

IRENA's PV Parity Indicators: Tracking Our Future

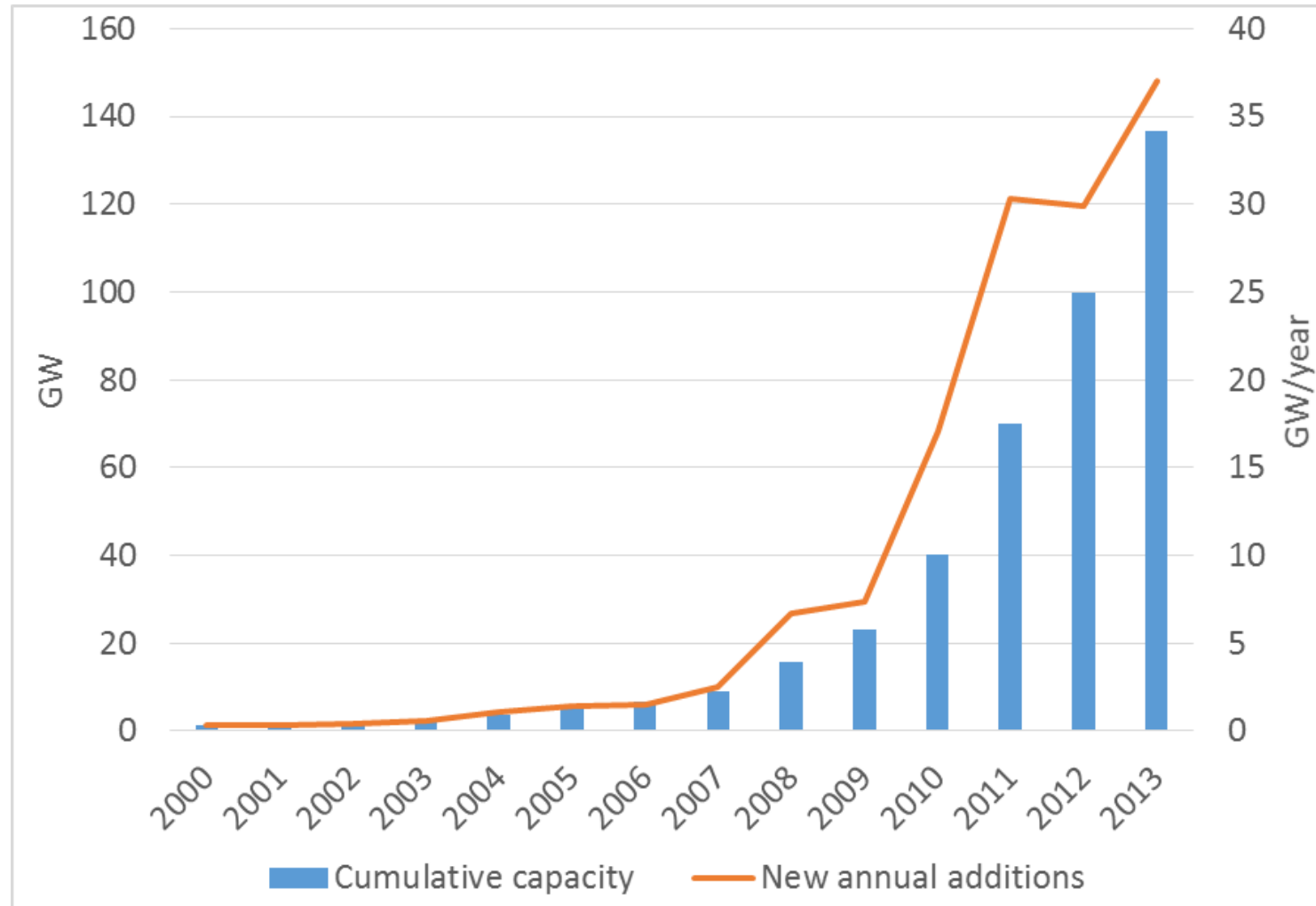


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Solar PV: The future

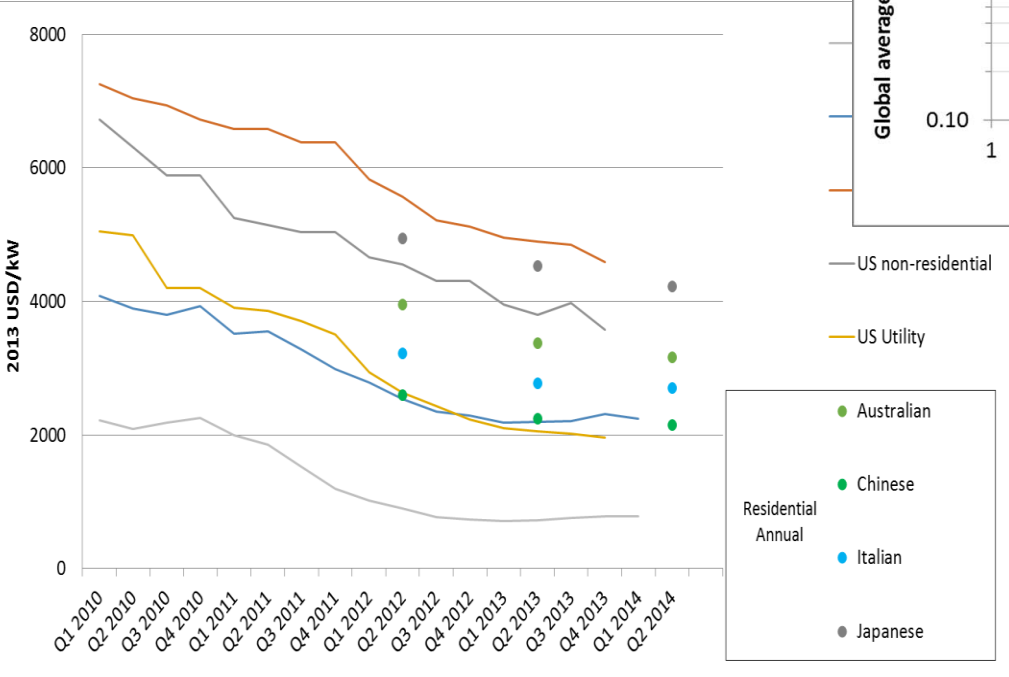
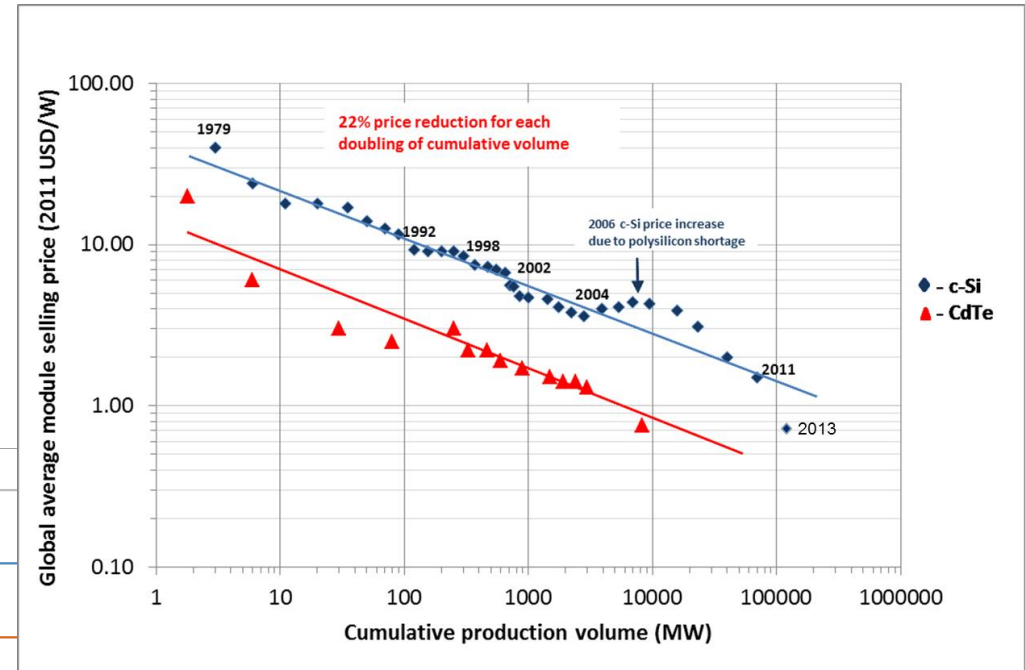


A dynamic market



Why PV Parity Indicators?

Rapidly declining solar PV module prices.....



....and installed costs

Why PV Parity Indicators?

- Narrow markets
- Lack of data
- High level of uncertainty on costs
- High level of variation in costs



PV Parity Indicators: A Solution

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- Tracks quarterly competitiveness
 - Indicators, not actual costs
 - Target audience are policy makers and thought leaders
 - Start with North America
 - Can lead to more detailed analysis
 - Supports other IRENA activities



Simple metrics Require detailed assumptions & analysis LCOE vs Effective Electricity Rate/Value

Atomic Physics

- 1) alpha (α) particle = ^4He (helium nucleus)
- 2) beta (β) particle = ^-1e (an electron)
- 3) a positron ^+1e (same mass as an electron but opposite charge)
- 4) gamma (γ) ray = no mass, no charge, just electromagnetic energy
- 5) $\lambda = \frac{v}{f}$ $\tau =$ rate of decay where $\Delta m =$ change in mass, $\Delta t =$ change in time
- 6) If the number of half-lives are known we can calculate the percentage of a pure radioactive sample left after undergoing decay since the fraction remaining = $(0.5)^n$

Neutrons = 7 n, where Neutrons designates the number of electrons in shell n.

Mathematical Formulas:

- $CGC(-x) = -CGC(x)$
- $COE(-x) = \cos(x)$
- $SEC(-x) = \sec(x)$
- $\tan(-x) = -\tan(x)$
- $\sec^2(x) + \tan^2(x) = 1$
- $\tan(2x) = \frac{2 \tan(x)}{1 - \tan^2(x)}$
- $\cos(2x) = \cos^2(x) - \sin^2(x)$
- $\sin(2x) = 2 \sin(x) \cos(x)$
- $\cos^2(x) = \frac{1 + \cos(2x)}{2}$
- $\sin^2(x) = \frac{1 - \cos(2x)}{2}$

Calculus:

- $\frac{d}{dx} \sin(x) = \cos(x)$
- $\frac{d}{dx} \cos(x) = -\sin(x)$
- $\frac{d}{dx} \tan(x) = \sec^2(x)$
- $\frac{d}{dx} \sec(x) = \sec(x) \tan(x)$
- $\frac{d}{dx} \csc(x) = -\csc(x) \cot(x)$
- $\frac{d}{dx} \cot(x) = -\csc^2(x)$

Geometry:

- Area of Triangle: $A = \frac{1}{2} \times \text{base} \times \text{height}$
- Volume of Cone: $V = \frac{1}{3} \pi r^2 h$
- Pythagorean Theorem: $a^2 + b^2 = c^2$

SAM 2014.1.14: C:\Users\maylor\Documents\IRENA\IRENA\Power generation costing\PV Parity Indicators\PV GRID PARITY\SAM outputs\untitled1.sam

Photovoltaics (PV) Residential sector (1)

Select Technology and Market... **PWatts, Residential**

Location and Resource
Location: SAN_FRANCISCO, CA
Lat: 37.6 Long: -122.4 Elev: 5.0 m

PWatts Solar Array
DC Rating: 5 kW
AC-DC Derate: 0.77

Performance Adjustment
Percent of annual output: 100 %
Year-to-year decline: 0.5 % per year

PV System Costs
Total: \$ 18,000.00
Per Capacity: \$ 3.60 per Wdc

Financing
Analysis: 25 years
Debt Fraction: 100.0% percent

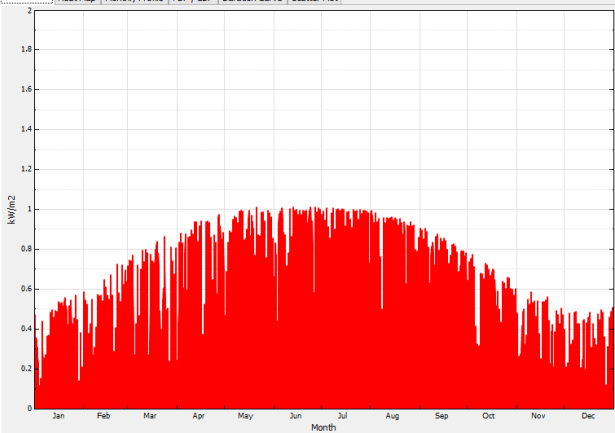
Incentives
State ITC
No cash incentives

Utility Rate
Use Metered? Yes

Metric	Value
Annual Energy	7,122 kWh
LCOE Nominal	28.89 ¢/kWh
LCOE Real	28.89 ¢/kWh
Electricity cost without system	\$ 1,698.07
Electricity cost with system	\$ 166.61
Net savings with system	\$ 1,531.46
Net present value (\$)	\$ -4,130.97
Payback (years)	11.7879
Capacity Factor	16.3 %
First year kWhac/kWdc	1,424

View and export data: Graphs Tables Cash Flows Time Series Loss Diagram

Time Series: Heat Map Monthly Profile PDF / CDF Duration Curve Scatter Plot

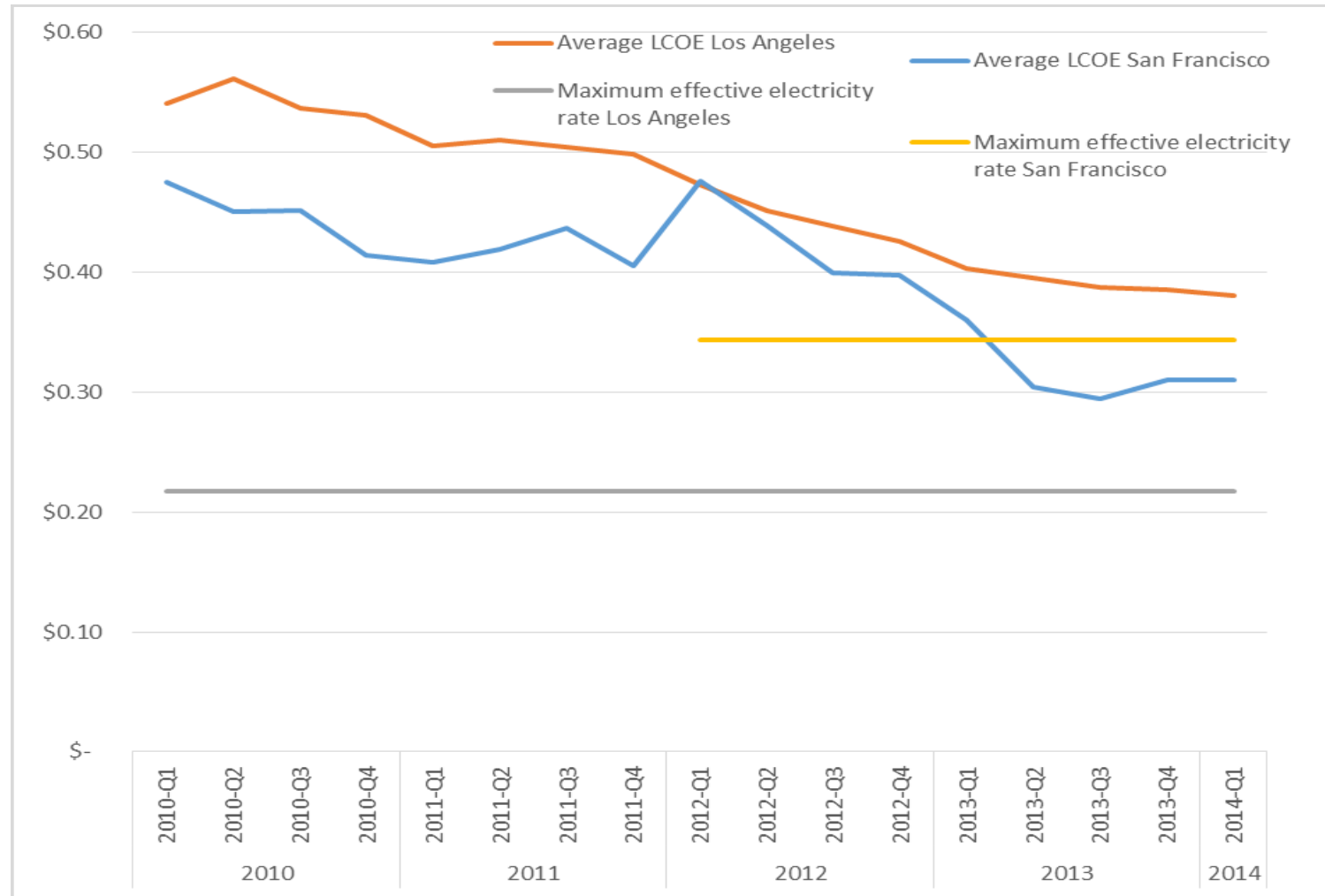


Global Horizontal (kW/m2)

- Global Horizontal (kW/m2)
- Beam Normal (kW/m2)
- Diffuse Horizontal (kW/m2)
- Plane of Array (kW/m2)
- Wind Speed (m/s)
- Ambient Temp (C)
- Cell Temp (C)
- Shading Factor for Beam Radiation, Hourly ()
- DC Output (kW/h)
- Hourly Energy (kWh)
- Year 1 electricity to/from grid (kWh)
- Year 1 hourly electric load (kWh)
- Year 1 subhourly peak to/from grid (kW)
- Year 1 hourly sales/purchases with system (\$)
- Year 1 hourly sales/purchases without system (\$)
- Hourly energy charge TOU period ()
- Hourly demand charge TOU period ()
- Hourly Energy (kWh)

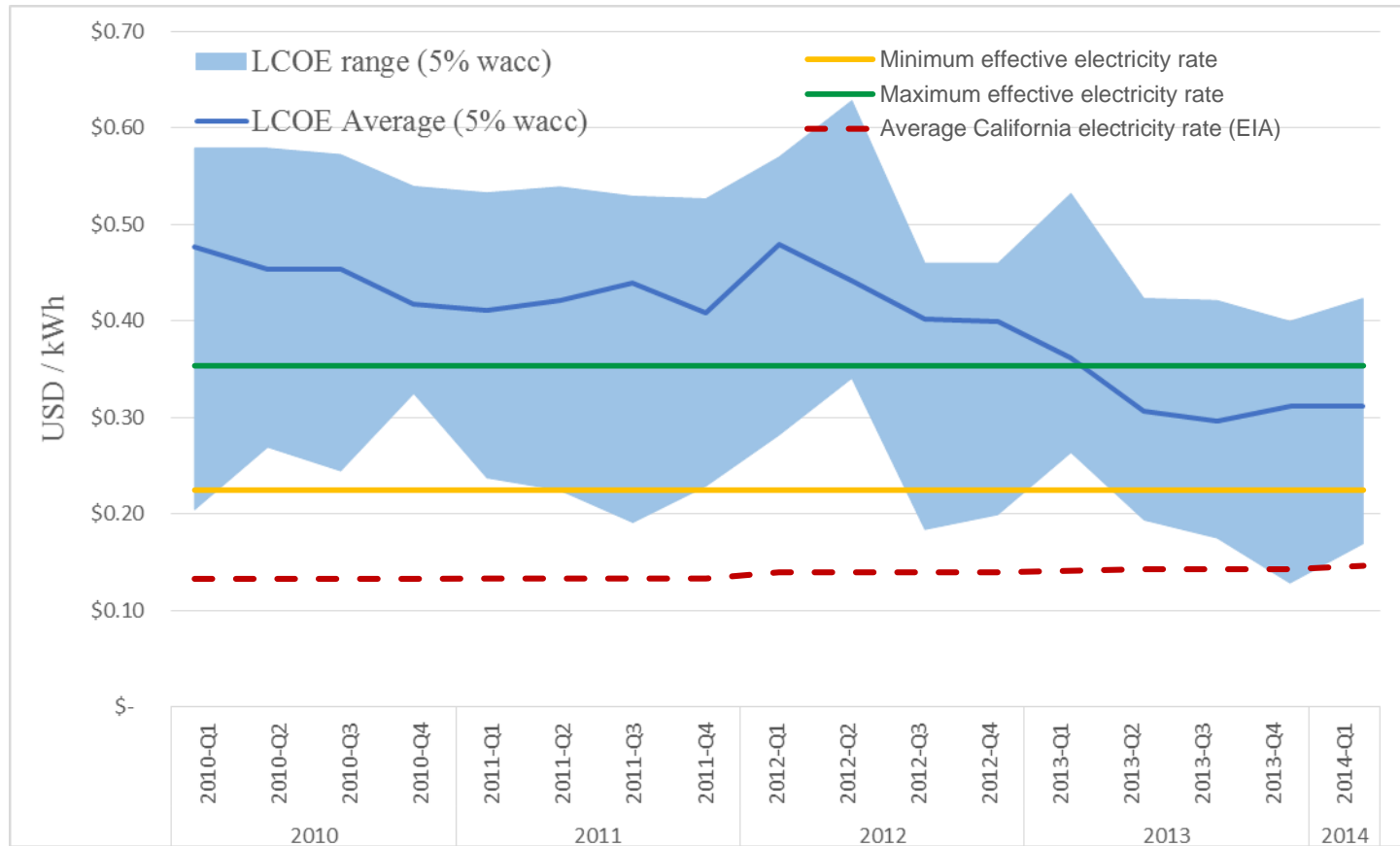
Monthly Output **After Tax Cashflow** **Annual Output** **Cost per Watt** **Stacked Real LCOE** **Stacked Nominal LCOE**

Residential PV Parity: A nuanced story

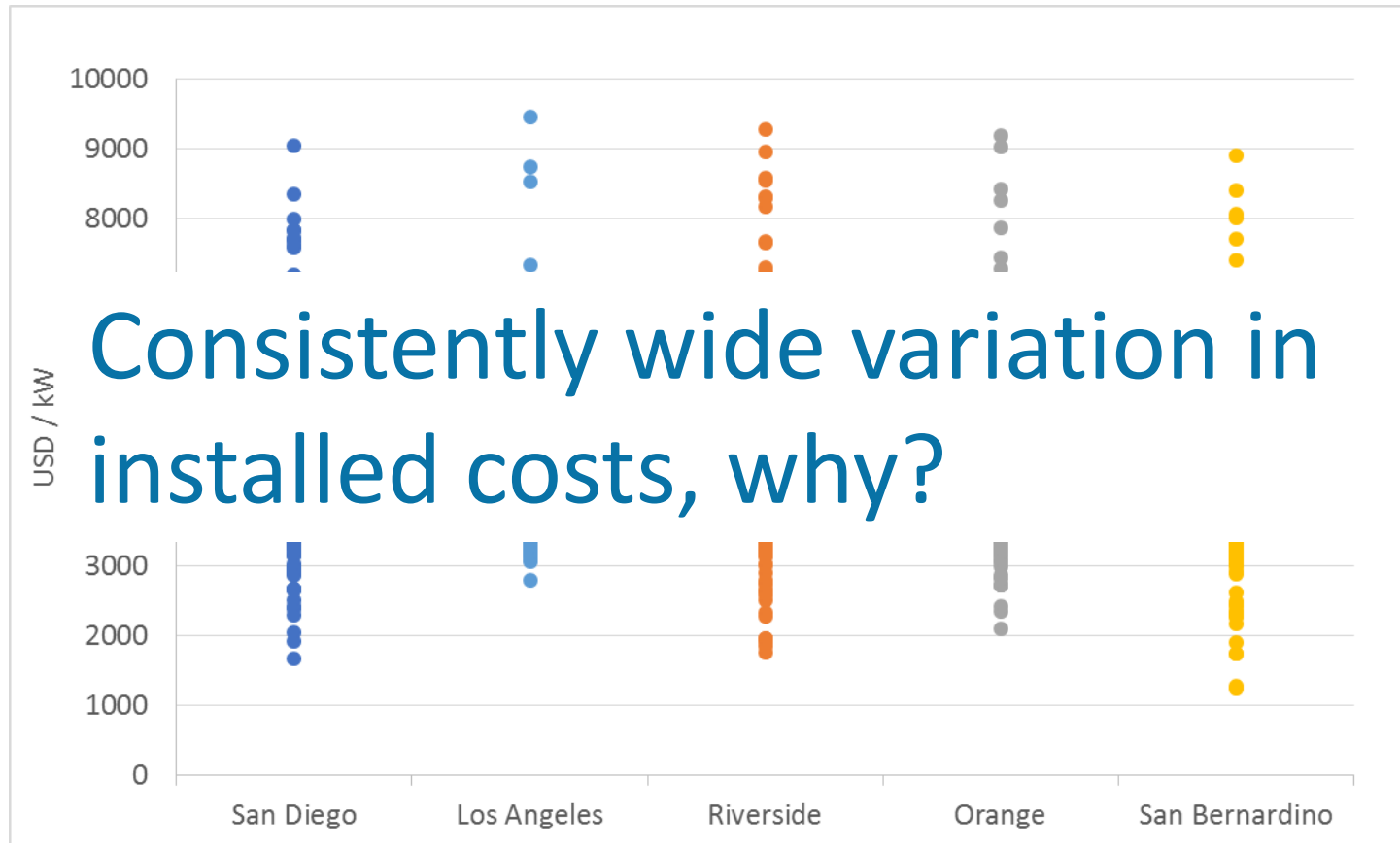


Recent module price reductions make solar PV competitive 8

Residential PV Parity: San Francisco



Installed cost variation by city



Plans for rollout

Q3, 2014

California

Q4, 2014

+

Other US states

Q1, 2015

+

Italy

Q2, 2015

+

?

Transparent data



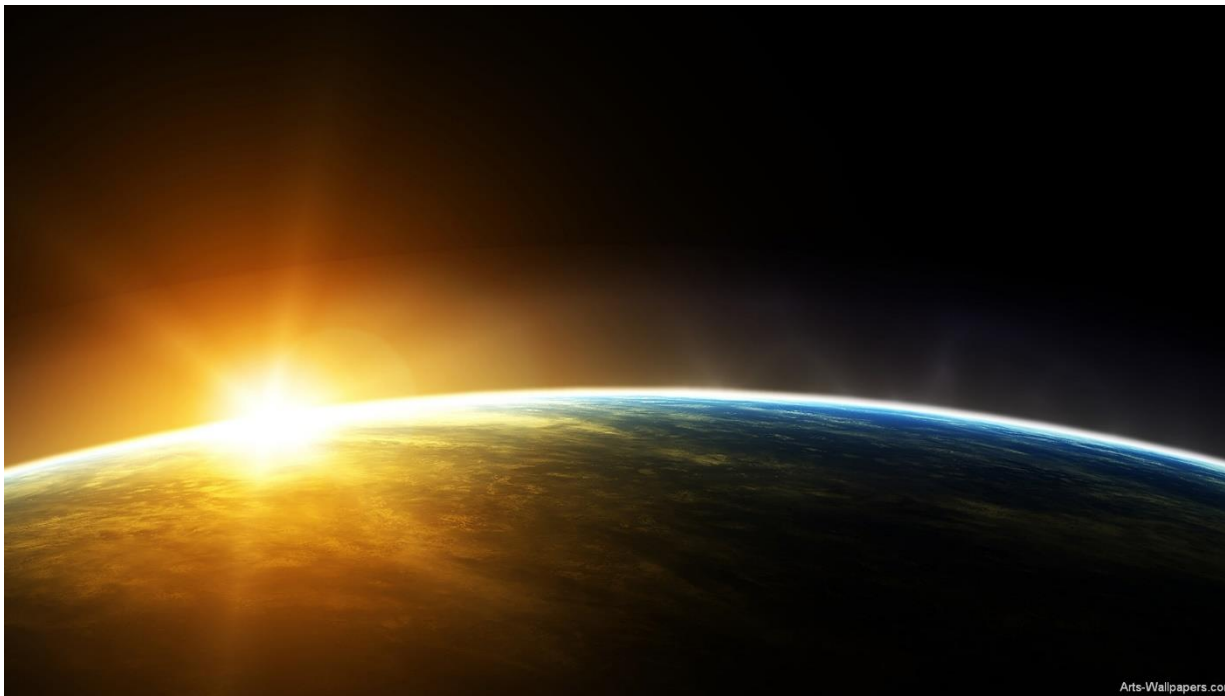
Simple methodology



Timely and policy relevant information



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