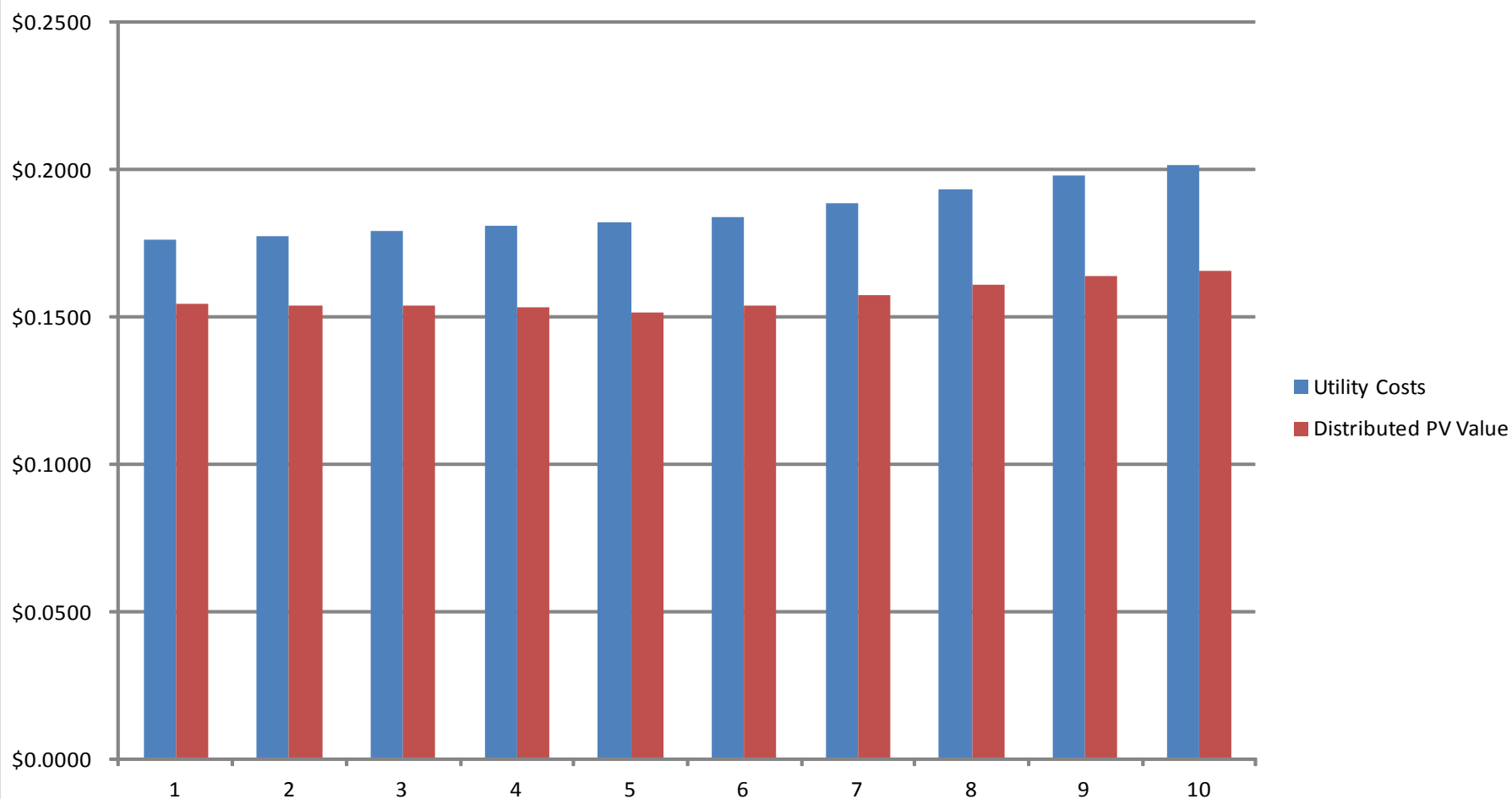
- **Growth from 2012 to 2021 in SDG&E Territory\***
  - 20,000 to approx. 50,000 distributed PV systems
  - 149 MWac to approx. 334 MWac of PV capacity
  - 288 GWh/year to approx. 648 GWh/year of PV output



\*Based on Current SDG&E PV Fleet and CEC Growth Projections

# COMPARISON OF UTILITY COST AND DISTRIBUTED PV VALUE BY YEAR

- Difference between utility costs and distributed PV value in each year is the “net cost” of serving distributed PV customers
- Net cost is ~3-4 ¢/kWh in each year



# SUMMARY OF 2012 RESULTS BY SERVICE

17 July 2013

Service	Unit	Utility Cost	Distributed PV Value
Energy	\$/kWh	\$0.0531	\$0.0531
Resource Adequacy Capacity	\$/kW-year	\$218.06	\$117.37
Ancillary Services	\$/kWh	\$0.0023	\$0.00
RPS Procurement	\$/kWh	\$0.0087	\$0.0087
Grid Management	\$/kWh	\$0.0004	\$0.0004
Transmission Capacity	\$/kW-year	\$102.83	\$48.13
Transmission O&M	\$/kW-year	\$11.55	\$0.00
Distribution Station Capacity	\$/kW-year	\$27.85	\$13.86
Distribution Line Capacity	\$/kW-year	\$74.06	\$0.00
Distribution Voltage Regulation and Reactive Supply	\$/kW-year	\$2.33	\$0.00
Distribution O&M	\$/kW-year	\$31.22	\$0.00
Interconnection	\$/kW-year	\$42.34	\$0.00
Metering/Billing/Customer Service/Administration	\$/kW-year	\$9.01	\$0.00



# ENERGY

- Actual CAISO energy prices used for marginal cost of energy to SDG&E and marginal value of energy generated by PV fleet
- Data Sources
  - Simulated hourly PV fleet output for 2012-2021
  - 2012 Actual CAISO hourly prices for SDG&E delivery point
  - 2017 and 2022 hourly CAISO forecasted prices (interim years interpolated)

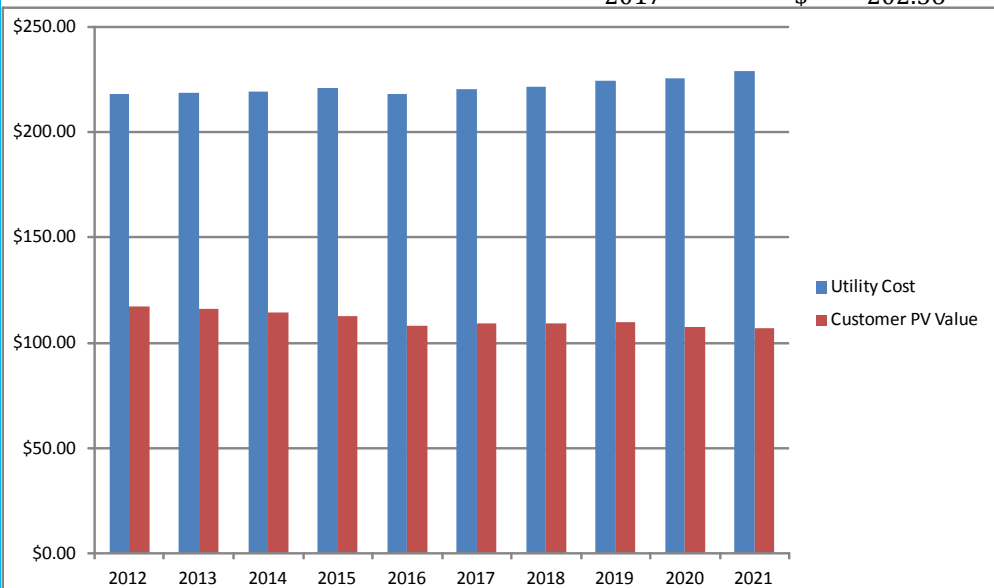
Year	Cost/kWh
2012	\$ 0.0531
2013	\$ 0.0521
2014	\$ 0.0512
2015	\$ 0.0503
2016	\$ 0.0495
2017	\$ 0.0485
2018	\$ 0.0498
2019	\$ 0.0511
2020	\$ 0.0525
2021	\$ 0.0536



# RESOURCE ADEQUACY CAPACITY

- Utility cost = net annual cost of new GE LMS 100 unit (installed cost + fixed O&M – net revenue)
- Distributed PV value = utility cost x (ELCC + reserve margin) - this accounts for effective capacity of PV fleet

Year	Levelized Installed Cost(\$/kW-Year)	Fixed O&M Cost (\$/kW-Year)	Net Revenues (\$/kW-Year)	Net Annual Capacity Cost (\$/kW-Year)
2012	\$ 202.56	\$22.33	\$6.84	\$218.06
2013	\$ 202.56	\$23.00	\$6.84	\$218.73
2014	\$ 202.56	\$23.69	\$6.84	\$219.42
2015	\$ 202.56	\$24.41	\$5.95	\$221.02
2016	\$ 202.56	\$25.14	\$9.66	\$218.04
2017	\$ 202.56	\$25.89	\$8.00	\$220.48
		\$26.67	\$8.00	\$221.30
		\$27.47	\$5.00	\$224.64
		\$28.29	\$6.00	\$225.30
		\$29.14	\$3.00	\$228.73



# ANCILLARY SERVICES (A/S)

- A/S costs for load variability = 1% of energy costs (CAISO-wide 2012 value) → applies to all customers
- A/S costs for PV variability = incremental regulation up/down costs due to PV forecasting error → applies only to PV customers

Year	Ancillary Service Costs for Load Variability (\$/kWh)	Incremental Ancillary Service Costs for PV Variability (\$/kWh)
2012	\$0.0005	\$0.0018
2013	\$0.0005	\$0.0018
2014	\$0.0005	\$0.0018
2015	\$0.0005	\$0.0018
2016	\$0.0005	\$0.0018
2017	\$0.0005	\$0.0018
2018	\$0.0005	\$0.0018
2019	\$0.0005	\$0.0018
2020	\$0.0005	\$0.0018
2021	\$0.0005	\$0.0018

# RPS PROCUREMENT

- Reflects the cost to SDG&E to procure RPS-eligible energy, above average wholesale energy price (“renewable premium”)
- Accounts for increasing annual RPS requirement and increasing annual wholesale energy price

Year	Cost/kWh
2012	\$ 0.0087
2013	\$ 0.0090
2014	\$ 0.0101
2015	\$ 0.0112
2016	\$ 0.0124
2017	\$ 0.0138
2018	\$ 0.0152
2019	\$ 0.0167
2020	\$ 0.0183
2021	\$ 0.0188

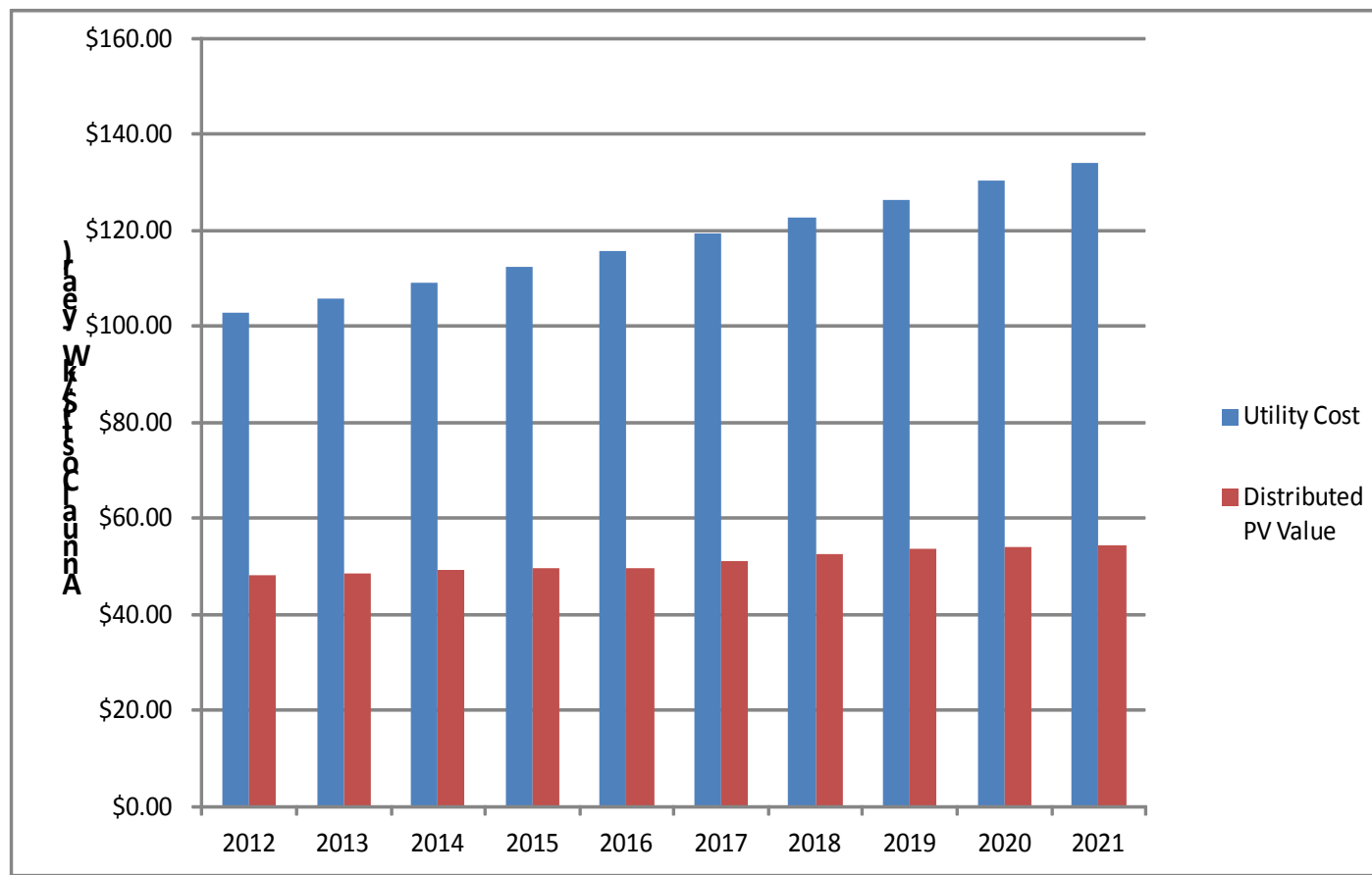
# GRID MANAGEMENT CHARGE

- Reflects the charge to SDG&E on energy that is delivered over CAISO high-voltage transmission network

Year	Cost/kWh
2012	\$0.0004
2013	\$0.0004
2014	\$0.0004
2015	\$0.0004
2016	\$0.0004
2017	\$0.0005
2018	\$0.0005
2019	\$0.0005
2020	\$0.0005
2021	\$0.0005

# TRANSMISSION CAPACITY COST

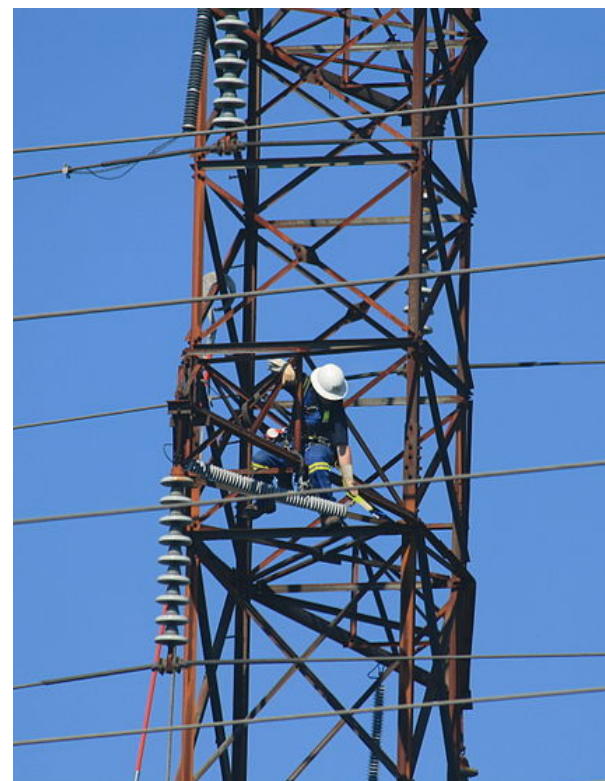
- Cost of marginal transmission capacity to SDG&E
- Utility cost based on Sunrise Powerlink project
- Distributed PV value = utility cost x ELCC (effective capacity of PV fleet)



# TRANSMISSION O&M

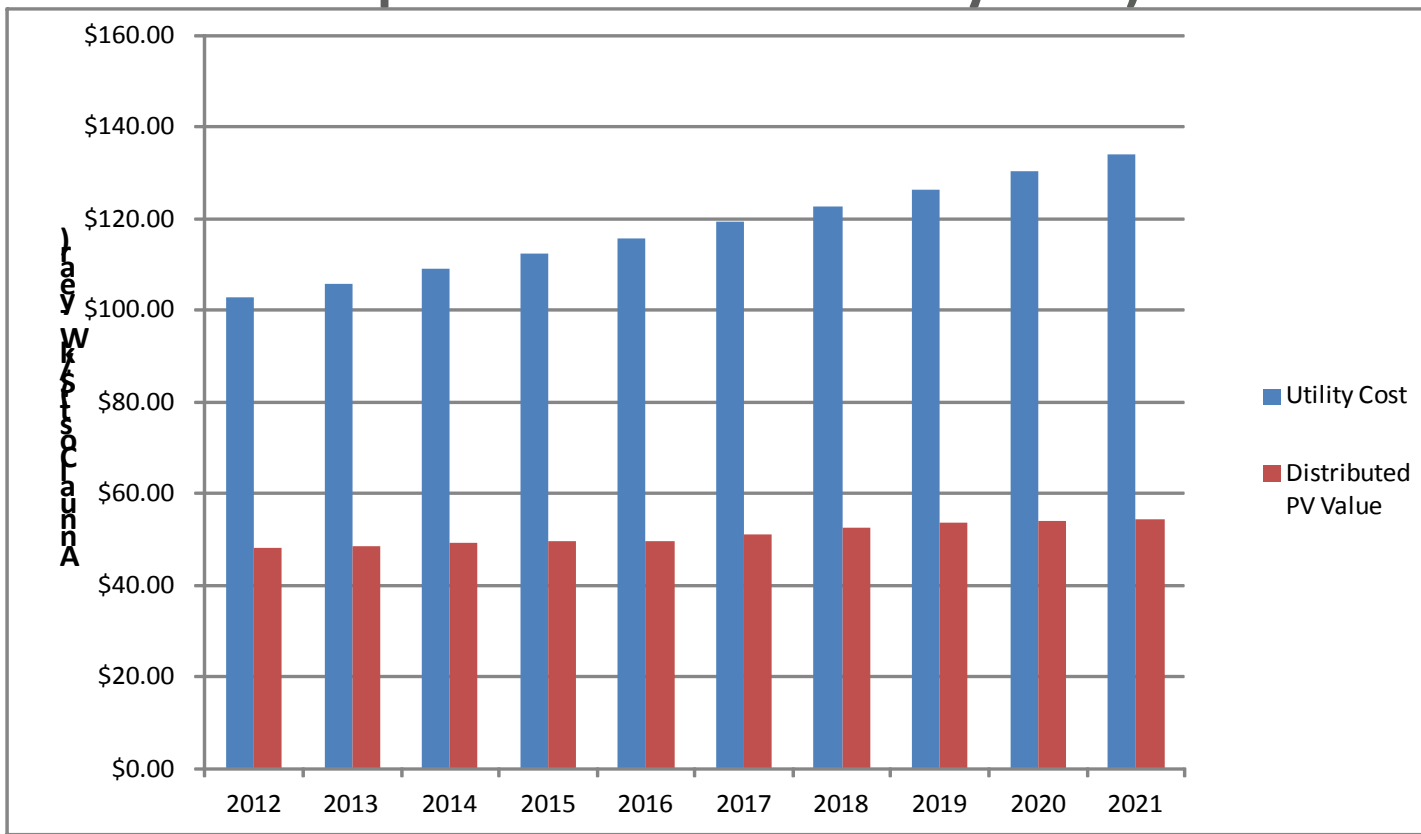
- Annual O&M cost on SDG&E transmission infrastructure (based on 2012 FERC filing)
- Study assumed distributed PV does not avoid this cost

Year	Cost/kW-year
2012	\$ 11.55
2013	\$ 12.56
2014	\$ 12.83
2015	\$ 13.02
2016	\$ 13.19
2017	\$ 13.35
2018	\$ 13.52
2019	\$ 13.66
2020	\$ 13.82
2021	\$ 13.99



# DISTRIBUTION STATION CAPACITY

- Marginal cost of distribution substation capacity
- Utility cost based on SDG&E 2012 General Rate Case (GRC) Phase II
- Distributed PV value = utility cost x (amount by which PV fleet reduces peak load on SDG&E system)



# DISTRIBUTION LINE CAPACITY

- Marginal cost of distribution line capacity
- Based on SDG&E 2012 GRC Phase II
- Study assumed distributed PV does not avoid this cost

Year	Cost/kW-year
2012	\$74.06
2013	\$76.28
2014	\$78.57
2015	\$80.93
2016	\$83.36
2017	\$85.86
2018	\$88.43
2019	\$91.08
2020	\$93.82
2021	\$96.63





# DISTRIBUTION O&M

- Annual distribution system O&M cost
- Based on SDG&E 2012 GRC
- Study assumed distributed PV does not avoid this cost

Year	Cost/kW-year
2012	\$ 31.22
2013	\$ 33.96
2014	\$ 34.69
2015	\$ 35.20
2016	\$ 35.66
2017	\$ 36.11
2018	\$ 36.56
2019	\$ 36.95
2020	\$ 37.37
2021	\$ 37.82



# DISTRIBUTION VOLTAGE REGULATION AND REACTIVE SUPPLY

- Incremental cost of voltage regulation equipment to maintain distribution system reliability → provided only to PV customers
- Based on assumed SVC equipment cost for all circuits above 25% PV penetration in each year

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Cumulative circuits over 25%	49	56	70	93	103	107	109	120	135	150
Annual increase in circuits over 25%	22	7	14	23	10	4	2	11	15	15

Year	Total Incremental SVC Cost (\$/year)	Cost/kW-year
2012	\$1,516,817	\$ 2.33
2013	\$450,140	\$ 2.33
2014	\$716,047	\$ 2.33
2015	\$1,428,406	\$ 2.33
2016	\$1,265,108	\$ 2.33
2017	\$404,410	\$ 2.33
2018	\$224,035	\$ 2.35
2019	\$833,292	\$ 2.35
2020	\$1,477,697	\$ 2.35
2021	\$1,477,697	\$ 2.50

# INTERCONNECTION

- **One-time utility costs to interconnect PV customers (e.g., meter replacement or meter software update)**
- **NEM interconnection program costs (e.g. Distribution Interconnection Information System software)**

Year	Total Cost	Cost/Customer	Cost/kW-year
2012	\$ 1,319,185	\$ 251	\$34.72
2013	\$ 916,152	\$ 350	\$61.08
2014	\$ 929,249	\$ 247	\$42.24
2015	\$ 944,188	\$ 187	\$31.47
2016	\$ 959,873	\$ 151	\$25.26
2017	\$ 933,716	\$ 879	\$155.62
2018	\$ 945,322	\$ 608	\$105.04
2019	\$ 985,202	\$ 290	\$49.26
2020	\$ 1,025,924	\$ 197	\$33.09
2021	\$ 1,055,227	\$ 202	\$34.04

# METERING, BILLING, ADMINISTRATION AND CUSTOMER SERVICE

- Annual costs (e.g., NEM customer service representatives and NEM customer billing)
- Program administration for New Solar Homes Partnership and SDG&E program liaison for CSI

Year	Total Cost	Cost/kW-year
2012	\$1,342,422	\$9.01
2013	\$1,382,695	\$8.54
2014	\$1,424,176	\$7.83
2015	\$1,466,901	\$7.02
2016	\$1,510,908	\$6.19
2017	\$1,556,235	\$6.25
2018	\$1,602,922	\$6.24
2019	\$1,651,010	\$6.00
2020	\$1,700,540	\$5.61
2021	\$1,751,556	\$5.24

# SOCIETAL BENEFITS/COSTS OF DISTRIBUTED PV

- Costs or benefits borne by society as a whole, not the utility
- Separated from direct utility costs and avoided costs
- These were described in the report, but not quantified

Societal Costs	Societal Benefits
Recycling and Decommissioning	Solar Jobs and Economic Development
Operations & Maintenance (e.g., water use)	Improved Recovery After Natural Disasters and Other Emergencies
Safety Risks (e.g., electrocution, falls)	Environmental Benefits (e.g., avoided air pollution and terrestrial/aquatic environmental damage)
Environmental and Human Health Impacts from PV Equipment Manufacturing (mostly outside the US)	Energy Security
Lost Utility Jobs and Tax Revenue	Improved Human Health

# WRAP-UP AND NEXT STEPS

- Stakeholder written comments on the draft report must be submitted to EPIC via email by July 19
- Contact Information
  - Scott Anders (EPIC) – [scottanders@sandiego.edu](mailto:scottanders@sandiego.edu)
- Final Report will be completed by July 31, 2013

# EXTRA SLIDES

# COST OF SERVICE COMPONENTS

## Services Provided by Utility to PV Customers

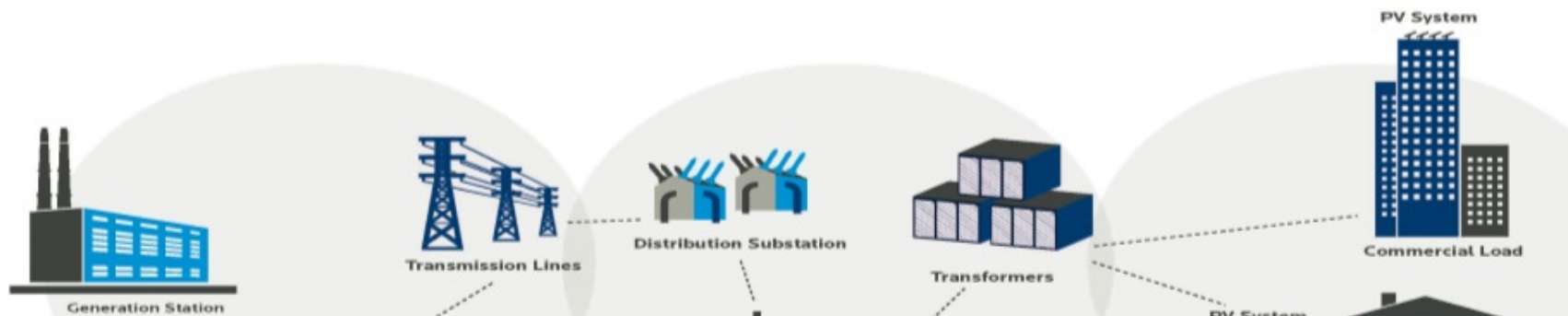
Energy, Resource Adequacy Capacity, Ancillary Services, RPS Procurement

Transmission Capacity and O&M, Grid Management

Distribution Substation Capacity and O&M

Distribution Line Capacity and O&M, Voltage Regulation

Interconnection, Metering/Billing, Administration



Reduced Energy Generation and Resource Adequacy Capacity

Reduced Transmission/Distribution Capacity Requirements

Lowered Marginal Transmission & Distribution Line Losses

Reduced RPS Procurement

## Services Provided by PV Customers to Utility



Annual Summary of Utility Costs												17 July 2013
Service	Basis	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Energy	Variable (\$/SDG&E Annual Load)	\$/kWh	\$0.0531	\$0.0521	\$0.0512	\$0.0503	\$0.0495	\$0.0485	\$0.0498	\$0.0511	\$0.0525	\$0.0536
Resource Adequacy Capacity	Fixed (\$/SDG&E Peak Load)	\$/kW-year	\$218.06	\$218.73	\$219.42	\$221.02	\$218.04	\$220.48	\$221.30	\$224.64	\$225.30	\$228.73
Ancillary Services - Load Variability	Variable (\$/SDG&E Annual Load)	\$/kWh	\$0.0005	\$0.0005	\$0.0005	\$0.0005	\$0.0005	\$0.0005	\$0.0005	\$0.0005	\$0.0005	\$0.0005
Ancillary Services - Incremental PV Variability	Variable (\$/PV Fleet Energy)	\$/kWh	\$0.0018	\$0.0018	\$0.0018	\$0.0018	\$0.0018	\$0.0018	\$0.0018	\$0.0018	\$0.0018	\$0.0018
RPS Procurement	Variable (\$/SDG&E Annual Load)	\$/kWh	\$0.0087	\$0.0090	\$0.0101	\$0.0112	\$0.0124	\$0.0138	\$0.0152	\$0.0167	\$0.0183	\$0.0188
Grid Management	Variable (\$/SDG&E Annual Load)	\$/kWh	\$0.0004	\$0.0004	\$0.0004	\$0.0004	\$0.0004	\$0.0005	\$0.0005	\$0.0005	\$0.0005	\$0.0005
Transmission Capacity	Fixed (\$/SDG&E Peak Load)	\$/kW-year	\$102.83	\$105.92	\$109.10	\$112.37	\$115.74	\$119.21	\$122.79	\$126.47	\$130.27	\$134.17
Transmission O&M	Fixed (\$/SDG&E Peak Load)	\$/kW-year	\$11.55	\$12.56	\$12.83	\$13.02	\$13.19	\$13.35	\$13.52	\$13.66	\$13.82	\$13.99
Distribution Station Capacity	Fixed (\$/SDG&E Peak Load)	\$/kW-year	\$27.85	\$28.69	\$29.55	\$30.43	\$31.35	\$32.29	\$33.25	\$34.25	\$35.28	\$36.34
Distribution Line Capacity	Fixed (\$/SDG&E Peak Load)	\$/kW-year	\$74.06	\$76.28	\$78.57	\$80.93	\$83.36	\$85.86	\$88.43	\$91.08	\$93.82	\$96.63
Distribution Voltage Regulation and Reactive Supply	Variable (\$/PV Fleet Capacity)	\$/kW-year	\$2.33	\$2.33	\$2.33	\$2.33	\$2.33	\$2.35	\$2.35	\$2.35	\$2.35	\$2.60
Distribution O&M	Fixed (\$/SDG&E Peak Load)	\$/kW-year	\$31.22	\$33.96	\$34.69	\$35.20	\$35.66	\$36.11	\$36.56	\$36.95	\$37.37	\$37.82
Interconnection	Variable (\$/PV Fleet Capacity)	\$/kW-year	\$34.72	\$61.08	\$42.24	\$31.47	\$25.26	\$155.62	\$105.04	\$49.26	\$33.09	\$34.04
Metering/Billing/Customer Service/	Variable (\$/PV Fleet Capacity)	\$/kW-year	\$9.01	\$8.54	\$7.83	\$7.02	\$6.19	\$6.25	\$6.24	\$6.00	\$5.61	\$5.24

