

## Field Guide to Solar PV Energy Features

As of February 8, 2017

### Describing Solar PV

**[“Solar Ready Buildings Planning Guide”](http://www.nrel.gov/docs/fy10osti/46078.pdf)** published in December 2009 by the National Renewable Energy Laboratory, operated for the Department of Energy by the Alliance for Sustainable Energy LLC. <http://www.nrel.gov/docs/fy10osti/46078.pdf>

**[“Solar Photovoltaic Specification, Checklist and Guide”](https://www1.eere.energy.gov/buildings/residential/pdfs/rerh_pv_guide.pdf)** was published by U.S. Environmental Protection Agency. This guide provides a good understanding of solar PV systems, how they work, and best practices for maximum production. [https://www1.eere.energy.gov/buildings/residential/pdfs/rerh\\_pv\\_guide.pdf](https://www1.eere.energy.gov/buildings/residential/pdfs/rerh_pv_guide.pdf)

**[“Solar Energy Glossary”](https://www.energy.gov/eere/sunshot/solar-energy-glossary)** has an extensive glossary of solar terms that are useful in describing solar features. <https://www.energy.gov/eere/sunshot/solar-energy-glossary>

***EnergySage Inc.:*** This website classifies (premium, standard, economy) many major manufacturers of solar modules. It provides a straightforward description of comparing solar panels using key criteria. It describes why multiple quotes should be secured prior to making a purchase decision. The cost-benefit of solar PV is simply articulated to give the typical homeowner, appraiser, or sales agent a better understanding of the benefits of solar PV. This site is good reading for those seeking to understand solar systems. <http://www.energysage.com/solar/buyers-guide/selecting-solar-panels>

**[“The PV Durability Initiative”](http://www.cse.fraunhofer.org/publications/the-pv-durability-initiative)** scores five solar manufacturers from accelerated life testing and long-term field exposure data. Fraunhofer Center for Sustainable Energy Systems offers a library of videos and articles on solar photovoltaic systems. <http://www.cse.fraunhofer.org/publications/the-pv-durability-initiative>

Examples of **[permanent documentation](#)** to make a utility worker or emergency response personnel aware there is a photovoltaic system on the property. The examples assist real estate professionals in identifying signs of a potential solar PV system installation. The website is by PNM, New Mexico’s largest electricity provider. <https://www.pnm.com/one-line-diagram-storage-examples>

***Commercial Green and Energy Efficient Addendum*** - Assists appraisers in analyzing commercial "Green" features and properties and has a page dedicated to solar identifying documents that might be available to describe the system more accurately. Real estate agents should ask the property owner to have the builder, energy rater, green rater, or the person with the most knowledge of the features to complete the Addendum and place it in the MLS or Co-Star as an attachment. [http://www.appraisalinstitute.org/assets/1/29/AI\\_821\\_Green\\_Commercial\\_Interactive1.pdf](http://www.appraisalinstitute.org/assets/1/29/AI_821_Green_Commercial_Interactive1.pdf)

***Residential Green and Energy Efficient Addendum*** - Assists appraisers in analyzing residential "Green" features and properties including a page dedicated to solar PV systems and solar thermal water heating systems. Real estate agents should ask the property owner to have the builder, energy rater, green rater, or the person with the most knowledge of the features to complete the Addendum and place it in the MLS as an attachment. Note: The Addendum is going through a major update and will be released in 2017 after it has been mapped to the Real Estate Standards Dictionary (RESO) and Mismo language. If the link is broken, search the internet using the same name.

<http://www.appraisalinstitute.org/assets/1/7/Interactive820.04-ResidentialGreenandEnergyEffecientAddendum.pdf>

**Book: *Residential Green Valuation Tools*** has case studies and examples on how to use solar PV valuation tools, including PV Value®. It has numerous resources and examples of how to value, market, and mortgage green and energy efficient residential properties. This book does have a charge but can be downloaded as a pdf or a hard copy will be mailed by ordering through the Appraisal Institute website. The book was published 2014 by the Appraisal Institute and was authored by Sandra K. Adomatis, SRA, LEED Green Associate.

<http://www.appraisalinstitute.org/residential-green-valuation-tools/>

***Solar Energy Resource Center*** has a variety of resources and guides to assist homeowners and real estate professionals in understanding the basics of solar PV systems.

[https://energy.gov/eere/sunshot/solar-energy-resource-center-0?Topic=Solar%20Basics and Educating%20Consumers](https://energy.gov/eere/sunshot/solar-energy-resource-center-0?Topic=Solar%20Basics%20and%20Educating%20Consumers)

## Impact on Real Estate Values

**Assessor:** Most states do not assess solar photovoltaics now. In some areas the assessors are asked to value the systems when they are part of real estate even when they are not taxed. The following study from the North Carolina Solar Center describes the issues that surround the assessment of solar PV systems. Since the writing of the report, a few states have changed taxing policies but there is no consistent way solar PV is being handled even within the state or U.S. in general.

***The Cost of Value: PV and Property Taxes:*** published in 2010 by North Carolina Solar Center and authored by Justin Barnes, Amy Heinemann, and Brian Lips. A follow up study by [Property Taxes and Solar PV Systems: Policies, Practices, and Issues](http://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2015/01/2012-Barnes-The-Cost-of-Value...-report.pdf) ICLEI Local Governments for Sustainability USA, published July 2013, investigates the current state and local property taxation practices as they apply to solar PV systems, various issues associated with assessing and taxing them under PV-specific and general property tax laws. **Review the links to state specific sites that provide assessment information at the end of the study.** <http://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2015/01/2012-Barnes-The-Cost-of-Value...-report.pdf>

<https://nccleantech.ncsu.edu/wp-content/uploads/Property-Taxes-and-Solar-PV-Systems-2013.pdf>

Additional information regarding assessment, state laws, incentives, solar access laws, and policies can be found at the [Database of State Incentives for Renewables & Energy Efficiency](http://www.dsireusa.org/) (DSIREUSA) <http://www.dsireusa.org/>

***“Property Taxes and Solar PV Systems: Policies, Practices, and Issues”*** published in 2013 by North Carolina Solar Center, and funded via the U.S. Department of Energy SunShot Initiative, and Meister Consultant Group. Reviews the taxing laws and policies concerning solar PV. <https://nccleantech.ncsu.edu/wp-content/uploads/Property-Taxes-and-Solar-PV-Systems-2013.pdf>

## Valuation of Solar PV

*Valuing Solar PV should be done using the cost, sales comparison, and income approaches when data are available. The key factors in developing the value of solar PV systems is knowing the kilowatt hour cost at the location, the escalation rate of the utility costs, and the characteristics of the solar PV system. Solar PV works best in areas with higher elevation and low humidity; electricity costs vary as do the rate at which electricity prices are increasing in the area (electric escalation rate). The most recent studies in this guide provide an overview of the published works illustrating how experts see solar PV value using a vary of methods.*

**Important Value Consideration:** *As the price of solar PV declines, so will the price buyers in the market are willing to pay. Avoid using cost estimates that are not based on current quotes or value based on studies using older data. All the studies listed below are based on dated data and the value reflects a specific time in the market. Homeowners will typically remember the installed price but lose track of the current installed cost of solar PV. It is always good to remind homeowners of the current prices based on your research through local installers' estimates or other reliable resources. Solar PV efficiencies are continuing to increase as well; therefore, the newer systems produce more energy than panels installed a few years ago. The panels are becoming more esthetically pleasing and lower in cost.*

**“Standardizing Appraisals for PV Installations”** is a conference paper presented at the 39<sup>th</sup> IEEE PVSC conference in Tampa, FL on June 21, 2013. The authors include Geoffrey T. Klise, Jamie L. Johnson, and Sandra K. Adomatis. The paper discusses the importance of using proper valuation techniques to capture the value of solar PV systems. Solar PV resources are identified at the end of the paper. <http://energy.sandia.gov/download/22767/>

**“How PV System Ownership Can Impact the Market Value of Residential Homes”** This paper was published in 2015 by Sandia Laboratory and authored by Geoffrey Klise and Jamie Johnson. It discusses three primary ownership options (customer, third-party, PACE) and discusses the appraisal perspective of each ownership.

<http://energy.sandia.gov/download/23081/>

**PV Value® Pro** – [www.pvvalue.com](http://www.pvvalue.com) Is a user-friendly program that discounts the cash flow based on the energy produced by the solar PV system for an estimated production period to arrive at value of the system. This discounted cash flow is also known as the income approach. This discounted cash flow analysis requires specific details of the system including system and inverter wattage, warranty for system panels and inverter, exact address, orientation (azimuth) and tilt, age of system, and derate factor. These system characteristics should be available on the installation paperwork or on the building permit. Solar PV systems require a building permit in most all parts of the U.S. PV Value will be converting to a new platform in the summer or fall of 2017. The new platform will be at [www.eivalue.com](http://www.eivalue.com).

**High Performance Buildings Magazine.** This is a free online magazine that provides very detailed case studies. The site includes case studies on net zero energy commercial and residential buildings that implement solar PV systems. <http://www.hpbmagazine.org/Case-Studies/>

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[http://www.appraisalinstitute.org/assets/1/29/AI\\_821\\_Green\\_Commercial\\_Interactive1.pdf](http://www.appraisalinstitute.org/assets/1/29/AI_821_Green_Commercial_Interactive1.pdf)

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<http://www.appraisalinstitute.org/residential-green-valuation-tools/>

## Most Recent Studies of Residential Solar PV Systems

[“Leasing Into the Sun: A Mixed Method Analysis of Transactions of Homes with Third Party Owned Solar”](#) published 2017 is the first study of sale price effects of residential solar PV systems owned by a third party (TPO). The authors include Ben Hoen, Joe Rand and Sandra Adomatis and is published by Lawrence Berkeley National Laboratory and funded by the U.S. Department of Energy SunShot Initiative. The study used a dataset of 113 TPO solar home sales, 2,914 host-owned (non-TPO) solar homes and 17,079 non-PV homes. These data were analyzed using a hedonic pricing model and a subset were analyzed by two appraisers using a paired-sales technique. Both methods fail to uncover evidence of a premium for TPO solar homes. <https://emp.lbl.gov/publications/leasing-into-the-sun-a-mixed-method-a>

[“Selling Into the Sun: Price Premium Analysis of a Multi-State Dataset of Solar Homes”](#) published 2015 is an eight-state study of residential solar PV systems using sales data spanning 2002 through 2013. The authors include Ben Hoen, Sandra Adomatis, Thomas Jackson, Joshua Graff-Zivin, Mark A. Thayer, Geoffrey T. Klise, and Ryan H. Wiser. It was published by Lawrence Berkeley National Laboratory and funded by the U.S. Department of Energy SunShot Initiative. The study used a robust dataset of 3,595 solar PV homes and 18,871 non-PV homes. These data were analyzed using hedonic pricing models to account for various home/site, neighborhood, and market characteristics. The find clear evidence of solar home premiums. <https://emp.lbl.gov/publications/selling-sun-price-premium-analysis>

[“Appraising Into the Sun: Six-State Solar Home Paired-Sales Analysis”](#) published by Lawrence Berkeley National Laboratory in 2015 is a six-state study of residential solar PV systems using the cost approach, income approach and paired-sales analysis. The sales data included solar PV homes sold between 2011 and 2013. The report was co-authored by Sandra Adomatis and Ben Hoen. This work was supported by U.S. Department of Energy under the SunShot Initiative. [https://emp.lbl.gov/sites/all/files/lbnl-1002778\\_0.pdf](https://emp.lbl.gov/sites/all/files/lbnl-1002778_0.pdf)

[“The Impact of Photovoltaic Systems on Market Value and Marketability”](#) Denver, Colorado Metro Area PV Market Value study - This 2013 study was paid for by the Colorado Energy Office to identify market value impacts PV has in the northwest Denver metro area. The study was authored by an appraiser and vetted by other appraisers in the area. The study uses the income approach including PV Value®, cost and paired-sales analysis, a comparison of sales prices with and without solar PV to establish the market’s view of value. <https://www.colorado.gov/pacific/energyoffice/atom/14956>

[“A Study on the Residential Market Valuation of EPS and Solar PV in the Greater Portland and Bend, Oregon Markets”](#), a study published June 9, 2014, by Watkins & Associates for Energy Trust of Oregon and Earth Advantage. This study uses a sales comparison approach to "isolate" the market value of PV systems. [http://assets.energytrust.org/api/assets/reports/EPS\\_Solar\\_Valuation.pdf](http://assets.energytrust.org/api/assets/reports/EPS_Solar_Valuation.pdf)

Avoid using sales price premiums for solar PV systems from studies outside your market area. Markets vary in value because of social issues, kilowatt hour costs, knowledge of solar PV, and climatic conditions.

**Older Solar PV Studies** – Proceed with caution when using sales price premiums identified in older studies unless you are valuing systems as of a retrospective date of value. (A date back in time from current date.)

***“An Analysis of the Effects of Residential Photovoltaic Energy Systems on Home Sales Prices in California”*** was published 2012 by Energy Technologies Area, E.O. Lawrence Berkeley National Laboratory. The authors include Ben Hoen, Ryan H. Wiser, Mark A. Thayer, and Peter Cappers. The study covers a large dataset of California homes that sold from 2000 through mid-2009. <https://eetd.lbl.gov/publications/residential-photovoltaic-energy-sys-0>

***“Exploring California PV Home Premiums”*** published 2013 by Energy Technologies Area, E.O. Lawrence Berkeley National Laboratory and authored by Ben Hoen, Geoffrey T. Klise, Joshua Graff-Zivin, Mark A. Thayer, Joachim Seel, and Ryan H. Wiser. <https://eetd.lbl.gov/publications/exploring-california-pv-home-premiums>

***“Residential Photovoltaic Energy Systems in California: The Effect on Home Sales Prices”*** can be found at Energy Technologies Area, E.O. Lawrence Berkeley National Laboratory. This study was published in March 2012 and authored by Ben Hoen, Ryan Wiser, Mark Thayer, and Peter Cappers. This study uses a large dataset of California homes that sold from 2000 through mid-2009 identifying a sales price premium for homes with solar PV systems. <https://eetd.lbl.gov/sites/all/files/publications/lbnl-5901e.pdf>

***“Understanding the Solar Home Price Premium: Electricity Generation and “Green” Social Status”*** a 2012 paper by Samuel Dastrup, Josh Graff Zivin, Dora Costa and Matthew Kahn. The paper was published in the European Economic Review. The research was one of the first to find a statistically identifiable premium across a large set of homes. Their dataset is California focused and spans the period 1997-2010. <http://www.sciencedirect.com/science/article/pii/S0014292112000244>

## Solar Trends

**[Annual U.S. Berkeley Lab Tracking the Sun Report](#)** describes trends in the installed price of distributed photovoltaic (PV) systems in the United States. This report is derived from an extensive dataset of solar system level metrics the lab collects annually from a large variety of sources. The dataset covers approximately 85% of all the US installations. This is the gold-standard of publicly available reports on installed costs and contains details by state, system type, and year among other categories. The report relies on historical data, but also contains some projections of future trends. This report is published by Lawrence Berkeley National Laboratory via funding from the US Department of Energy. Archived Tracking the Sun and other solar related reports are available on the [website](https://emp.lbl.gov/projects/solar). <https://emp.lbl.gov/projects/solar>

**[SEIA & GTM Solar Market Insight Report](#)** describes installation trends of photovoltaic (PV) systems in the United States, including residential, commercial and utility scale. The annual report is derived from an extensive internally collected private dataset of solar system level metrics. The report includes deep analysis of solar markets, technologies and pricing, identifying the key metrics that will help solar decision makers navigate the market's current and forecasted trajectory. This report is published via a collaboration between the Solar Energy Industries Association (SEIA) and Greentech Media (GTM) Research. The full reports are only available via purchase, but executive summaries are publicly available. Archived versions of reports and summaries are available on the [website](http://www.seia.org/research-resources/us-solar-market-insight). <http://www.seia.org/research-resources/us-solar-market-insight>

**[Annual U.S. Solar Market Trends Report](#)** outlines different market forces shaping the adoption of PV across the U.S. PV pricing is included in these reports, and archived reports back to 2008 can be downloaded. This is a good annual report to understand how the market is trending including information on leases, community solar, energy storage, and where most of the installations are occurring. This report is published by Interstate Renewable Energy Council but has not been updated since 2014. <http://www.irecusa.org/publications/annual-u-s-solar-market-trends-report/>



## Secondary Mortgage Market Guidelines for Solar Photovoltaics

**Fannie Mae:** [Fannie Mae guidelines dated December 16, 2014](#), address the valuation of energy efficient features including solar photovoltaic leased and owned systems. However, the acceptable valuation methods have been interpreted to say, “no sale, no value” by some underwriters. The actual wording states, “Appraisers must compare energy-efficient features of the subject property to those of comparable properties in the Sales Comparison Approach adjustment grid. If the appraiser’s analysis determines that an adjustment is warranted based on the market reaction to such item(s), the adjustment must be included in the adjustment grid.”<sup>1</sup> <https://www.fanniemae.com/content/guide/sel121614.pdf>

**Freddie Mac** guidelines address the valuation of energy efficient properties but do not mention solar photovoltaic systems. The guide states, “If the property has energy-efficient features, the appraiser must identify the features. If energy-efficient features of a property, whether the subject property or comparable sales, affect value or marketability, the appraiser must make appropriate adjustments to reflect the market reaction to the energy-efficient features.” This can be found in section 44.15 of the seller guide. <http://dennisbadger.com/PDF/L-R-G/2008-03-FreddieMac.pdf>

**FHA/HUD** insure loans that meet their guidelines including address energy efficiency and solar photovoltaic leased and owned systems. The guide is specific regarding adjusting comparable properties naming the “direct sales comparison approach, cost approach or income approach as acceptable valuation methods.”<sup>2</sup> By addressing the three methods, the guide is clear that if sales are not available other methods can be used to value energy features. FHA also allows the cost of solar photovoltaic systems to be added to the mortgage amount but it cannot exceed 20% of the maximum insurable mortgage limit.<sup>3</sup> [https://portal.hud.gov/hudportal/HUD?src=/program\\_offices/housing/sfh/handbook\\_4000-1](https://portal.hud.gov/hudportal/HUD?src=/program_offices/housing/sfh/handbook_4000-1)

**Veteran’s Administration (VA)** makes loans to eligible veterans. Their guidelines have a brief statement regarding solar energy systems valuation that states, “Value must be based on real estate market data.”<sup>4</sup> [http://www.benefits.va.gov/warms/pam26\\_7.asp](http://www.benefits.va.gov/warms/pam26_7.asp)

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<sup>1</sup> Fannie Mae, *Selling Guide Fannie Mae Single Family*, (Part B, Subpart 4, Chapter 1, page 604)

<sup>2</sup> FHA, *FHA Single Family Housing Policy Handbook 4000.1*, (dated 9-14-2015), II.B.4 (D) page 505

<sup>3</sup> FHA, *FHA Single Family Housing Policy Handbook 4000.1*, (dated 9-14-2015) II A.2.C., page 152

<sup>4</sup> [http://www.benefits.va.gov/warms/pam26\\_7.asp](http://www.benefits.va.gov/warms/pam26_7.asp) Chapters 11 page 11-23

## Solar PV Installation Databases

**[Enphase Energy Inc. Database of solar PV installations](https://enlighten.enphaseenergy.com/public_systems)** utilizing Enphase microinverter technology. Some sites in this interface show production over the lifetime of the PV system, multiple tilt and azimuth configurations, array layout, module manufacturer, and the company that installed the PV system and /or provides the monitoring service. This site shows the array size, kilowatt hours produced, date installed, name of installer, and azimuth on some systems. [https://enlighten.enphaseenergy.com/public\\_systems](https://enlighten.enphaseenergy.com/public_systems)

**[Open PV Project](https://openpv.nrel.gov/index)** provides the real-time status of the solar PV market in the U.S. Information can be sorted by zip code, pre-incentive (gross) cost, and installation date. This site is from the National Renewable Energy Laboratory, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy LLC. <https://openpv.nrel.gov/index>

**[NYSERDA](https://data.ny.gov/Energy-Environment/Solar-Electric-Programs-Reported-by-NYSERDA-Beginn/3x8r-34rs)** displays PV incentive program data, including location (by city), PV system size, costs (gross and incentive), module and inverter manufacturer, incentive amounts, and whether the PV systems are customer or third-party owned. Chart, table and map views can be generated in the web browser with this data. This site is from the New York State Energy Research and Development Authority (NYSERDA). <https://data.ny.gov/Energy-Environment/Solar-Electric-Programs-Reported-by-NYSERDA-Beginn/3x8r-34rs>

**[Free service for sharing and comparing PV output data](http://pvoutput.org/)**. Solar PV system owners give PV Output permission to gather data from their own PV monitoring system to allow for comparing production data in a regional setting or across different components. <http://pvoutput.org/>

**[Details PV system name and address](https://www.sunnyportal.com/Templates/PublicPagesPlantList.aspx)**, PV system's size, site photo, date commissioned (operational), inverter specifications, energy production and specific yield, and performance ratio. This site is hosted by SMA Solar Technology AG. <https://www.sunnyportal.com/Templates/PublicPagesPlantList.aspx>

**[The Major Solar Projects List](http://www.seia.org/map/majorprojectsmap.php)** is a database of all ground-mounted solar projects, 1 MW and above, that are either operating, under construction, or under development. This site is by Solar Energy Industries Association. <http://www.seia.org/map/majorprojectsmap.php>

**[Solar PV installations](http://www.solrenview.com/)** are detailed if the system uses a Solectria inverter and the site name or installer name is known. This site is by Solectria Renewables. <http://www.solrenview.com/>

**[California Solar Initiative \(CSI\) and California Public Utilities Commission \(CPUC\)](https://www.californiasolarstatistics.ca.gov/)** data on installed PV systems. The site provides solar statistics, cost data, and installed capacity. The site is by State of California, California Energy Commission & California Public Utilities Commission. <https://www.californiasolarstatistics.ca.gov/>

## Maps of Installed Solar PV Systems Across the United States.

The maps are useful in identifying the solar adoption rates and potential comparable properties that have solar PV systems. The databases may be useful in identifying the solar PV system size and date installed.

Arizona Solar Map - <http://arizonagoessolar.org/SolarMap.aspx>

Berkeley, CA - <http://www.cityofberkeley.info/solarmap/>

Boston, MA - <https://www.mapdwell.com/en/boston>

Cambridge, MA - <https://www.mapdwell.com/en/cambridge>

Denver, CO - <http://www.cleanenergyauthority.com/solar-energy-news/denver-regional-solar-map-offers-solar-information-for-properties-010511/>

Los Angeles, CA - <http://solarmap.lacounty.gov/>

Madison, WI - <http://solarmap.cityofmadison.com/madisun/>

New Jersey -  
<http://www.njcleanenergy.com/files/file/CS%20Marketing/Solar5000.pdf>

New Orleans, LA - <http://neworleanssolarmap.org/>

New York, NY - <http://nycsolarmap.com/>

Orlando, FL -  
<http://www.arcgis.com/home/item.html?id=c2548af8587b4d04a8dfe3b7833e8421#!>

Portland, OR - <http://www.portlandoregon.gov/bps/article/446449>

Riverside, CA - <http://www.greenriverside.com/green-map>

Salt Lake City, UT - <http://solarsimplified.org/solar-resources/solar-map>

San Diego, CA - <http://sd.solarmap.org/>

San Francisco, CA - <http://sfenergymap.org/>

Seattle Puget Sound Area - <http://solarizewa.org/our-progress>

Tallahassee, FL - <http://www.talgov.com/you/you-learn-utilities-electric-solar-map.aspx>

Vermont Energy Atlas - <http://www.vtenergyatlas-info.com/solar> and <http://www.vtenergydashboard.org/>

Washington County, OR - <https://www.mapdwell.com/en/energytrust>

Washington DC - <https://www.mapdwell.com/en/dc>

Wellfleet, MA - <https://www.mapdwell.com/en/wellfleet>

Note: When web links are no longer in place, do an internet search using the title to find the new location. The links were last tested February 8, 2017.

This list compiled by Sandra K. Adomatis, SRA, LEED Green Associate with assistance by Ben Hoen, Lawrence Berkeley Laboratory.

Email: [adomatis@hotmail.com](mailto:adomatis@hotmail.com)

Twitter: @Sadomatis

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