Summary of PV Potential Assessment in RETI and the 33% Implementation Analysis

Re-DEC Working Group Meeting

December 9, 2009

Energy and Environmental Economics, Inc.

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Renewable Energy Transmission Initiative

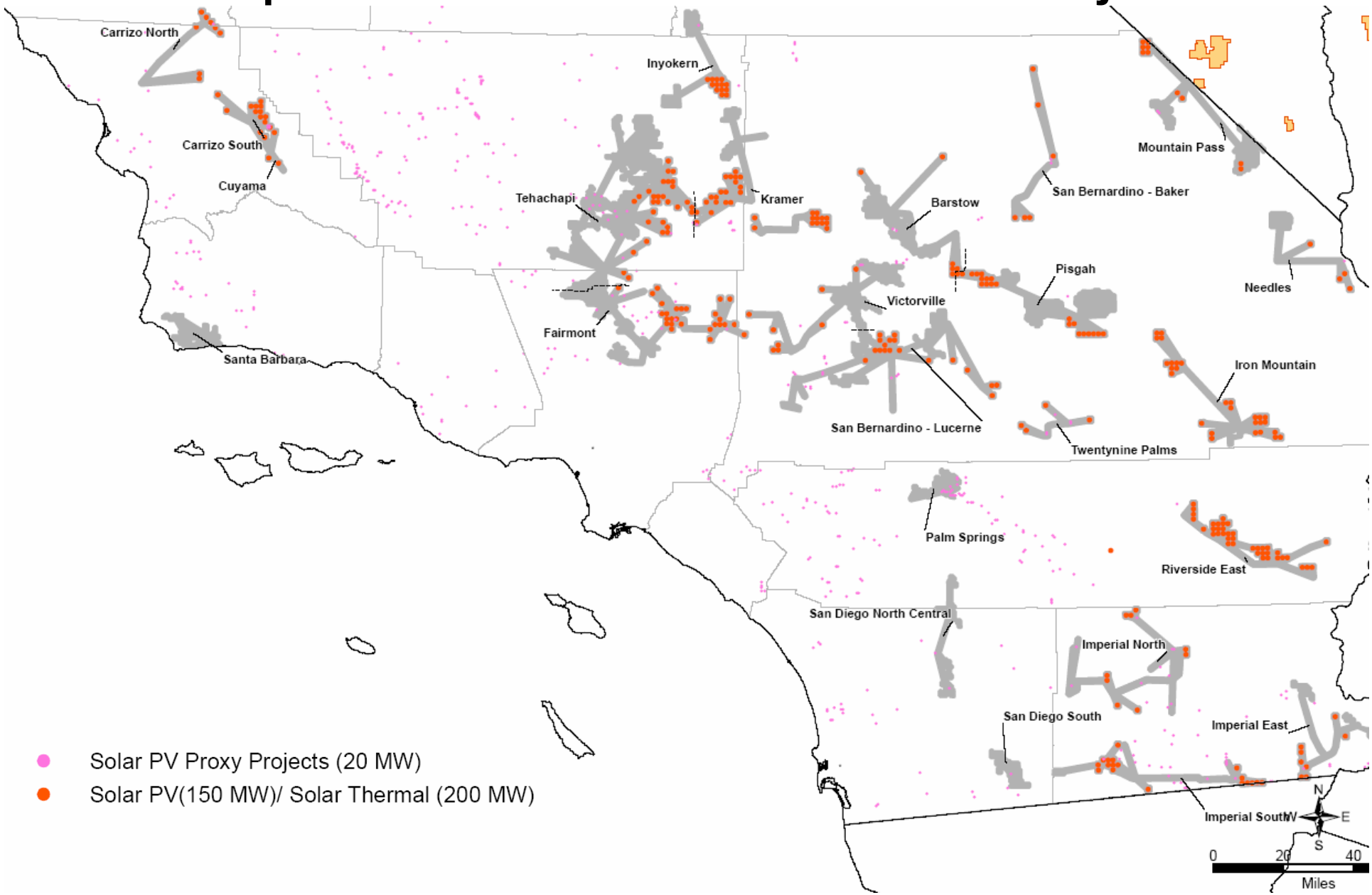
RETI is a statewide planning process to identify transmission projects needed to accommodate California's renewable energy goals.

- California law requires 20% of retail energy sales to come from renewable sources by 2010. The state has also adopted the goal of 33% by 2020.
- Development of renewable generation has slowed in CA. Transmission is a limiting factor.
- RETI is facilitating planning and permitting for competitive renewable energy zones (CREZs)

Solar in RETI

- Large Scale – 150-200 MW, solar thermal or solar PV. Detailed analysis.
- Distributed Wholesale Generation – 20 MW solar PV near substations. Very rough analysis.
- Smaller Systems – Behind the meter applications. Assumed to happen as part of RETI “Net Short” calculation.

Example RETI Phase 1 Solar Projects



- Solar PV Proxy Projects (20 MW)
- Solar PV(150 MW)/ Solar Thermal (200 MW)

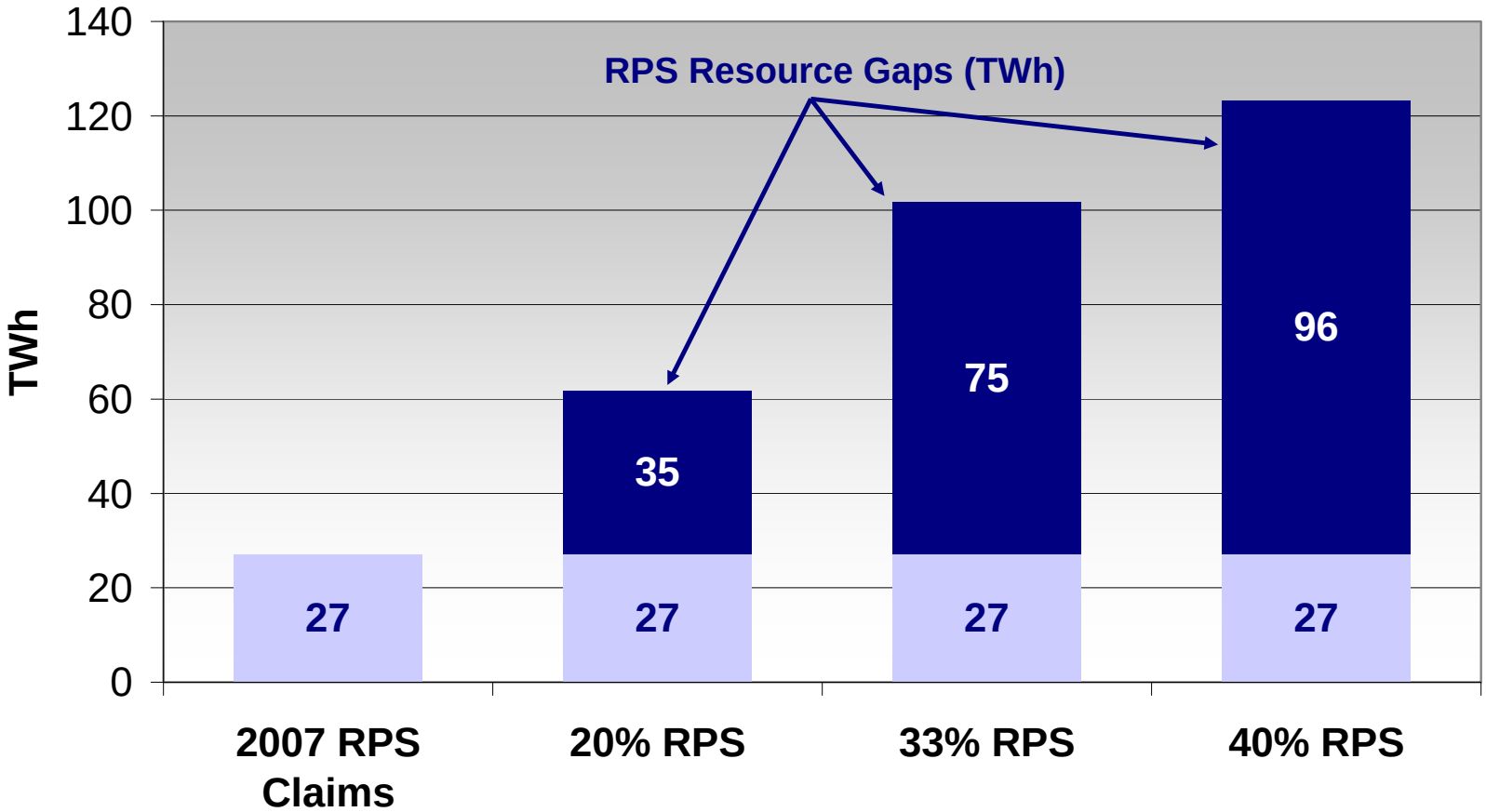
Solar PV Did Not Play a Significant Role In RETI Phase 1 (2008)

- Conventional tracking crystalline technology too expensive to compete
- Thin film technology deemed not fully proven and commercially available
- Thin film sensitivity showed potential for large scale competitiveness – if costs could be reduced ($3700/kW$_{ac}$)

CPUC 33% RPS Implementation Analysis

- CPUC commissioned 33% RPS Implementation Analysis as part of long-term procurement planning (LTPP) proceeding
- Goals of analysis:
  - Inform decision-makers about the likely cost and environmental impacts of implementing a 33% Renewables Portfolio Standard by 2020
  - Identify barriers to implementing a 33% RPS by 2020 and most likely timelines for achieving 33%
  - Inform decision-makers about the potential need for new transmission and new resources to integrate intermittent renewables
  - Inform California utilities' 2010 long-term procurement plans
- Report with preliminary results issued June 2009, available at www.cpuc.ca.gov/33percent

2007 Claimed RPS Resources for California Utilities and 2020 RPS Resource Gaps



Note: Gap based on 2007 CEC load forecast minus 2007 claims from CEC Net System Power Report. No adjustments for EE or CHP that is incremental to forecast.

33% RPS Cases Studied

1. **20% RPS Reference Case**: Existing state policy with 20% RPS
2. **33% RPS Reference Case:** Most likely case for reaching 33%, assuming that most contracts signed by IOUs with project developers proceed on schedule
3. **High Wind Case**: Meets 33% RPS resource gap with mix of new resources that includes substantial quantities of wind in California and Baja
4. **Out-of-State Delivered Case**: Meets 33% RPS resource gap with mix of new resources that includes wind resources in California and Wyoming and geothermal resources in Nevada
5. **High DG case**: Meets 33% RPS resource gap with mix of new resources that minimizes the need for new bulk transmission. These include 15,000 MW of distributed solar PV.

33% RPS Reference Case

Cost and Rate Impacts in 2020

- Total CA revenue requirement: ***$54.2 billion (16.9¢/kWh)***
- Incremental to 20% RPS Case: ***+$3.6 billion (+1.1¢/kWh)***
- New transmission investment: ***$12.3 billion***

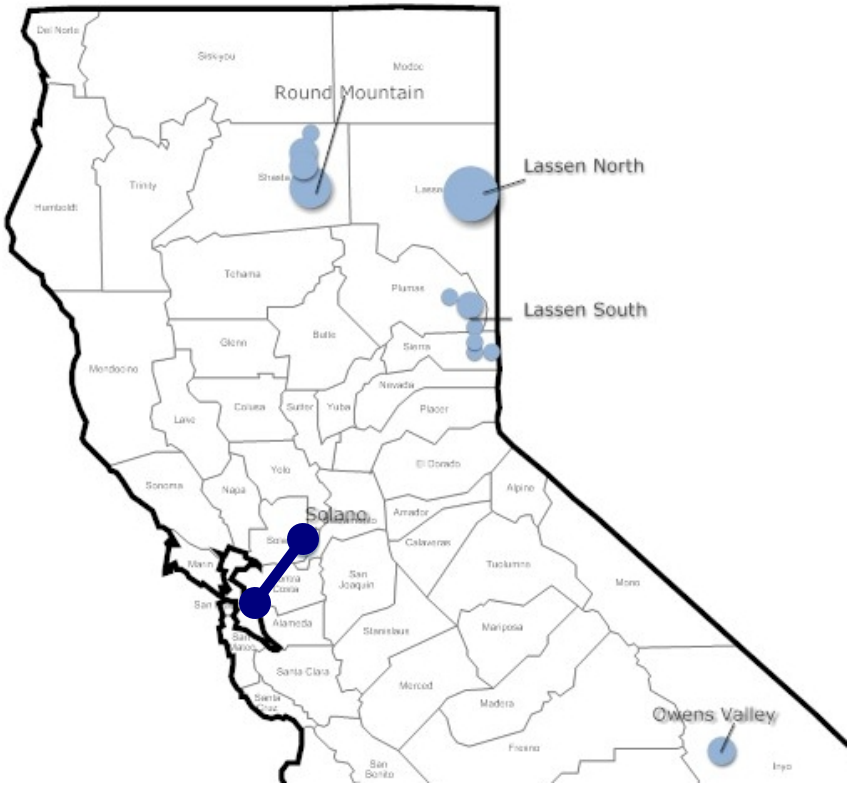
Resources Selected by Type

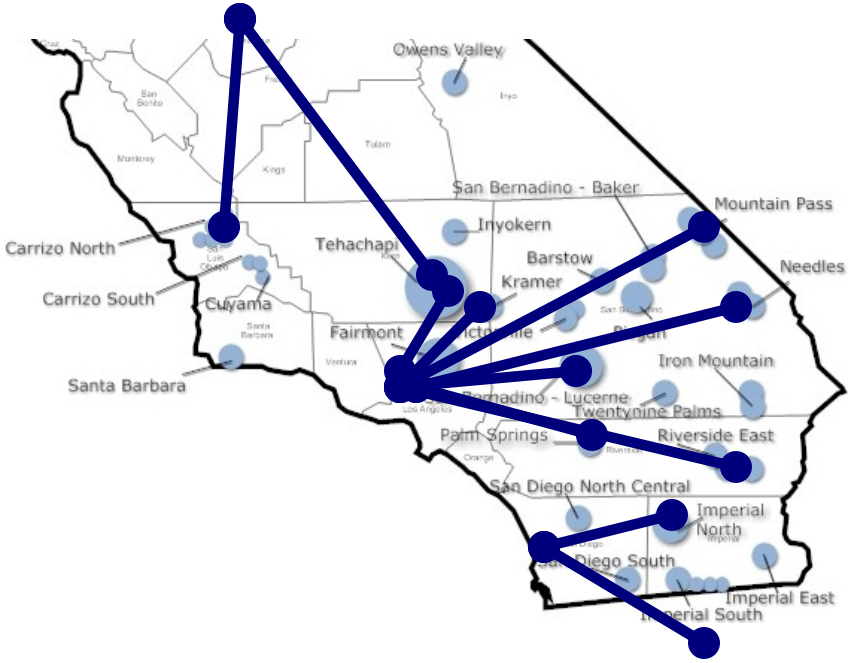
	In-State		Out-of-State		*Total*	
	MW	GWh	MW	GWh	*MW*	*GWh*
Biogas	279	2,078	-	-	*279*	*2,078*
Biomass	391	2,737	87	610	*478*	*3,346*
Geothermal	1,439	11,027	58	445	*1,497*	*11,471*
Hydro - Small	25	111	15	66	*40*	*177*
Solar PV	3,235	6,913	-	-	*3,235*	*6,913*
Solar Thermal	6,764	16,652	534	1,304	*7,298*	*17,956*
Wind	7,573	22,899	3,399	9,809	*10,972*	*32,709*
Total	***19,705***	***62,417***	***4,093***	***12,233***	***23,798***	***74,650***

Zones Selected

	MW	GWh	Notes
Total	***23,798***	***74,650***	
Tehachapi	3,000	8,862	Included in 20% Case
Distributed CPUC Database	525	3,118	Included in 20% Case
Solano	1,000	3,197	Included in 20% Case
Out-of-State Early	2,062	6,617	Included in 20% Case
Imperial North	1,500	9,634	Included in 20% Case
Riverside East	3,000	7,022	Included in 20% Case
Mountain Pass	1,650	4,041	
Carrizo North	1,500	3,306	
Distributed Biogas	249	1,855	
Out-of-State Late	1,934	5,295	
Needles	1,200	3,078	
Kramer	1,650	4,226	
Distributed Geothermal	175	1,344	
Fairmont	1,650	5,003	
San Bernardino - Lucerne	1,800	5,020	
Palm Springs	806	2,711	
Baja	97	321	

New Transmission Required for 33% RPS Reference Case





Interest in High DG Case

- A number of factors drive the CPUC's interest in studying a "High DG" case for meeting 33%:
  - High environmental impact of new transmission
  - High environmental impact of new central station generation
  - Increasing cost competitiveness and customer interest in PV – is PV nearing goal of "grid parity"?
  - Difficulties siting new transmission lines

"If it is conservatively assumed that only 10,000 MW of new high voltage transmission will be built by 2020 to realize the RETI net short target of 68,000 GWh, the estimated cost of this transmission will be in the range of $20 billion in 2008 dollars based on SDG&E's projections for the Sunrise Powerlink. How much thin-film PV located at IOU substations or at the point-of-use on commercial buildings or parking lots could the IOUs purchase for this same $20 billion? ... This equals an installed thin-film PV capacity of 14,000 to 18,000 MW for a $20 billion investment."

Bill Powers, PE, testimony in SDG&E's Sunrise Powerlink CPCN case

Resources Available for Selection in High DG Case

- Resources already selected for 20% Case
- RETI projects that can likely be interconnected without major transmission upgrades
  - Biomass: 2 projects in northern CA, 128 MW of total available capacity
  - Geothermal: 3 projects in northern CA, 175 MW of total available capacity
  - Wind: 6 projects across CA, 468 MW of total available capacity
- Out-of-state resources assumed deliverable over existing transmission (~2000 MW)
- Distributed solar PV resources

2. Identifying Potential Solar PV Sites

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Overview

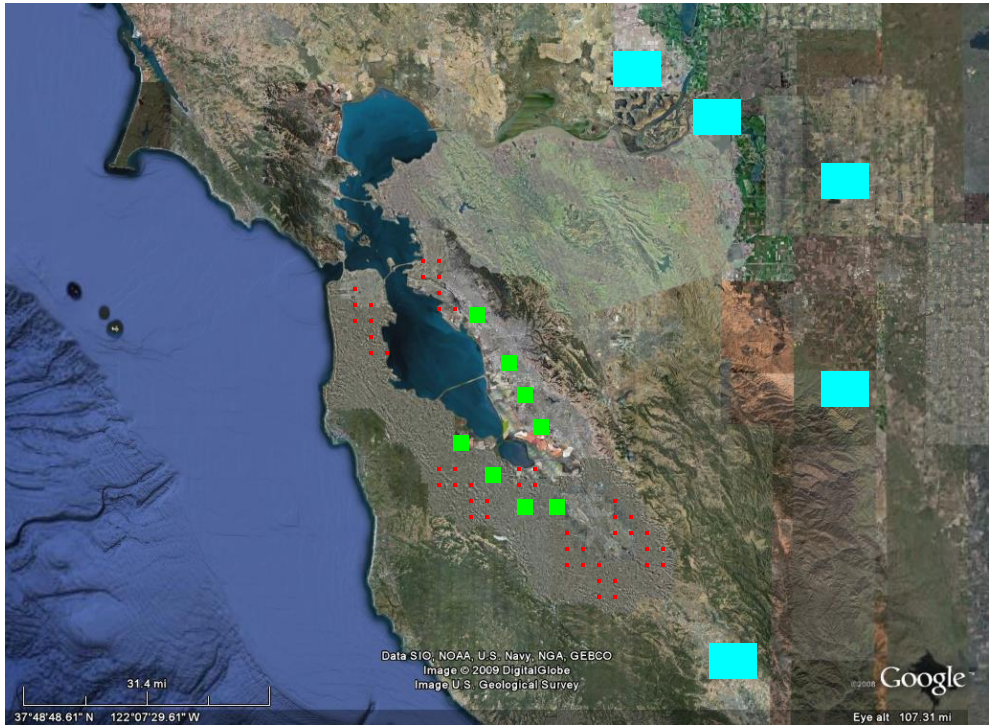
- Solar PV was assumed to be a major technology for DG
- B&V estimated the technical raw potential for DG
- Satellite imagery for rooftops and substation locations for larger utility scale

Distributed Solar PV

- 20 MW sites near non-urban 69 kV substations
- Smaller projects on rooftops, large commercial rooftops with 0.25 MW potential
- Limited by 30% peak load at a given substation

Illustrative Example of Distributed Solar PV

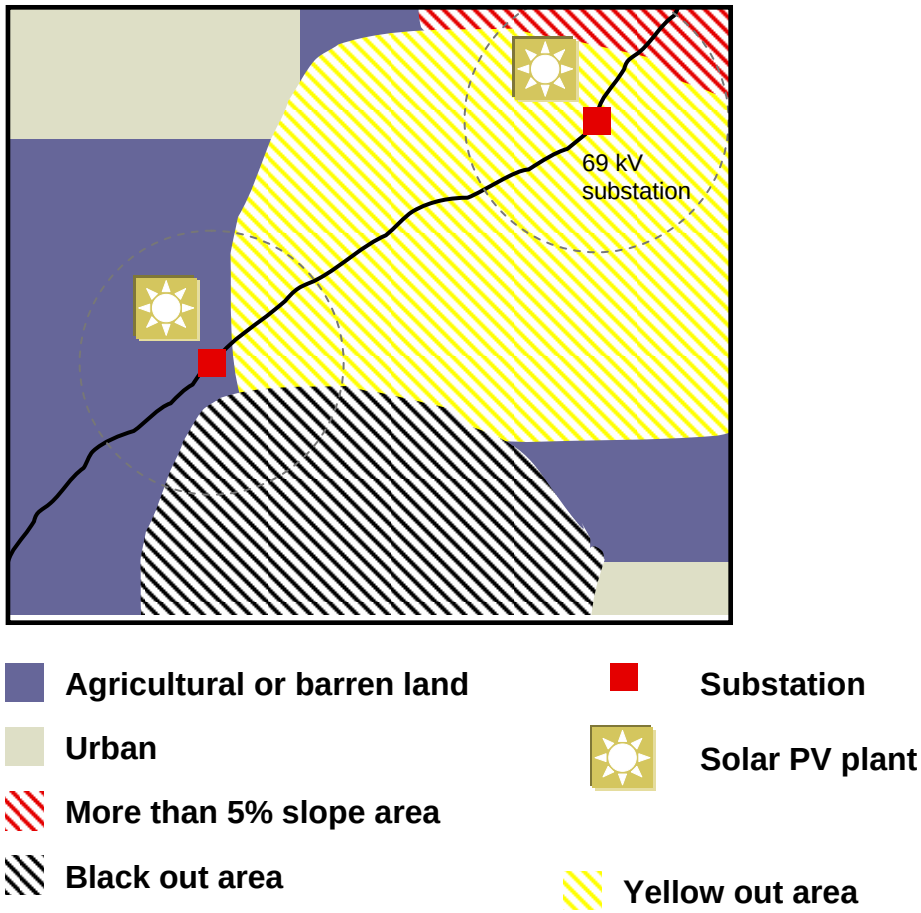
- 20 MW near substations
- Large commercial rooftops
- Residential rooftops



Ground Mounted PV

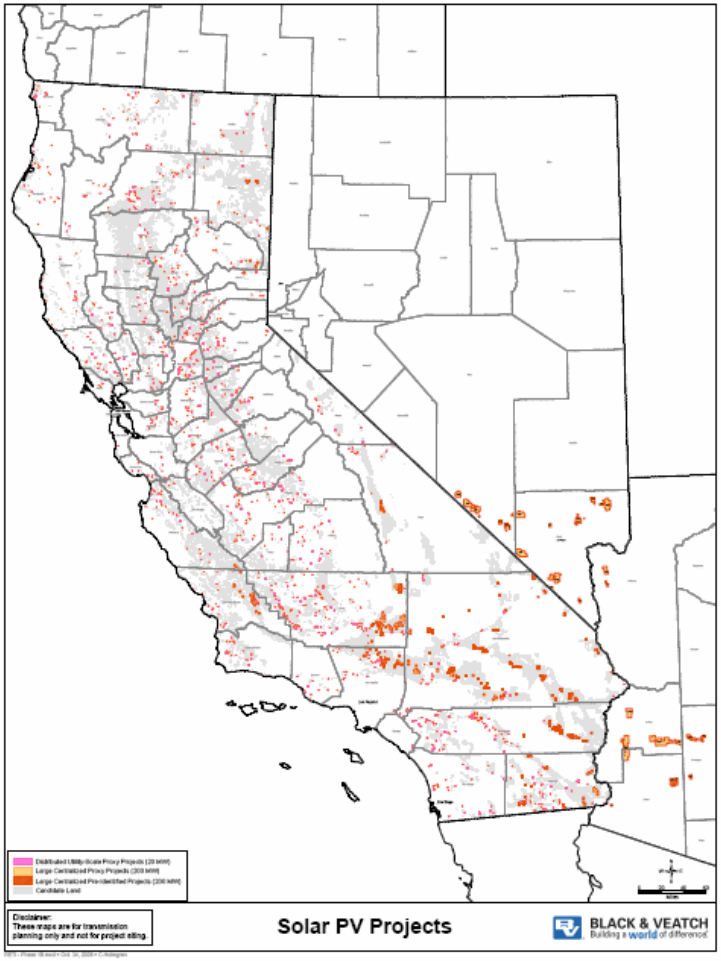
- Initial criteria
  - near sub stations equal or less than 69 kV
  - agricultural or barren land
  - less than 5% slope
- Environmental screen
  - Black out areas
  - Yellow out areas
- Land parcel
  - a continuous 160 acre plot (20 MWp)
  - within 20 miles

Example Map for Solar PV Non-Urban Projects



RETI Results on 20 MW Sites

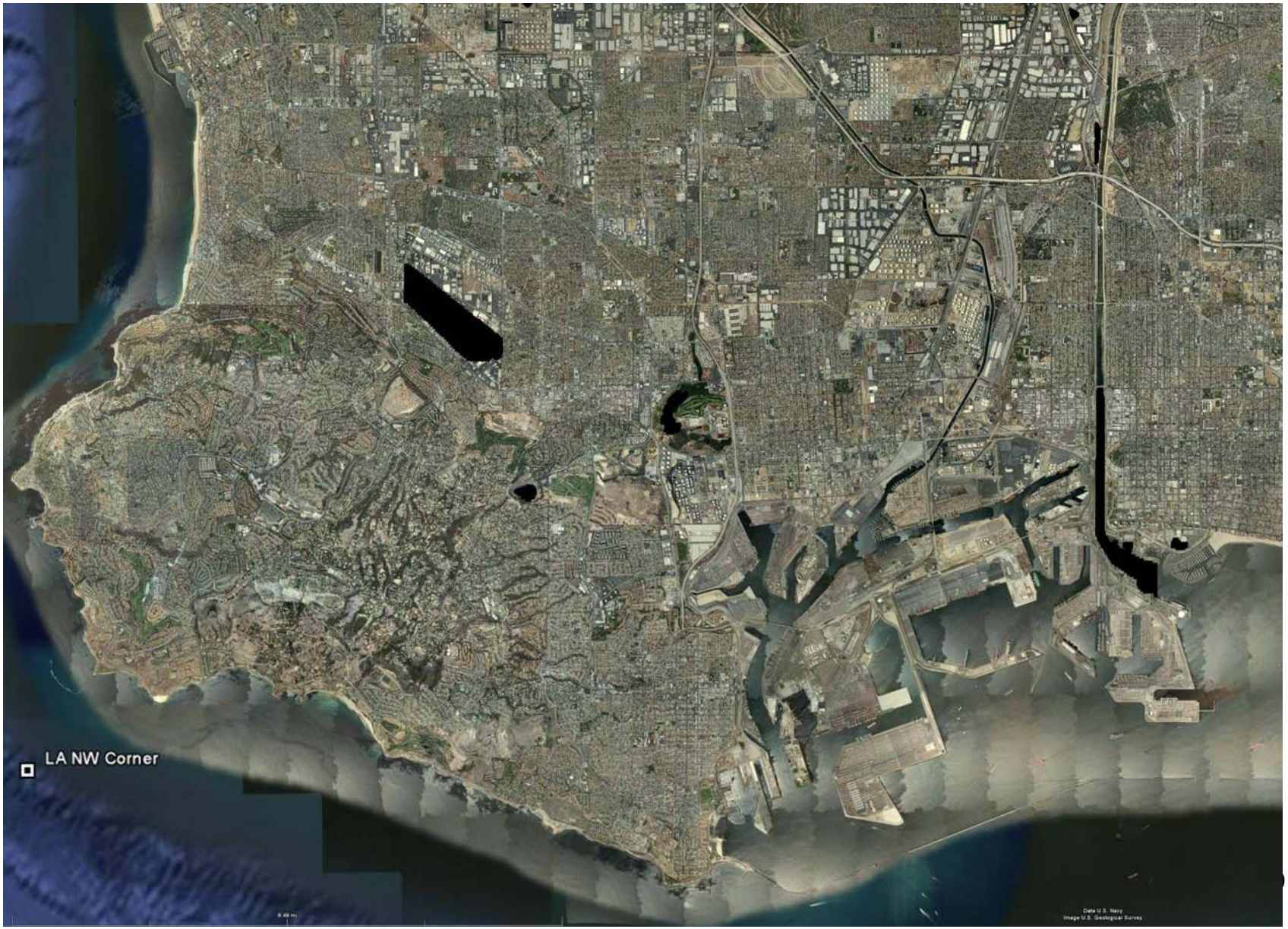
- 27,000 MW nameplate PV sites identified
- ~1300 sites identified
- Filters Applied
  - 160 acres + for 20 MW
  - No sites within 2 miles of urban zones
  - Near substations, most are 2 to 3 miles of the distribution subs with 69kV+ high-side voltage
  - Land slope < 5%
- 20 MW on substations with high side voltage of 69kV
- 40 MW on substations with higher voltage than 69kV
- Assumed not to be Rule 21 compliant



Black and Veatch Rooftop Analysis

- GIS used to identify large roofs in CA and count available large roof area
- Criteria
  - ‘Urban’ areas with little available land
  - Flat roofs larger than ~1/3 acre
  - Assumes 65% usable space on roof
  - Within 3 miles of distribution substation

Solar Photovoltaic Rooftop Identification



Solar Rooftop Identification

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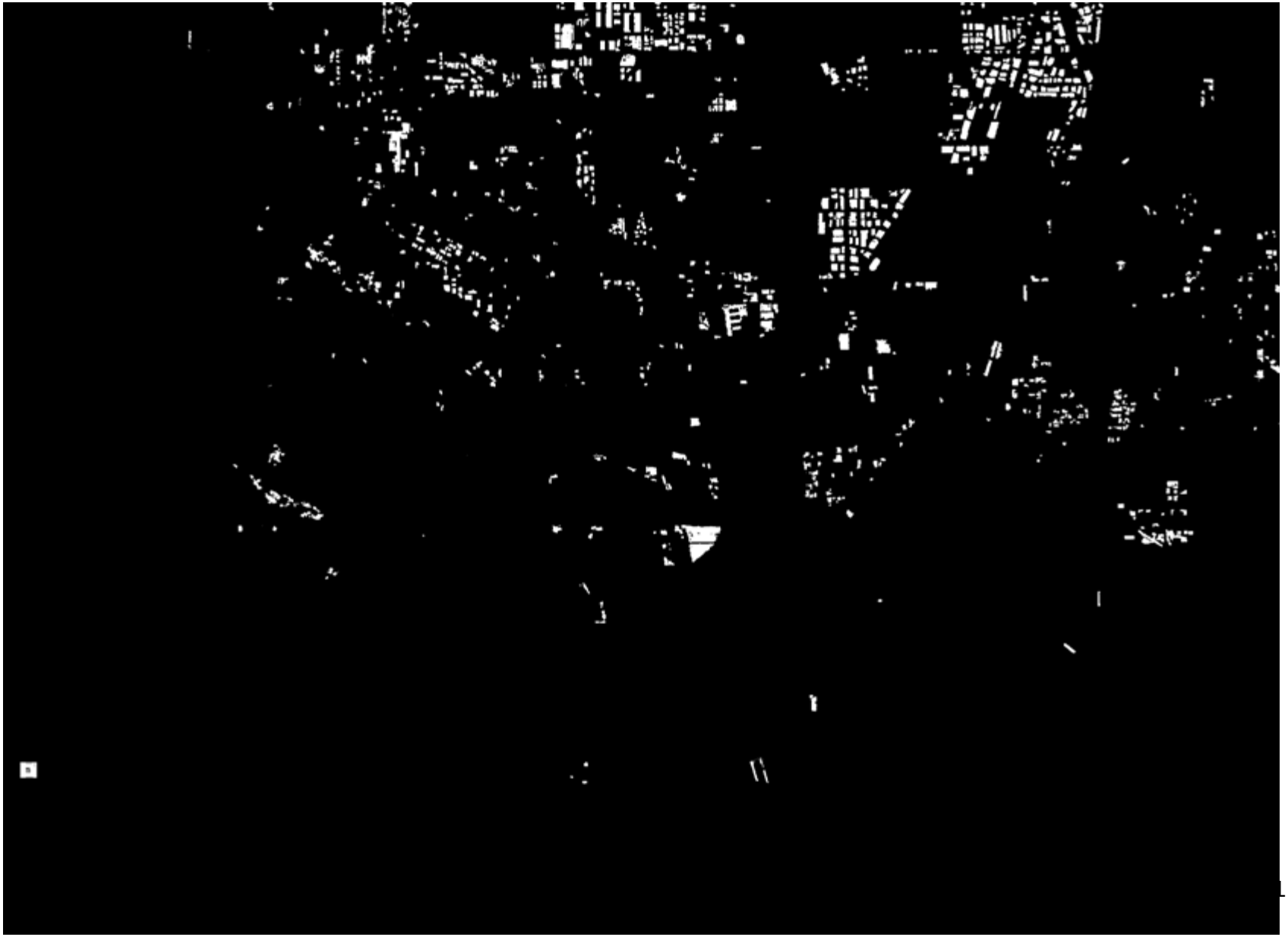
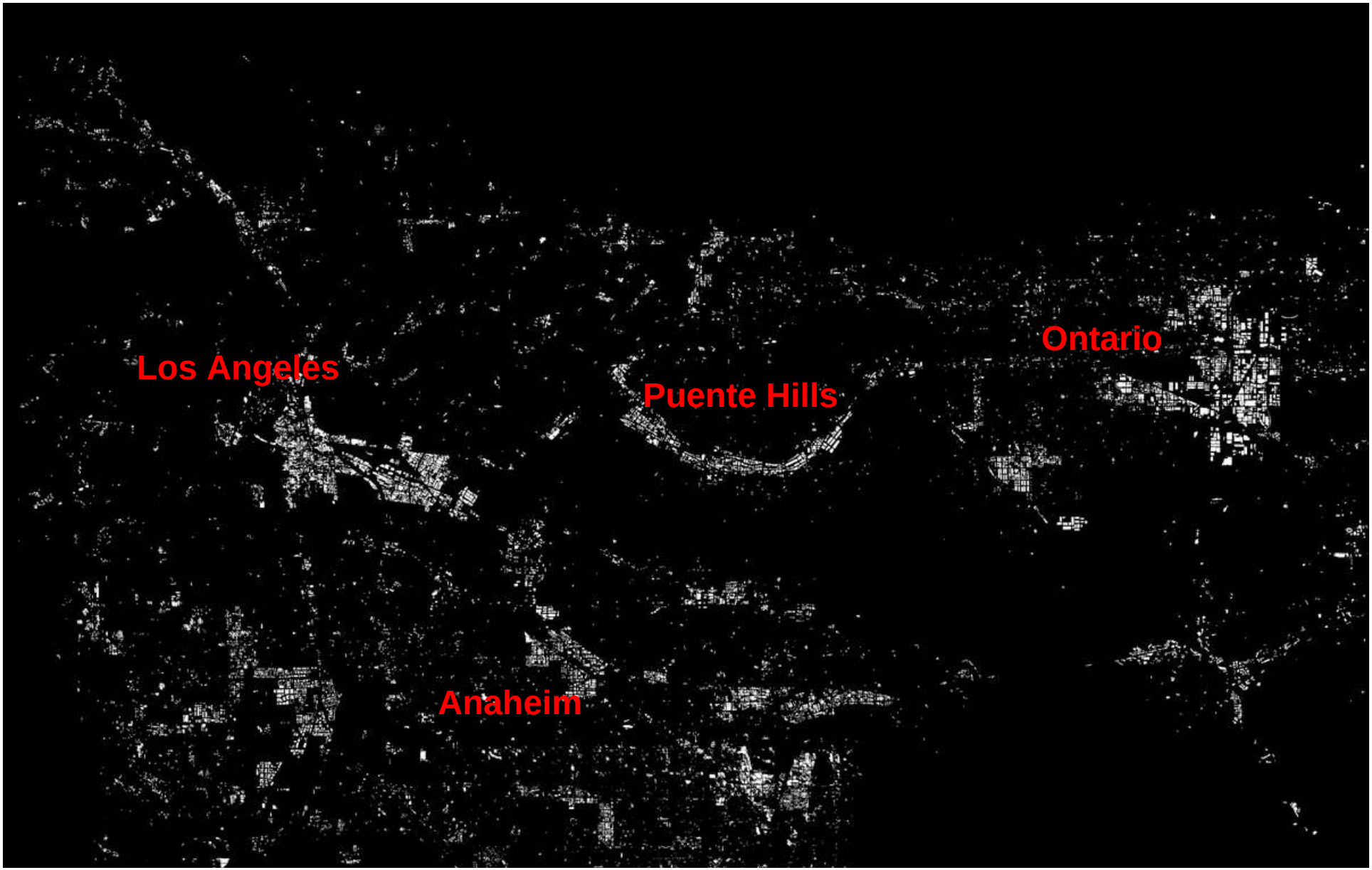
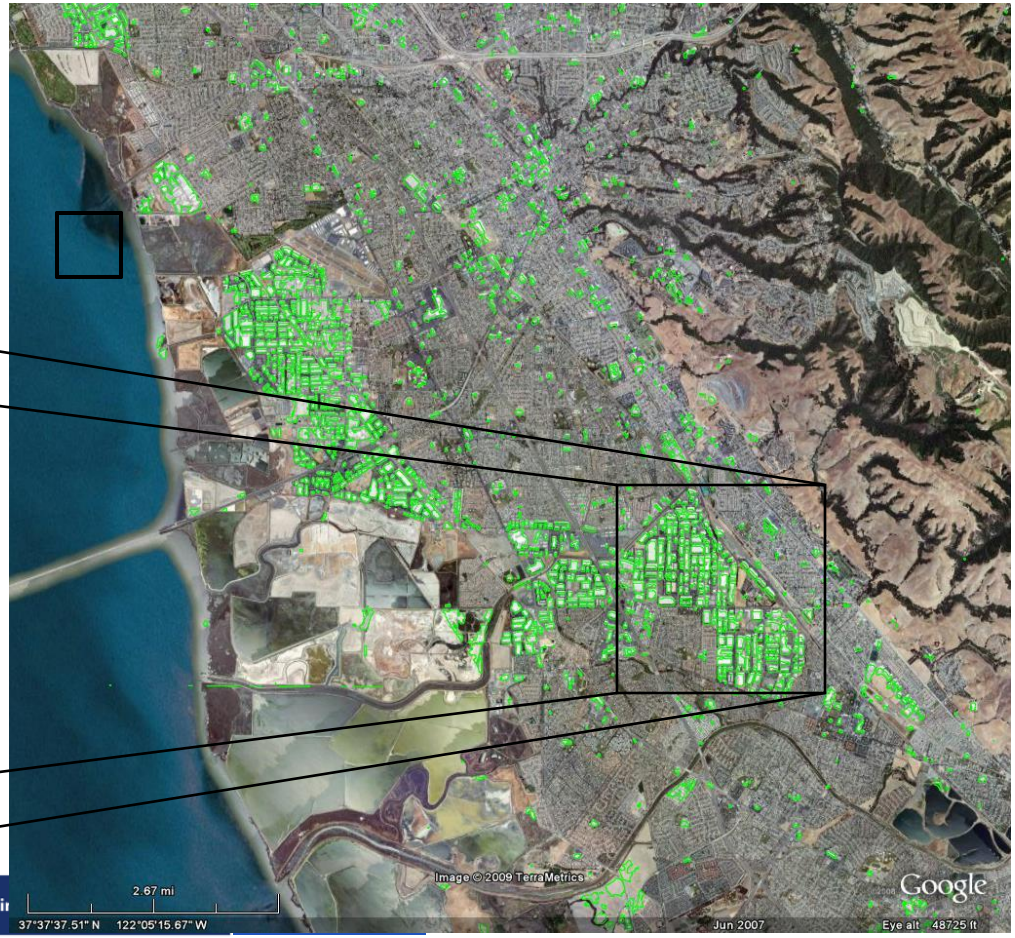


Los Angeles Area “Rooftop Resources”



East Bay Area Example

Analysis automates the counting of roof space and tallies total acreage of large roof space. Also checks proximity to distribution substation (not shown due to confidentiality).



Summary Results for Large Roofs

Raw Potential – Assuming 100% Participation

Total Statewide Large Rooftop Potential

	Large Roof Potential
PG&E	2922 MWac
SCE	5243 MWac
SDG&E	604 MWac
Other	2774 MWac
Total	**11,543 MWac**

3. DG Interconnection Screening

Snuller Price, E3

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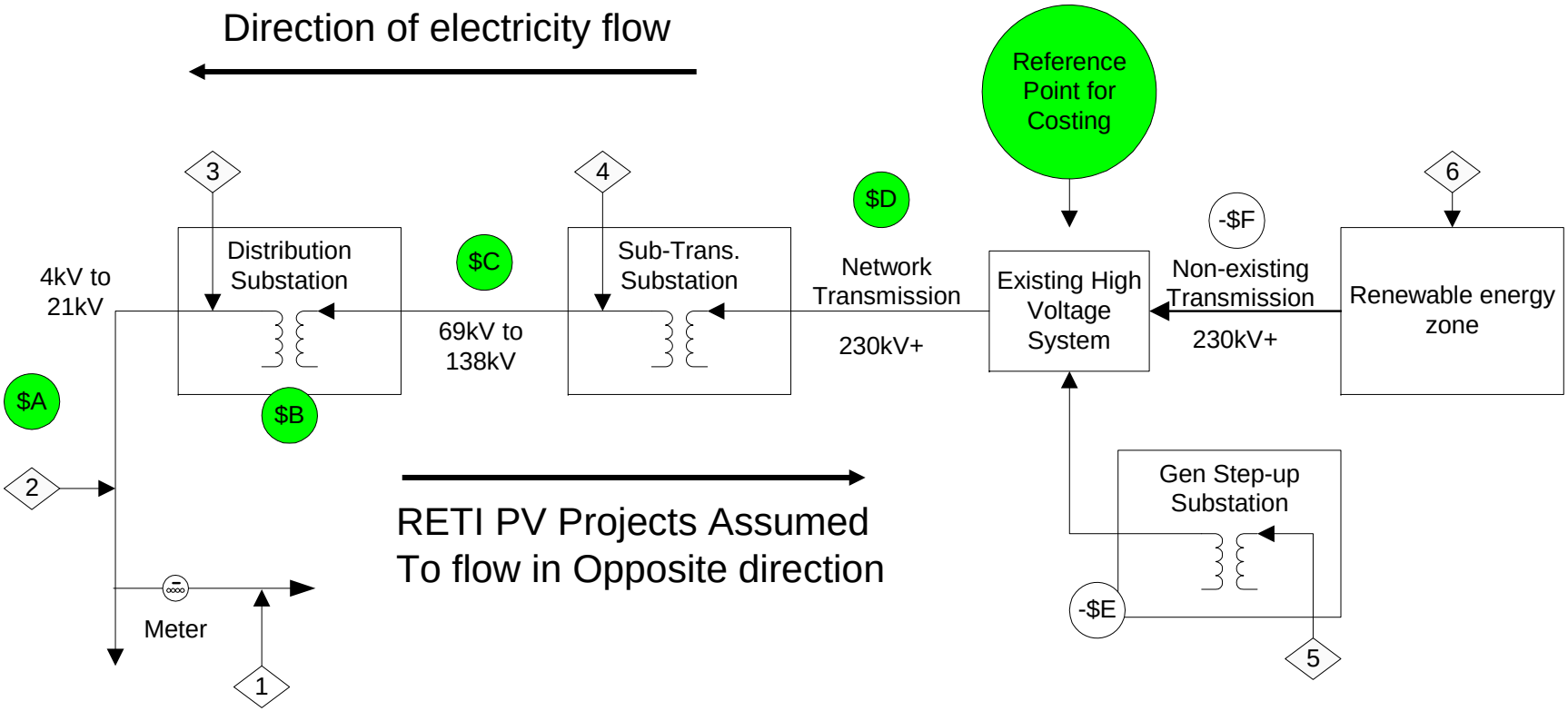
Working Definitions of DG

- Distributed generation (DG) is small-scale generation interconnected at sub-transmission system or lower.
  - Broad definition includes generation that is not necessarily physically close to loads.
- Wholesale DG (WDG) is generation interconnected to the distribution or sub-transmission system
- Customer DG is generation on the customer's side of the meter
  - Does not count toward California's RPS

Diagram of Interconnection Points



Avoided Capacity Cost Assumption

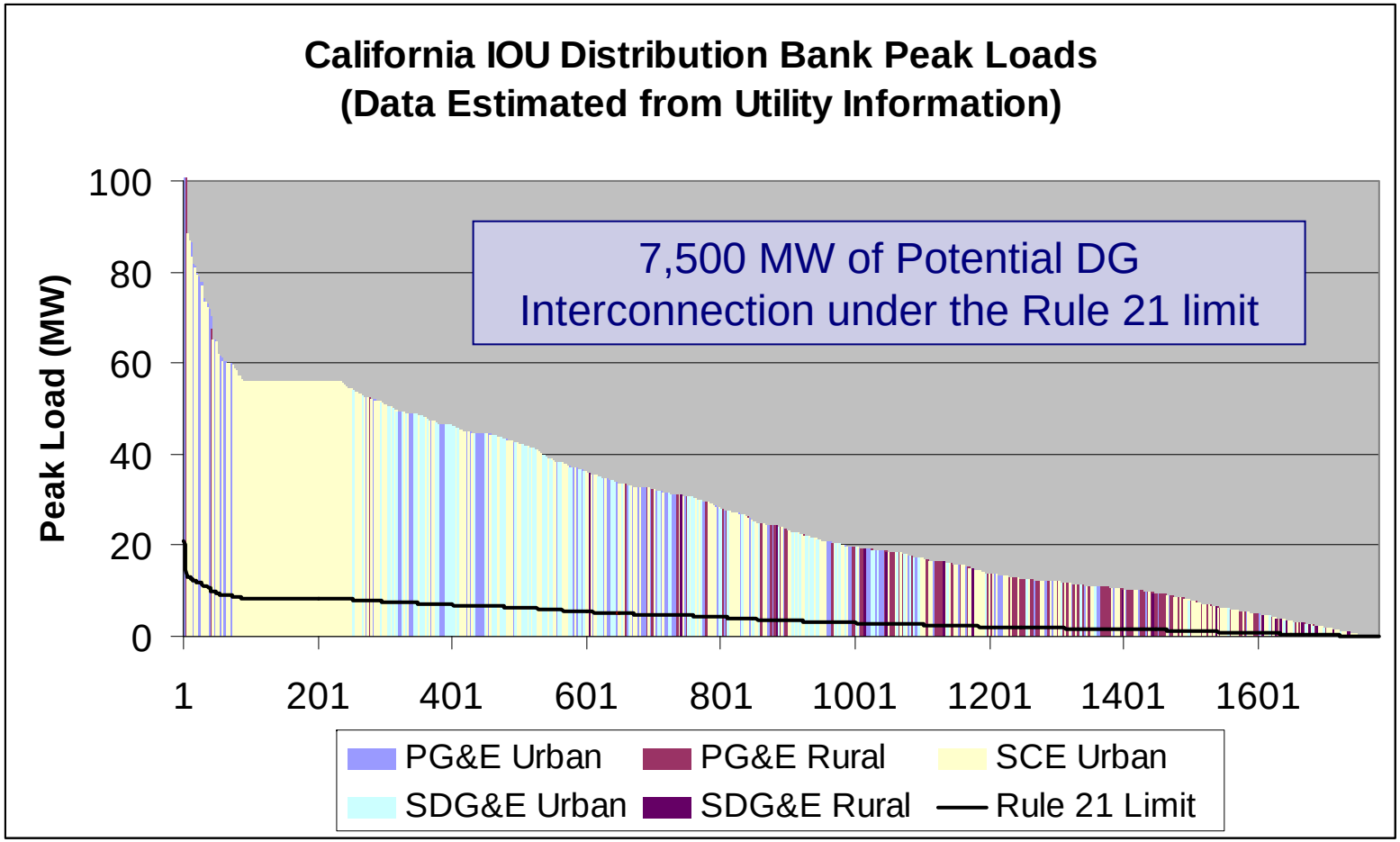
- **Distribution: $34/kW-yr**
  - Used average of EE avoided costs
- **Subtransmission: $34/kW-yr**
  - Used average of EE avoided costs
- **Transmission: $0/kW-yr**
  - Network is more difficult
  - Set to zero for 33% RPS analysis

See EE avoided costs, R.04-04-025

Issues

- Timeframe vs. geographic specificity – must use long time frame for avoided cost value
- Cost of non-Rule 21 RETI 20MW PV Installations not studied
  - Network transmission costs of $65/kW-year assumed for these resources

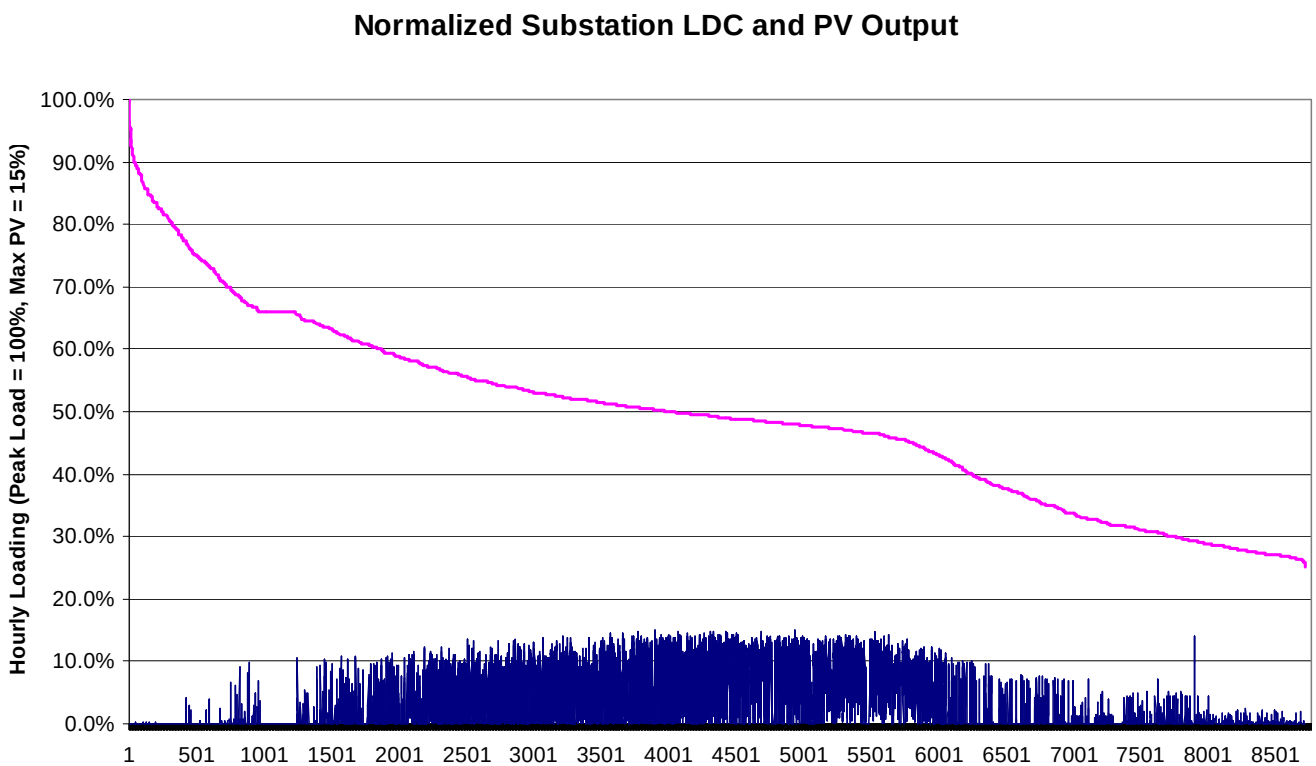
Utility Substation Bank Data



Rule 21 Interconnection sets 15% of line section peak limit

Revisit 15% threshold for some PV projects, given higher PV output at higher load levels

- Load Duration Curve compared to PV output

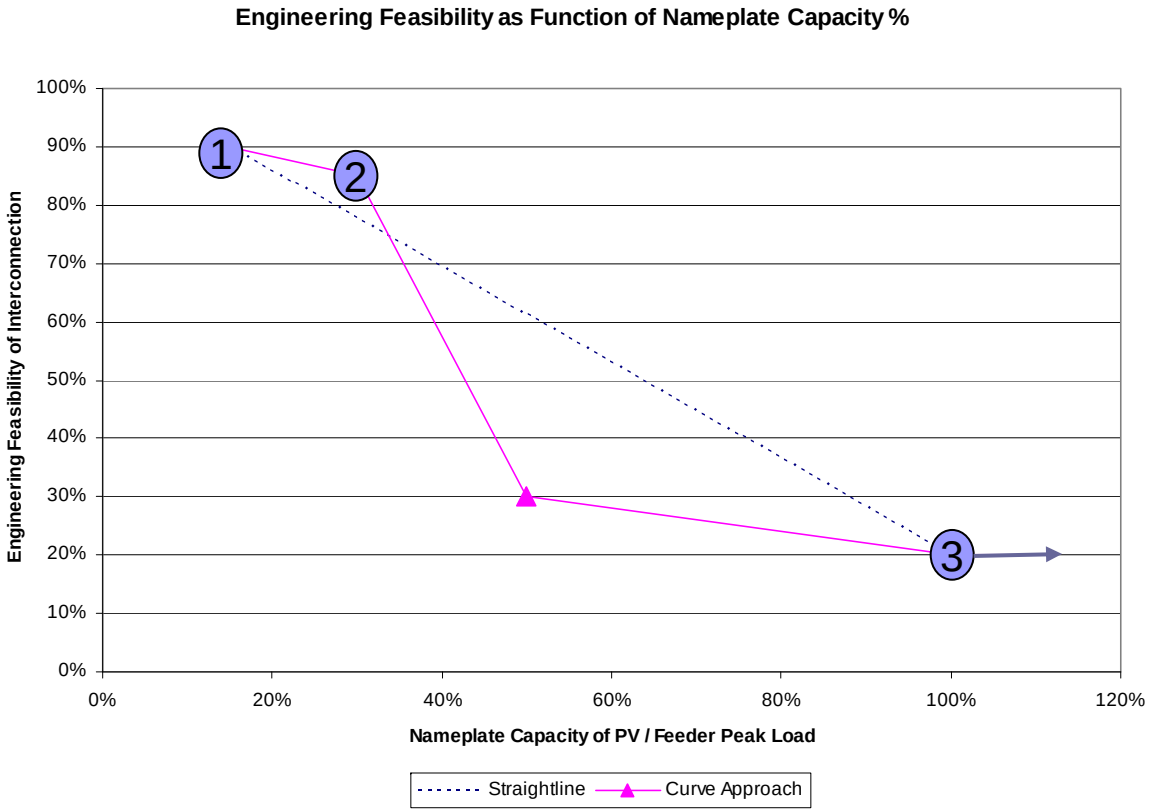


Actual data from a California public utility substation and PV installation

Technical Feasibility of PV Connections that are >15% & <100% of Peak Load

- Assumption on PV engineering feasibility

Caveat
These numbers are based on an educated guess not on any engineering analysis.

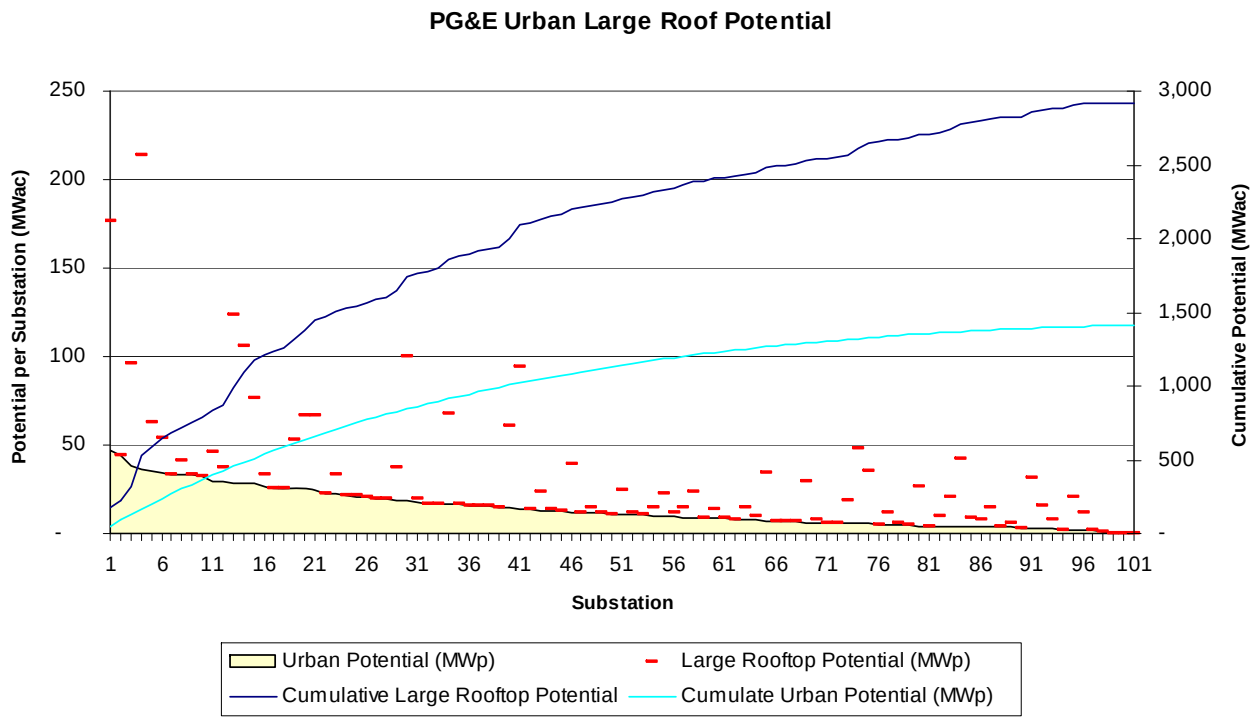


1 15% Peak Load
50% of in area PV

2 30% Peak Load
50% of in area PV

3 100+% Peak Load
RETI projects

PG&E Example – Bay Area



Clusters of large roofs make it impossible to do every roof and be below the 30% peak load.

PV Screening Criteria

	Land / Roof Availability	Interconnection	Participation
Urban Large Roofs	GIS Screening	Within 3 miles of substation, limited to 30% bank or feeder peak	33% Roofs max
Urban Small Roofs	Assumed available	30% bank or feeder peak	33% Roofs max
Rural <20MW	GIS Screening	30% bank or feeder peak	33% available land max
Rural >20MW	GIS Screening	Not constrained, but assigned interconnection cost of $68/kW-year	33% available land max

Total PV Availability for High DG Case by Type and Utility

Installed Capacity by PV System Type (MWac)

Utility	Ground Mounted (> 30%)	Ground Mounted	Large Roofs	Small Roofs	Total
PG&E	3,153	665	943	758	**5,519**
SCE	2,878	1,011	1,592	586	**6,067**
SDG&E	552	255	218	380	**1,406**
Other	2,417	335	1,057	500	**4,309**
Total	**9,000**	**2,266**	**3,810**	**2,224**	**17,300**

Other WDG Resources

- Biogas/Biomass
  - Resource potential developed based on discussion with stakeholders
  - Constrained by fuel availability
  - Total available capacity of 250 MW of Biogas, 35 MW of distribution-connected Biomass

Statewide DG Potential by Type

Nameplate MW	DG Type					
Connection	Biogas	Biomass	Geothermal	Solar PV	Wind	Total
1. Customer Site	-	-	-	2,224	-	2,224
2. Feeder	249	34	-	3,810	-	4,093
3. Distribution Bank	-	-	-	2,267	-	2,267
4. Subtransmission	-	128	175	9,000	468	9,771
Total	249	162	175	17,301	468	18,355

4. Results and Final Thoughts

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High DG Case Results

- Case constructed to minimize the need for new transmission corridors
- Start from 20% case
- Replace central station solar and wind with 15,000 MW of mostly distributed solar PV

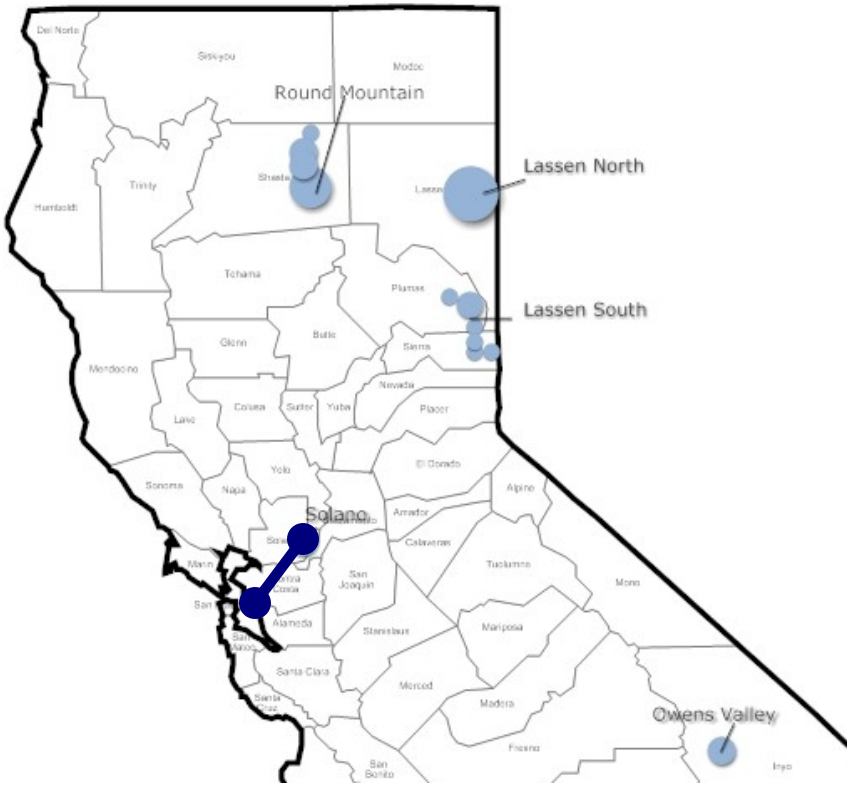
Zones Selected

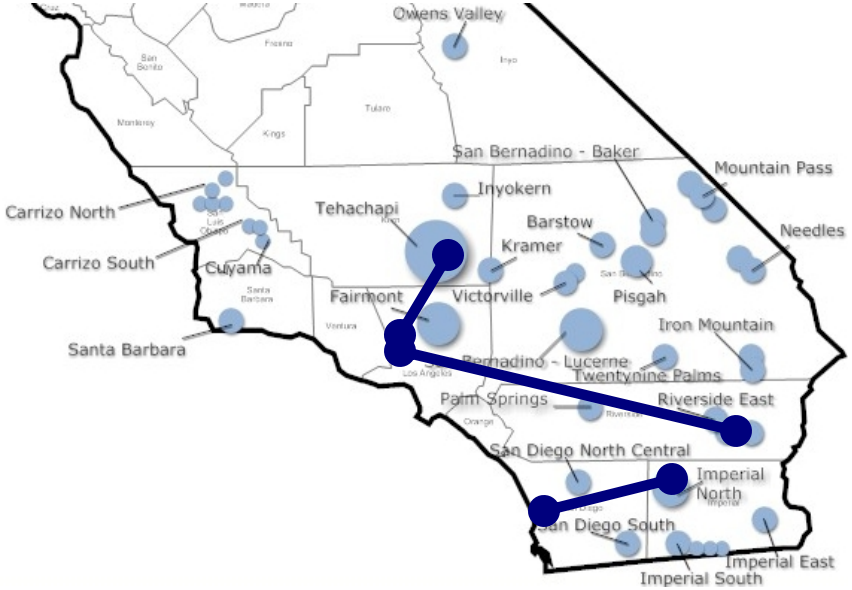
	MW	GWh	Notes
Total	***26,761***	***74,650***	
Tehachapi	3,000	8,862	*Included in Reference Case*
Distributed CPUC	525	3,118	*Included in Reference Case*
Solano	1,000	3,197	*Included in Reference Case*
Out-of-State Early	2,062	6,617	*Included in Reference Case*
Imperial North	1,500	9,634	*Included in Reference Case*
Riverside East	1,500	3,507	*Included in Reference Case*
Distributed Biogas	249	1,855	
Distributed	175	1,344	
Distributed Wind	468	1,289	
Out-of-State Late	1,934	5,295	
Distributed Biomass	162	1,138	
Remote DG	9,000	19,236	
Distributed Solar	5,186	9,558	

Resources Selected by Type

	In-State		Out-of-State		*Total*	
	MW	GWh	MW	GWh	*MW*	*GWh*
Biogas	279	2,078	-	-	*279*	*2,078*
Biomass	403	2,825	87	610	*490*	*3,435*
Geothermal	1,415	10,859	58	445	*1,473*	*11,303*
Hydro - Small	22	95	15	66	*37*	*161*
Solar PV	15,068	30,678	-	-	*15,068*	*30,678*
Solar Thermal	1,095	2,674	534	1,304	*1,629*	*3,978*
Wind	4,484	13,529	3,302	9,488	*7,785*	*23,017*
Total	***22,765***	***62,738***	***3,996***	***11,912***	***26,761***	***74,650***

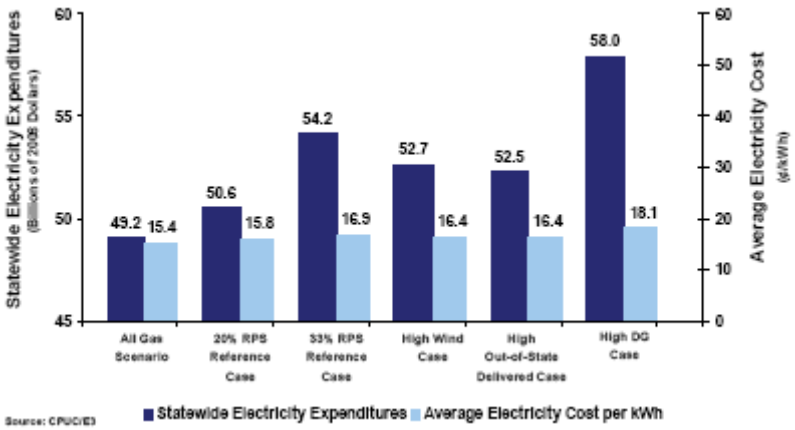
New Transmission Required for High DG Case





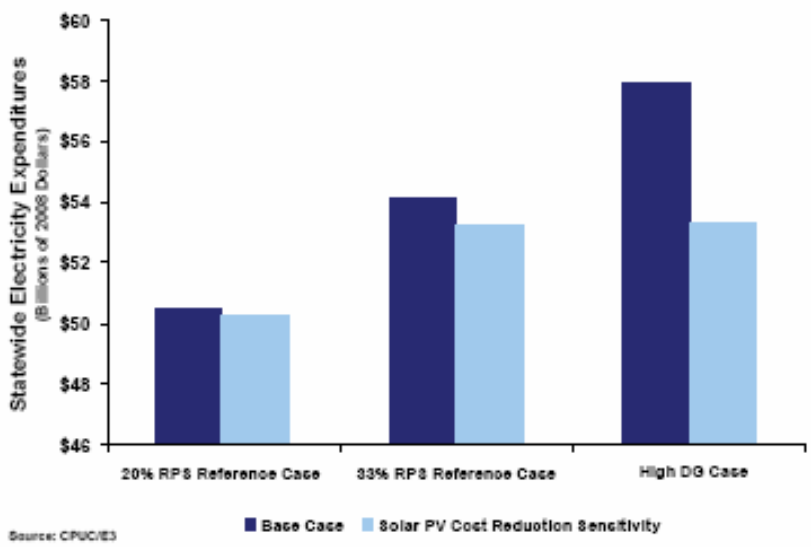
Cost Impacts of 33% RPS Cases

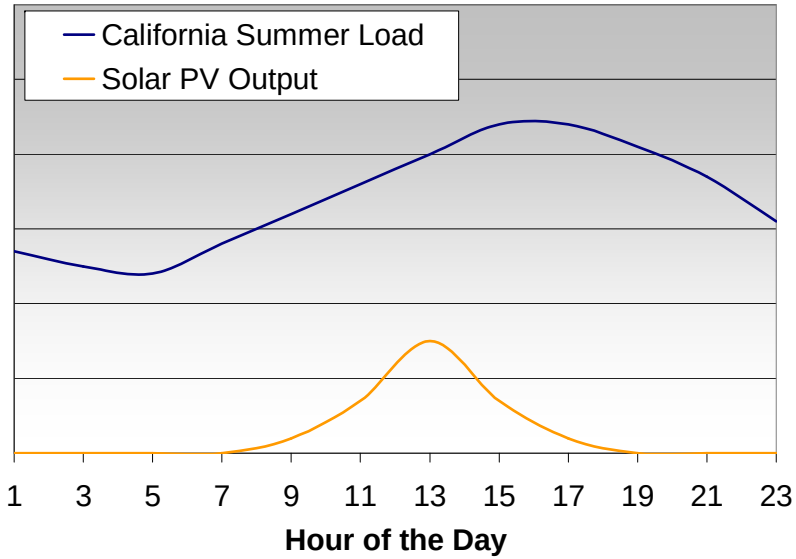
- Incremental cost of 33% Ref. Case in 2020:
  - +$3.6 billion relative to 20% RPS
  - Average retail rate: 16.9¢/kWh
  - 7% increase relative to 20% RPS
- Incremental cost of High DG Case in 2020:
  - +$3.8 billion relative to 33% Ref Case
  - +$7.4 billion relative to 20% RPS
  - Average retail rate: 18.1¢/kWh
  - 14.6% increase relative to 20% RPS



Solar PV Cost Reduction Sensitivity

- Delivered PV costs have come down substantially in the last year, and further reductions can be expected as the industry scales up
- We conducted a sensitivity analysis by reducing installed cost of PV from $7/We to $3.70/We
  - Price point developed for RETI to be in line with industry targets
  - Reduces levelized cost of PV from $306/MWh to $168/MWh
  - High DG case is similar in cost to 33% Reference Case



Final Thoughts and Next Steps

- We were not able to eliminate *all* transmission lines – assumed lines already approved go forward
- Much additional work could be done to refine the distributed PV potential estimates
- All cases assume indefinite continuation of current federal and state tax incentives
- We did not do any analysis on operations issues associated with high PV build
  - Ability of grid to absorb energy at PV output profile
  - Voltage and grid stability issues associated with lack of inertia
  - CAISO is now studying integration requirements of all 33% cases