MEETING PEAK DEMAND WITH PHOTOVOLTAICS

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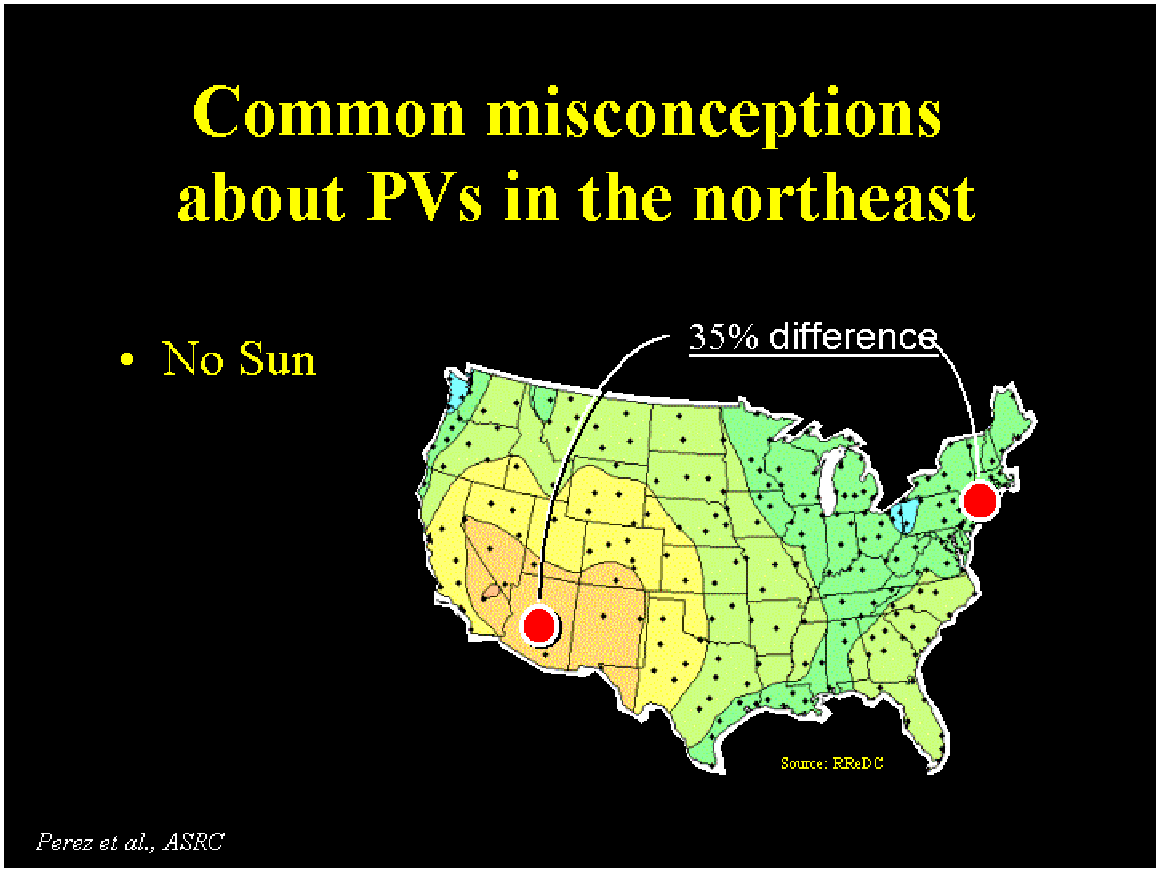
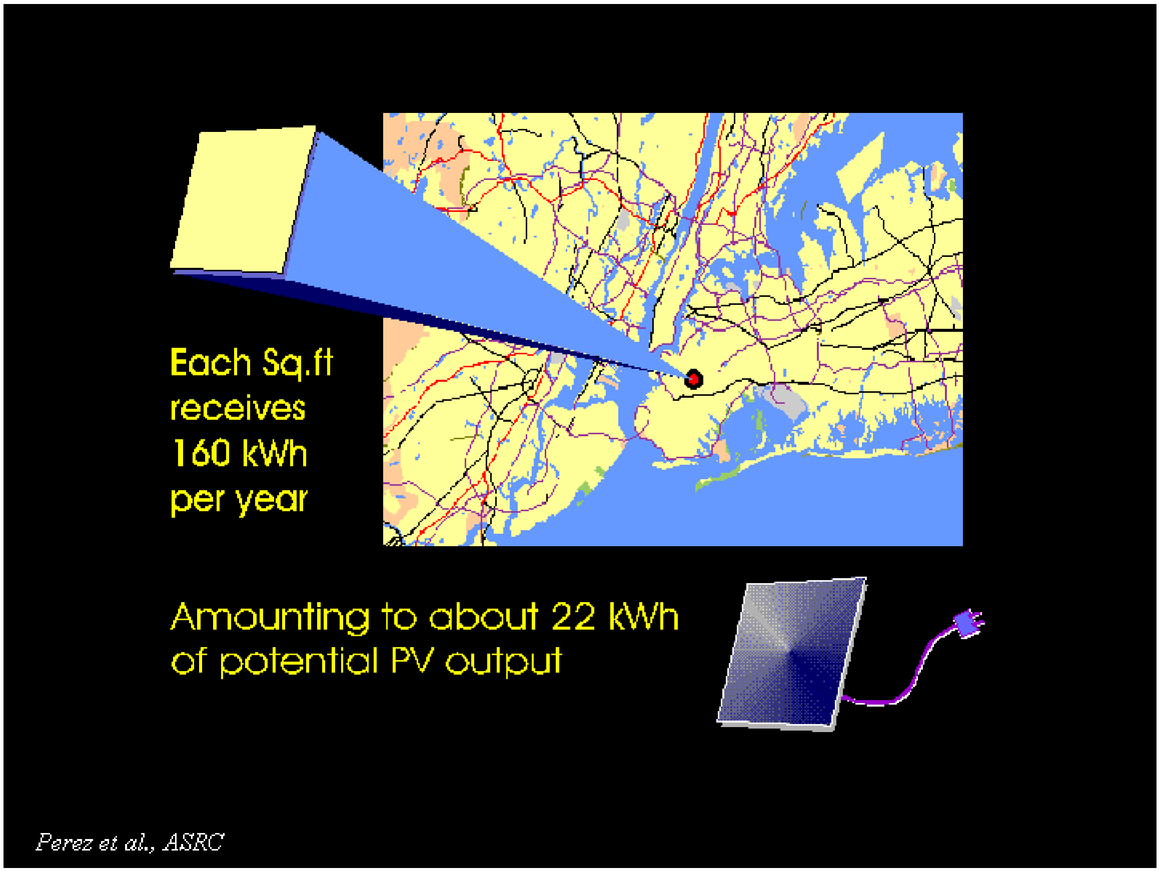
Solar energy is often perceived as “good for Arizona or Florida,” not for New York. This presentation shows that misconceptions about solar energy stand in the way of unique opportunities for clean energy solutions in New York State.



- NO SUN

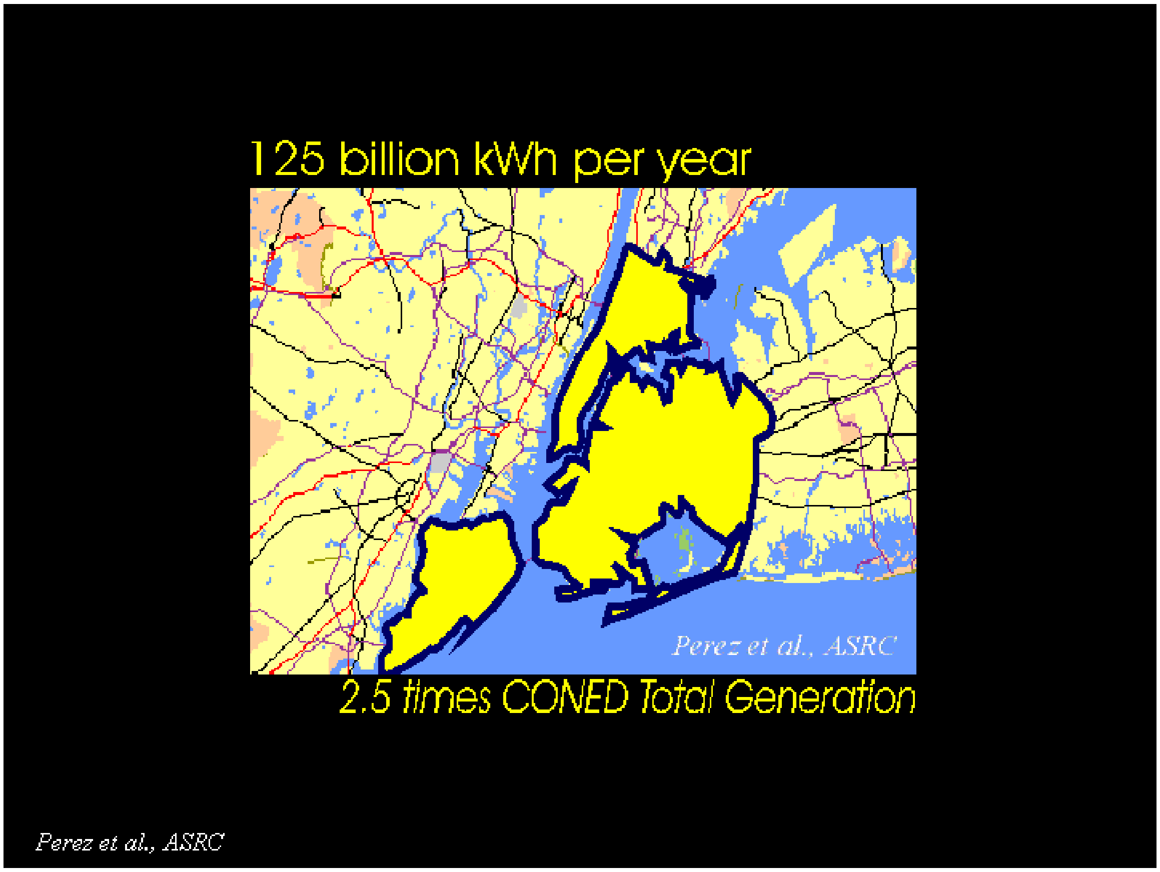
This climatic map of the continental US shows the amount of solar radiation received at the earth's surface. In fact, the difference in the solar energy collectable by a roof-mounted array is "only" about 35% between the southwestern U.S. deserts and downstate NY.



- NO SPACE

People often think that solar energy requires a lot of space. Misinformed news media often report that farmland and forests would have to make way in order deploy the technology.

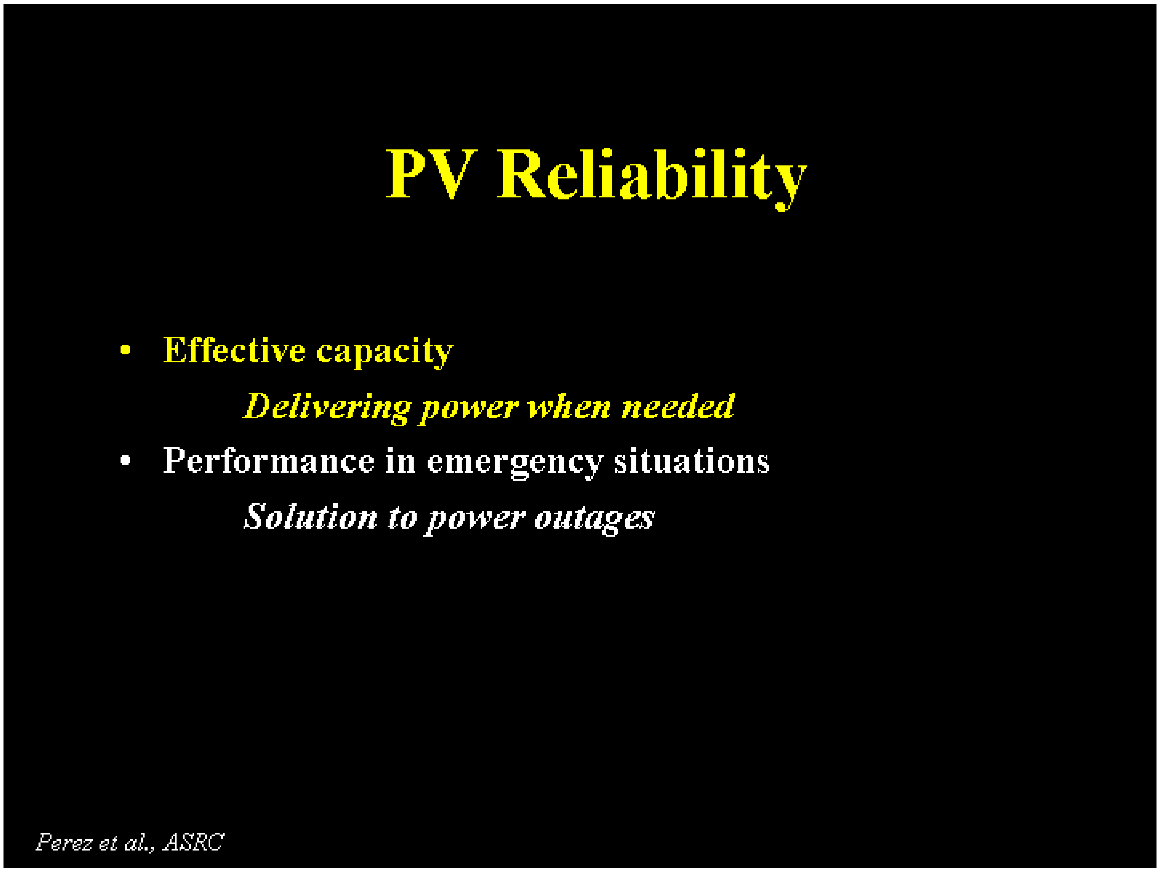
The facts tell otherwise. Solar resource is space-efficient. In NYC, each square foot of the Earth's surface receives 160 kWh of "raw" solar energy per year. Accounting for the sun-to-electricity conversion efficiency of a photovoltaic (PV) system, each square foot could yield 22 kWh's worth of electrical energy.



New York City acreage – the densest energy hub in the world – would yield 2.5 times more PV-generated electrical energy than today's total consumption. For the State as whole, the figure is greater than 100 to 1.

A substantial portion of NYC's acreage, e.g., commercial, industrial, and residential roofs, parking lots, and exclusion zones, could be used to deploy the PV technology.

The technology has evolved and is now ready for deployment in these different settings.

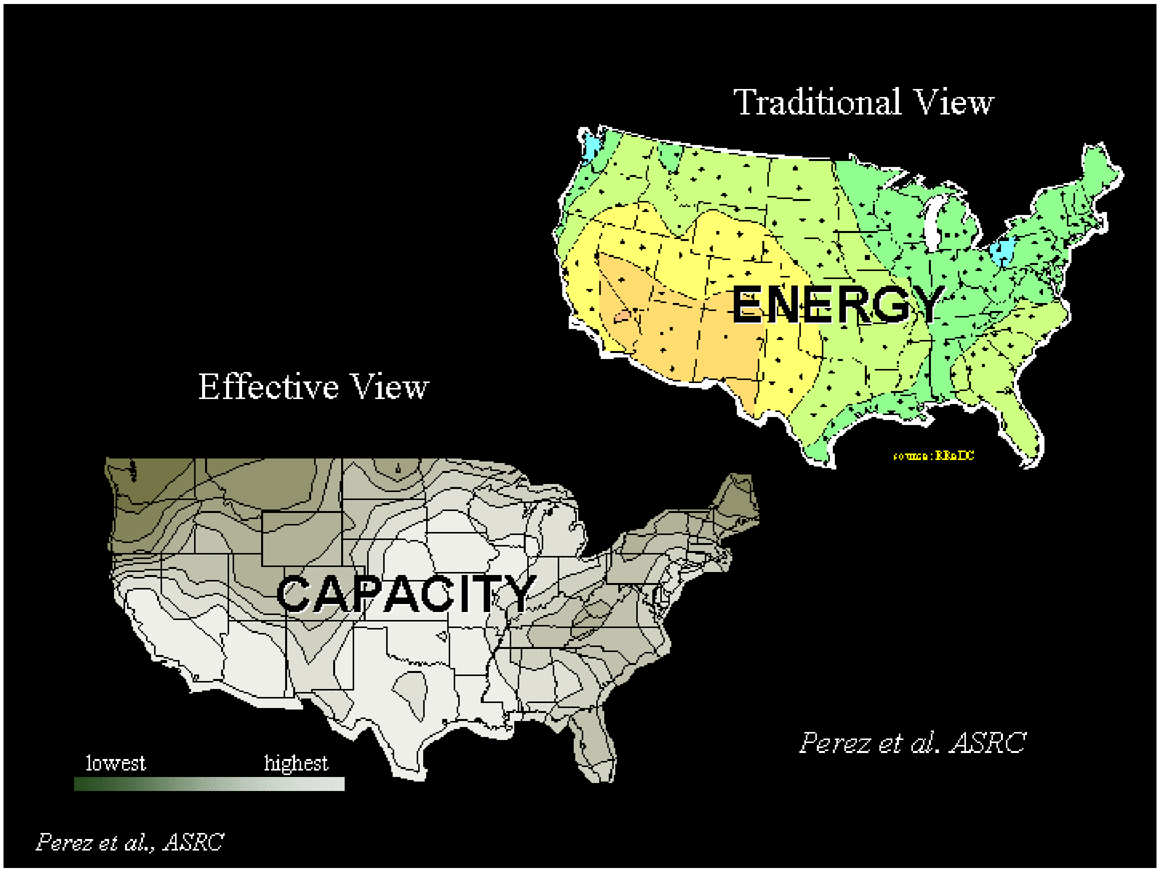


- NOT RELIABLE

A major ***perceived*** drawback of PV technology is that solar resource cannot be controlled or dispatched because it is constrained by clouds and the day-night cycle. As a consequence, the contribution that solar energy could make to increasing the available capacity of local grids has been underestimated.

In fact, the solar resource happens to be coincident with the maximum need for electrical power [peak loads] in large northeastern metropolitan areas. This is because peak loads happen in summer, driven by heat waves that are themselves associated with larger amount of sunshine.

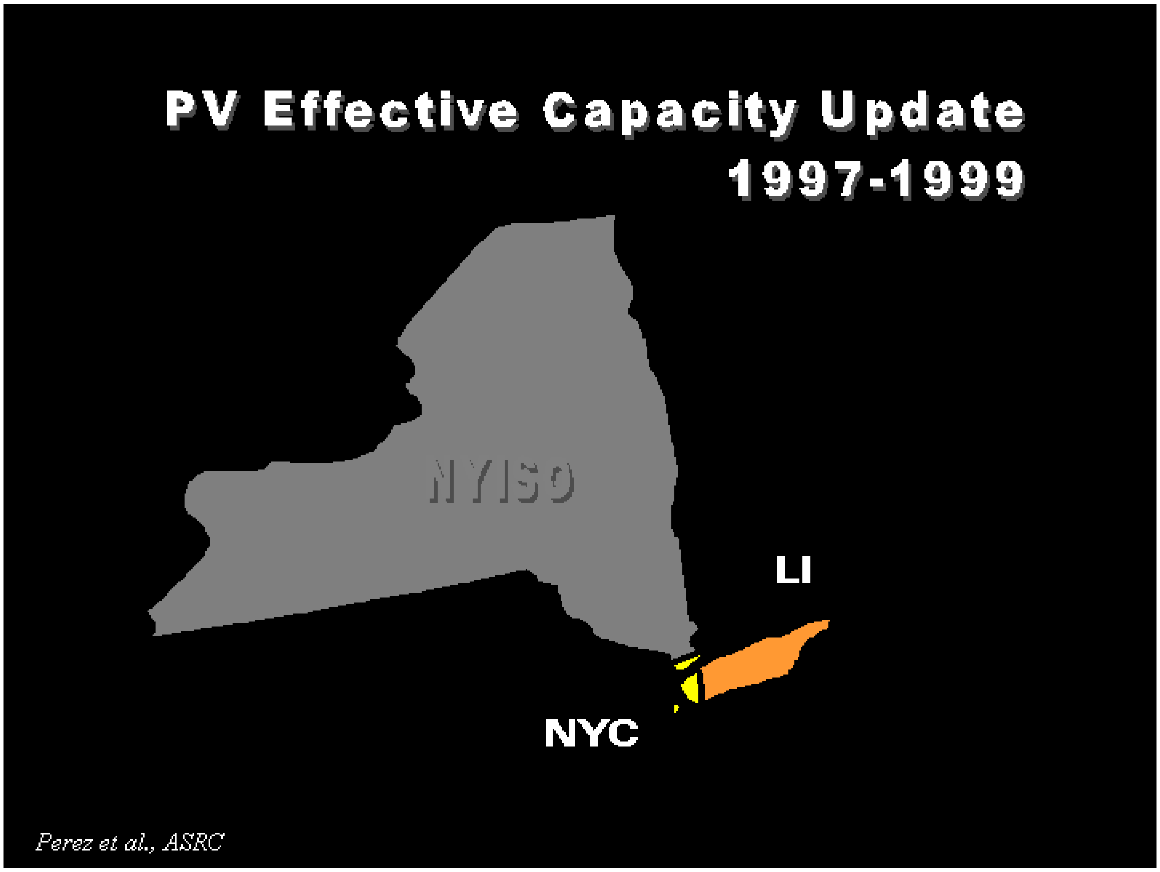
This attribute can be experimentally quantified by taking a look at the "effective capacity" of PVs.



A few years ago, analyzing load shape data for hundreds of U.S. electric utilities, the author and colleagues took a detailed look at the coincidence between the need for electrical power and the availability of the resource. An "effective solar resource" map was produced.

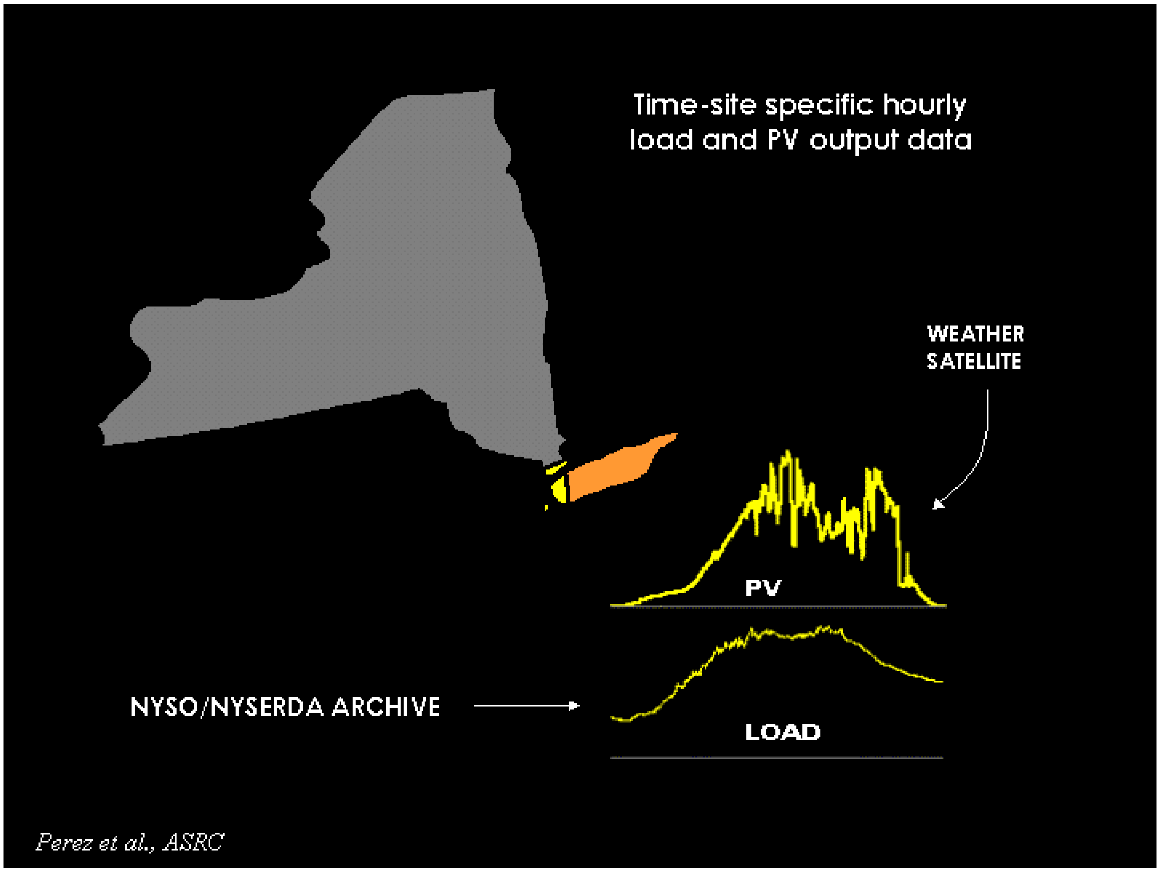
The features of this map are markedly different from the "traditional" climatic map. In particular, the map shows that the New York metro area scores near the top for coincidence of need and electrical power availibility.

(http://www.nrel.gov/research/pv/pv_util.html)



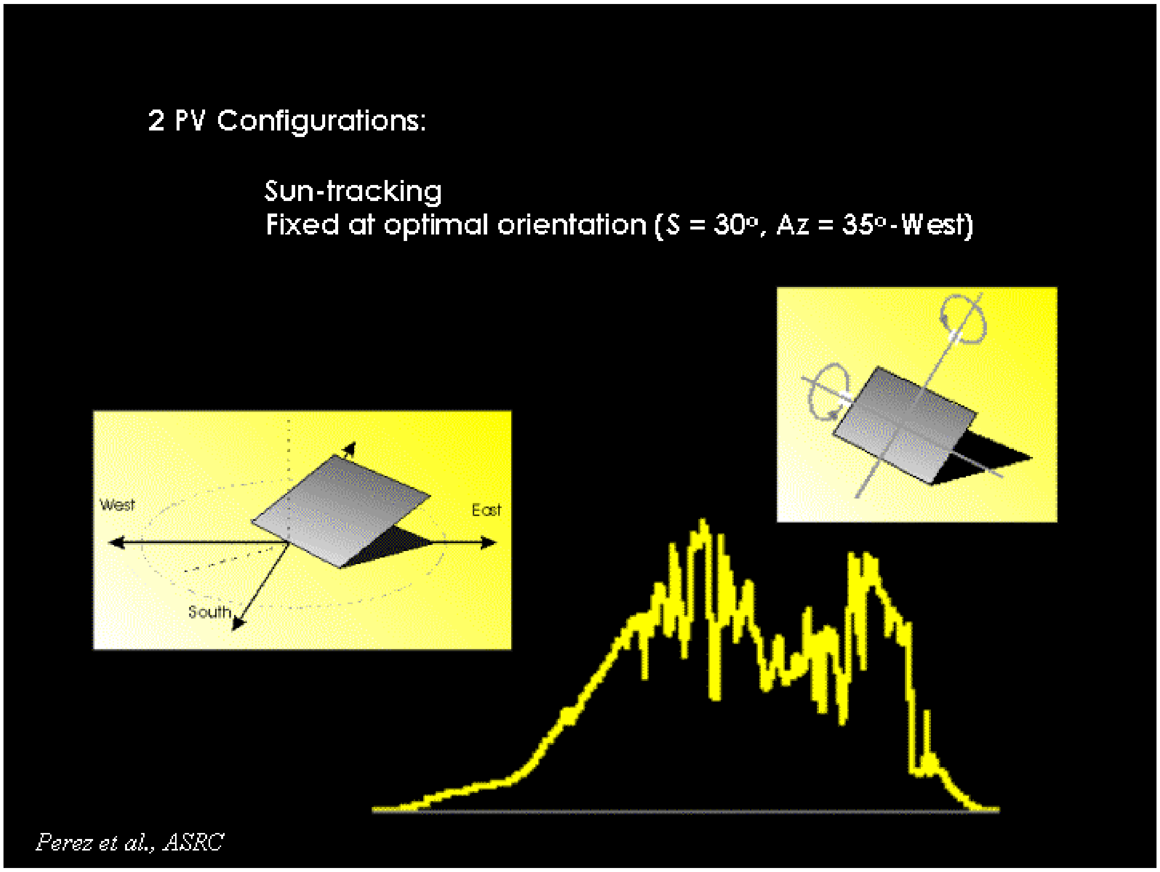
Last year, we took a detailed look at the effective capacity of PVs in downstate New York

Note: This project was funded in part by the New York State Energy Research and Development Authority (NYSERDA) and the United State Department of Energy (USDOE / NREL).

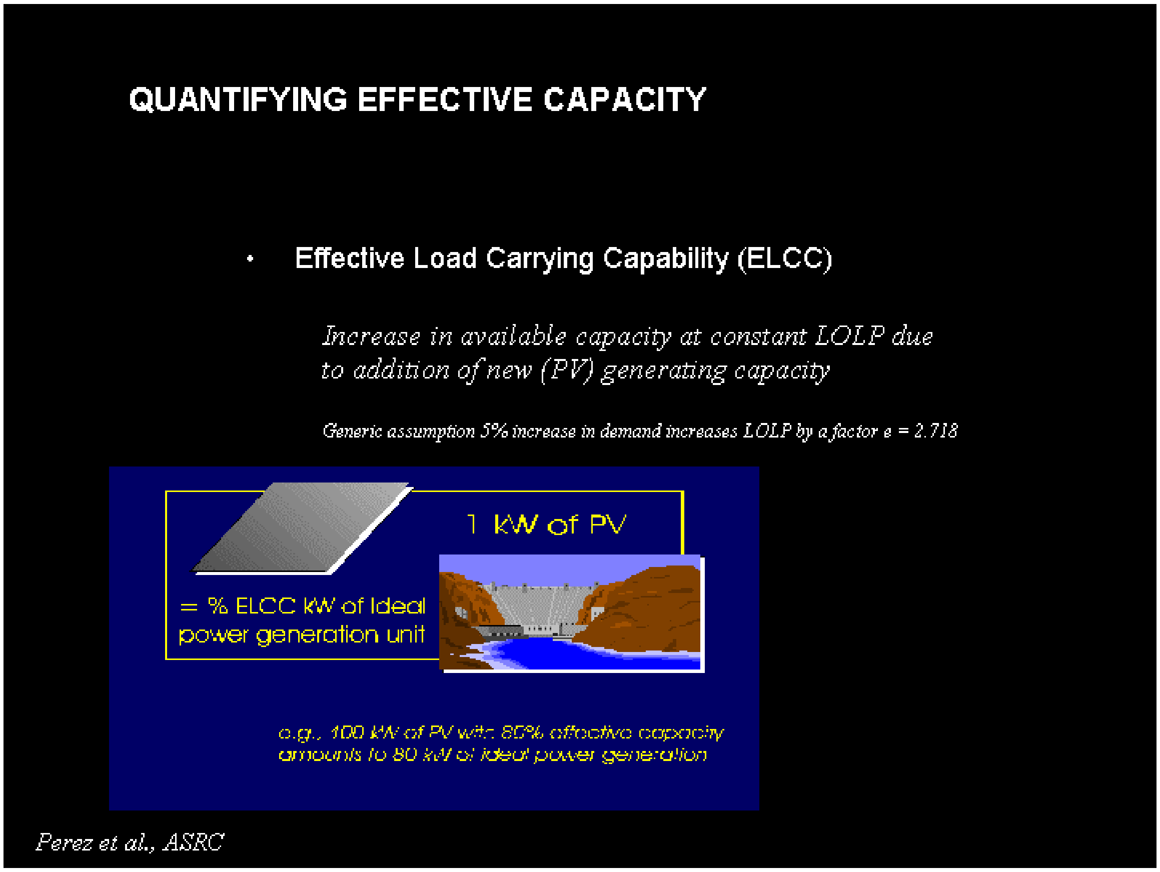


We looked at three years' worth of hourly load data and time-coincident solar resource data.

Note: *Time/site specific solar resource data were derived from weather satellite observation using a technique the author and his colleagues thoroughly validated and published. This technique lets us determine solar energy production at any point in time and space*.



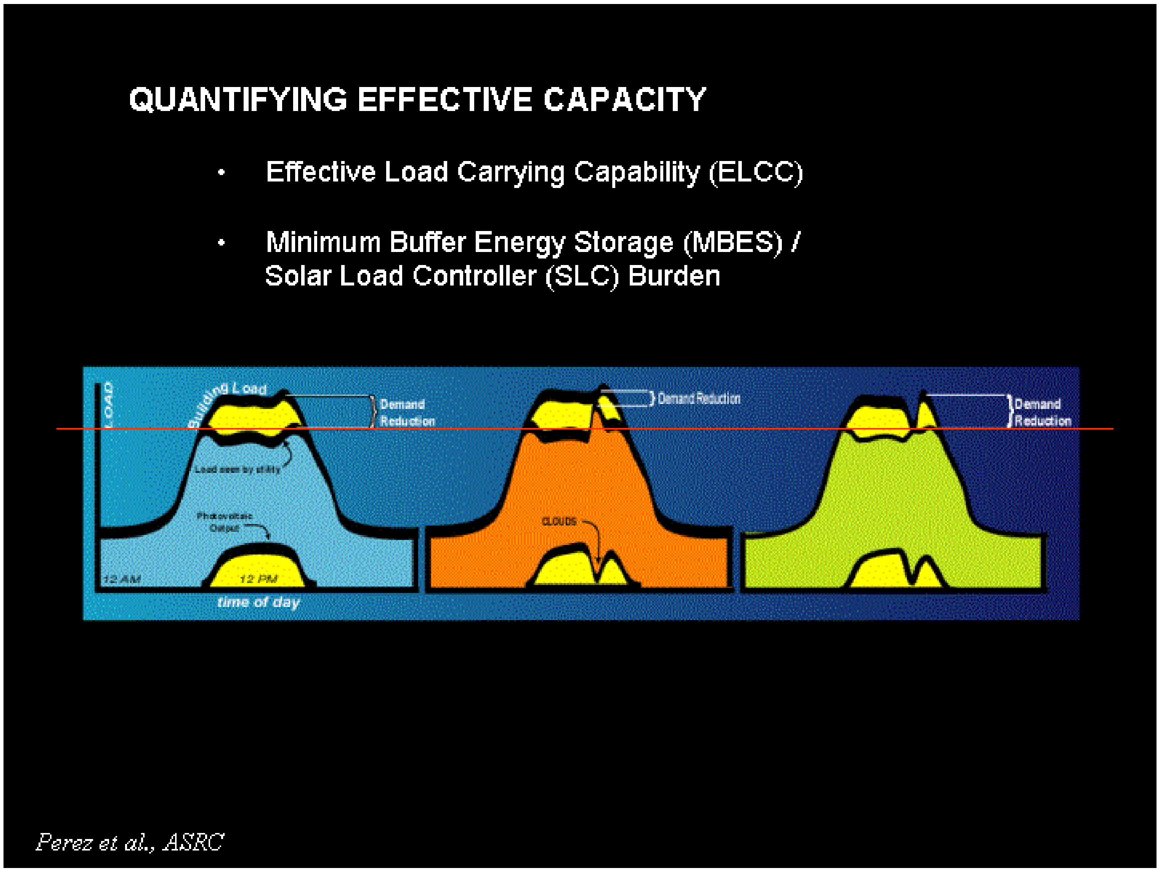
We considered two solar deployment technologies: (1) the ideal case: using sun-tracking solar arrays; (2) the practical case: using fixed solar arrays (i.e., the kind easily deployable on building roofs and other structures).



In order to measure the contribution PVs could make to a grid's available capacity, we used several complementary "yardsticks" to quantify effective capacity. The first of these measures is the Effective Load Carrying Capability (ELCC).

The ELCC is a statistical measure of capacity based upon the concept of "loss of load probability." In practice, the ELCC may be defined in terms of ideal resource equivalence.

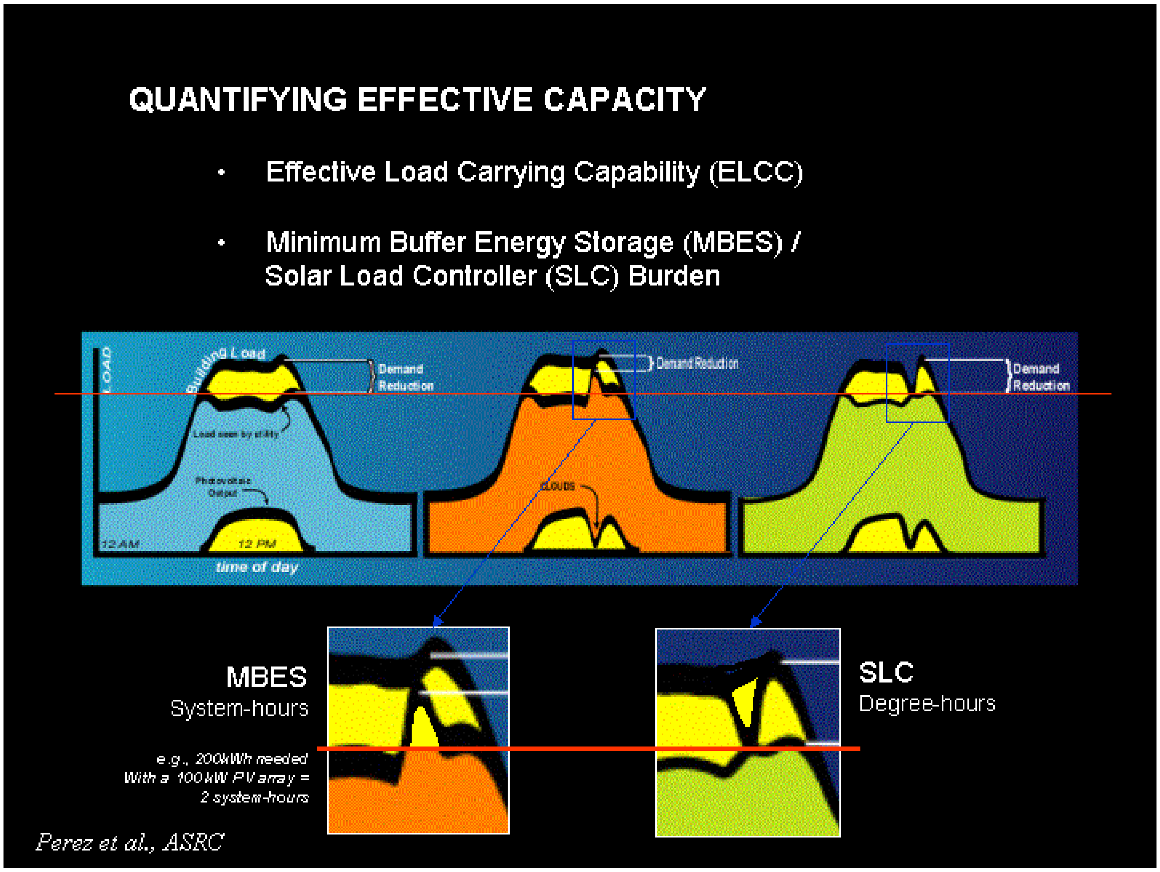
For instance, a 100 mW photovoltaic array has an ELCC of 60% when it adds the equivalent of 60 mW of an ideal controllable/dispatchable resource, such as an hydro power plant, to the grid's available capacity.



However, because the ELCC is a statistical measure that some may question, we define another yardstick that can be expressed either in terms of energy backup in the case of the minimum Buffer Energy Storage (MBES), or end-use load control in the case of the Solar Load Controller (SLC) Burden.

Assuming the worst case situation, this measure of capacity asks: What does it take, in terms of backup energy and/or load control, to guarantee that all loads above a given threshold are met by the solar resource?

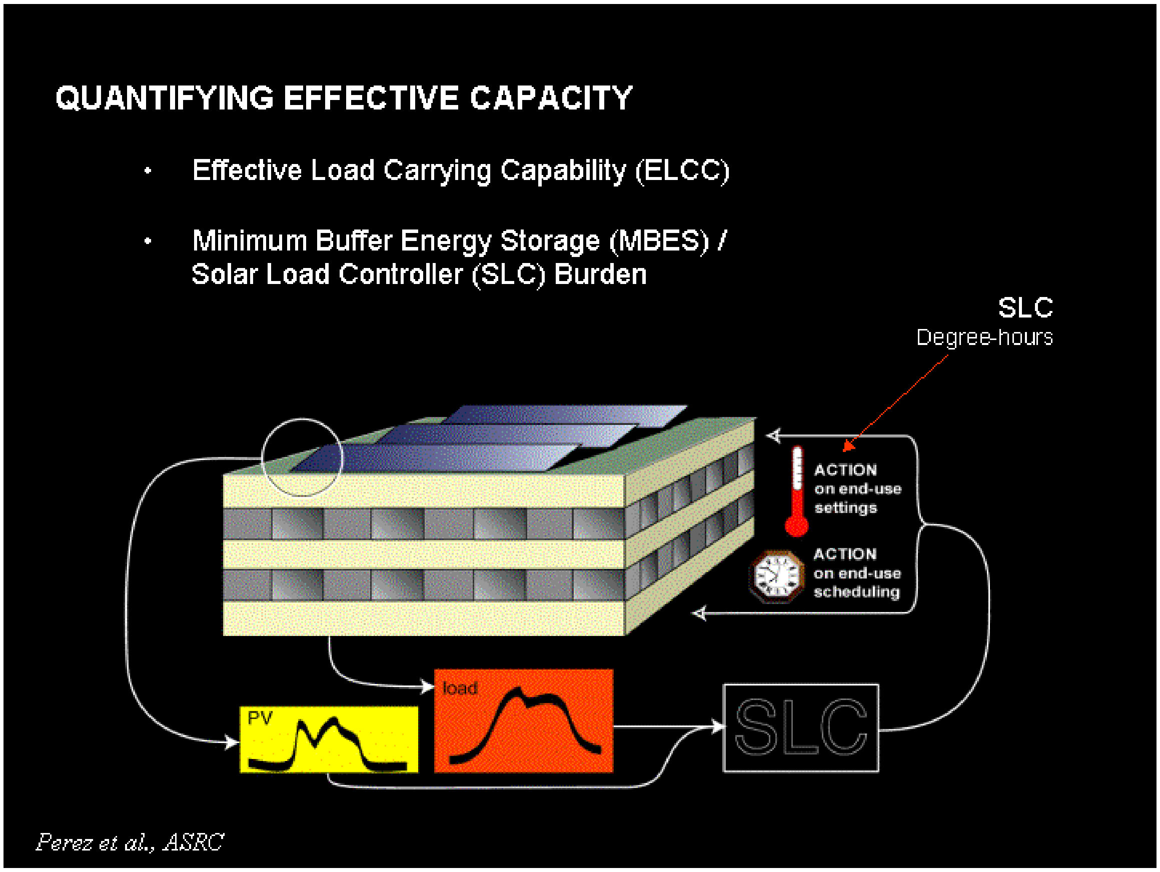
The left diagram represents the ideal case. The solar resource is in perfect match with the electrical load and displaces all the highest loads.



Sometimes conditions are not as ideal, so we looked at how much backup energy would be needed (middle diagram), or alternatively, how much end-use load control, i.e., consumption reduction, would be needed (right diagram), to guarantee that all resources above the red line are met.

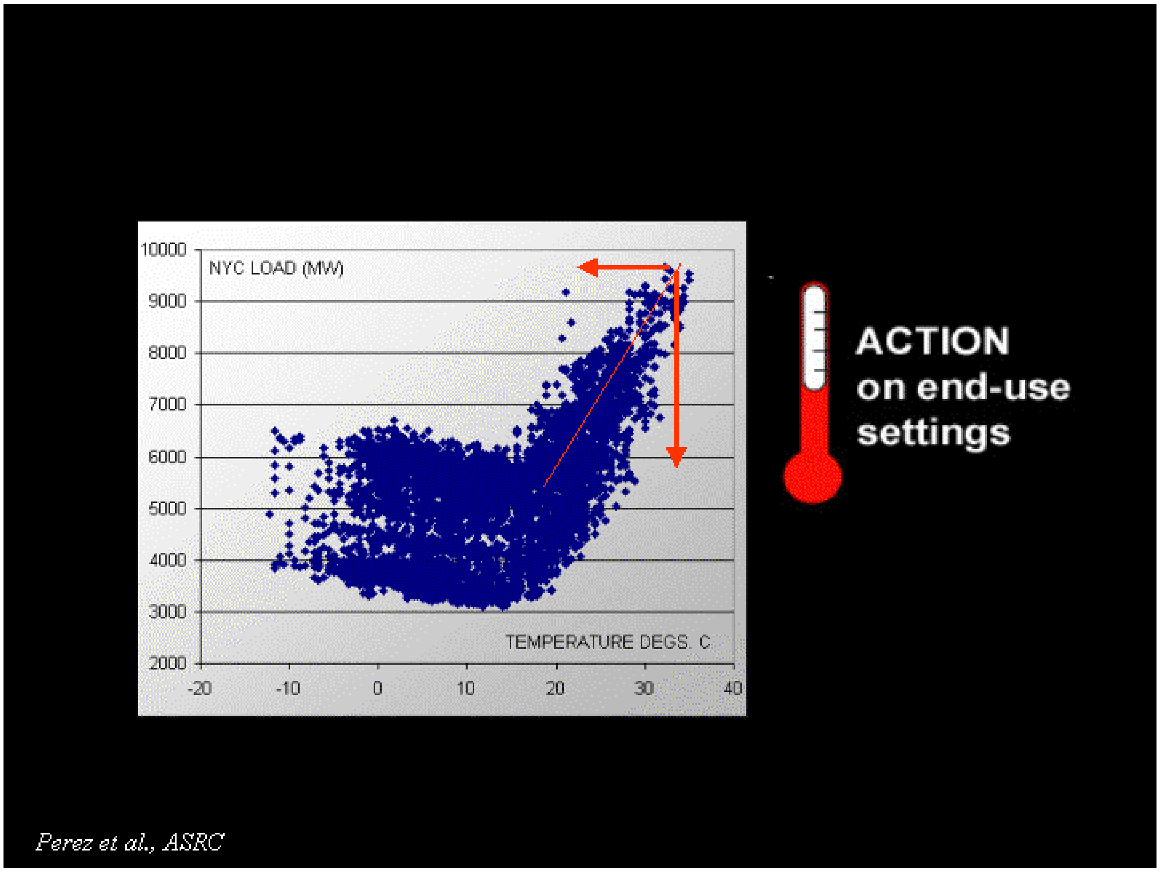
The unit for the MBES is “PV system-hour.” It is used to measure the required amount of reserve capacity of full PV system output. *Typically, one system-hour will add 10 percent to the cost of standardized a PV installation.*

One possible unit for solar load control (SLC) is “end-use cooling degree-hour” of user discomfort. Thus, 3 degree-hours represent 1 degree end-use temperature increase during 3 hours.

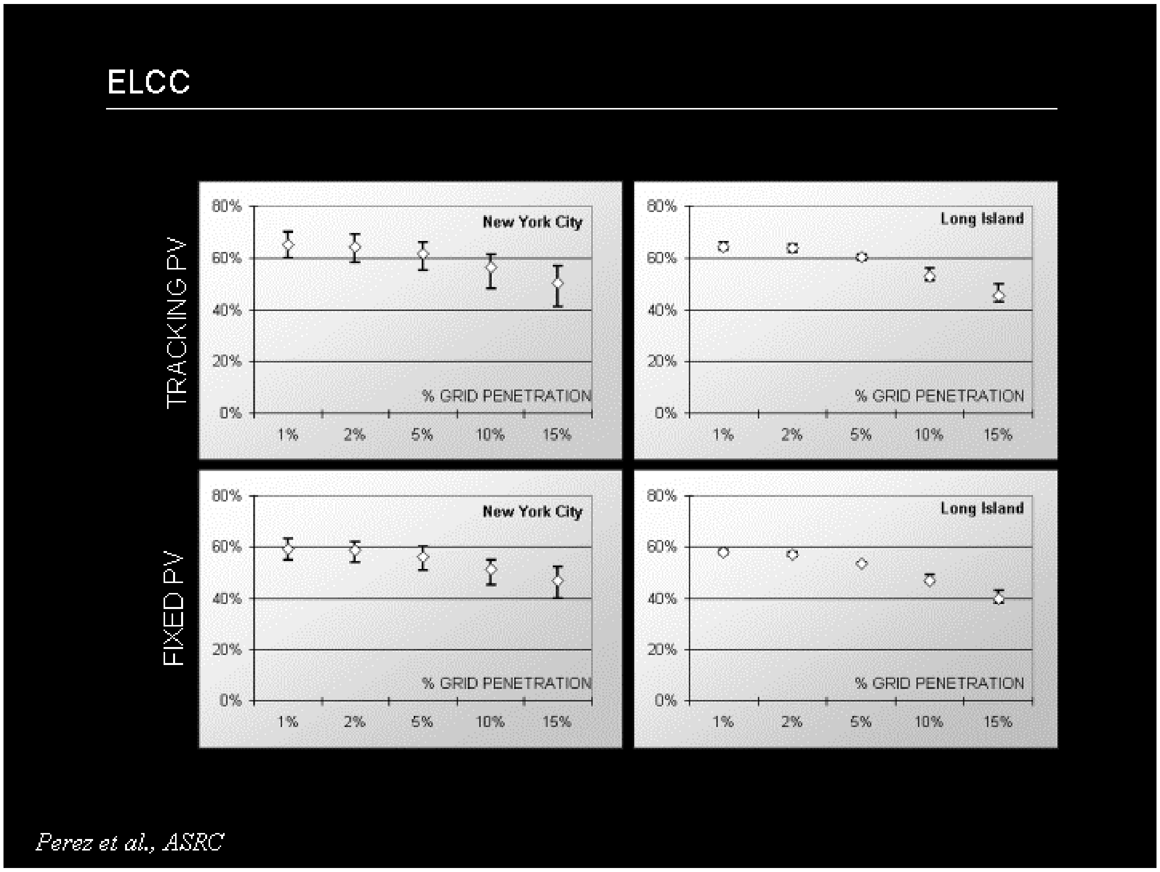


This slide illustrates how end-use load control could be implemented in response to local or regional PV output and load requirements.

For more details, see: http://lunch.asrc.cestm.albany.edu/~perez/slc/slc-paper.htm



End-use temperature-based load control would be particularly effective in a place like New York City. The diagram above illustrates one year's worth NYC hourly electrical loads as a function of ambient temperature. The right side of the diagram shows that the City's load grows as a function of cooling requirements. Hence, any action on these requirements via thermostat adjustment would have an impact on the load.

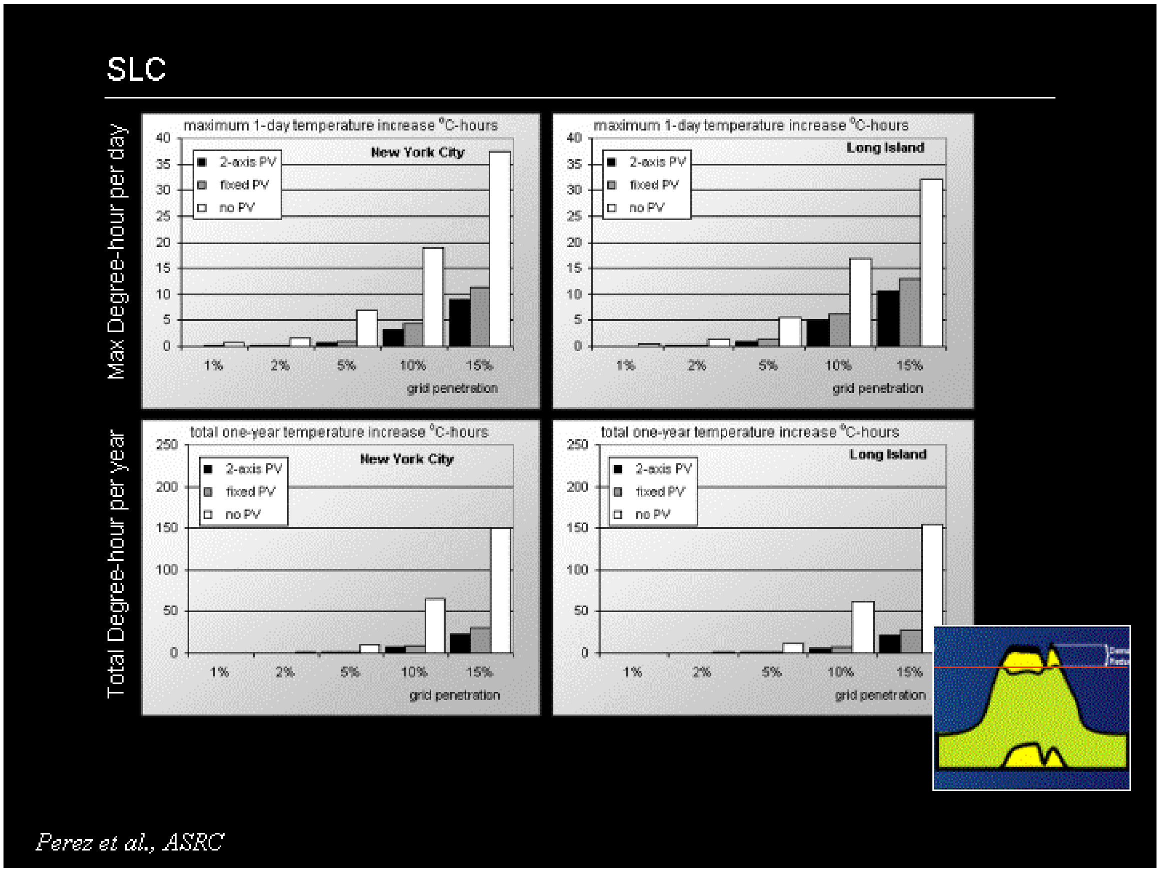


These diagrams show the results of our analysis of 1997-1999 load data in New York City (left) and Long Island (right) for the ELCC yardstick.

The top two diagrams correspond to the ideal sun-tracking PV configuration. The bottom two correspond to the practical fixed PV option. The Y-axis represents the percent ELCC as defined above. The X-axis represents the penetration of the PV resource on the considered grid. *Note that a 15 percent penetration on the NYC grid would represent ~ 1,500 mW*.

These results show that, at the considered penetration levels, the ELCC of PV is in the 50 percent to 60 percent range.

Thus, a 100 mW PV resource would be equivalent to a 50MW to 60MW ideal controllable resource.

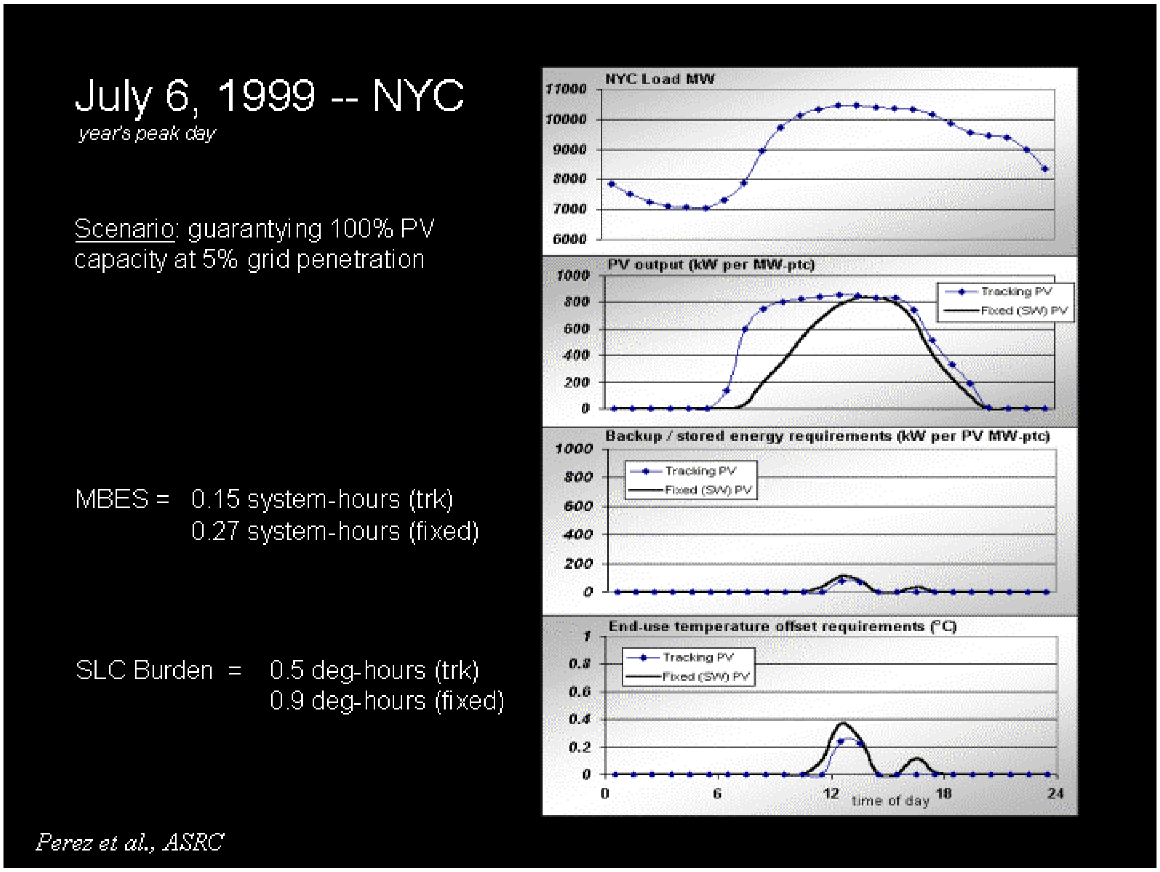


As above, the two left diagrams correspond to NYC and the right ones to L.I. The X-axis, again, represents PV penetration on the considered grids.

The top two diagrams represent the one-day amount of degree-hour discomfort (degree Celsius) on the worst day of the summer cooling season during the 3 years of analysis. The two bottom diagrams represent the total amount of degree-hour discomfort during the entire cooling season.

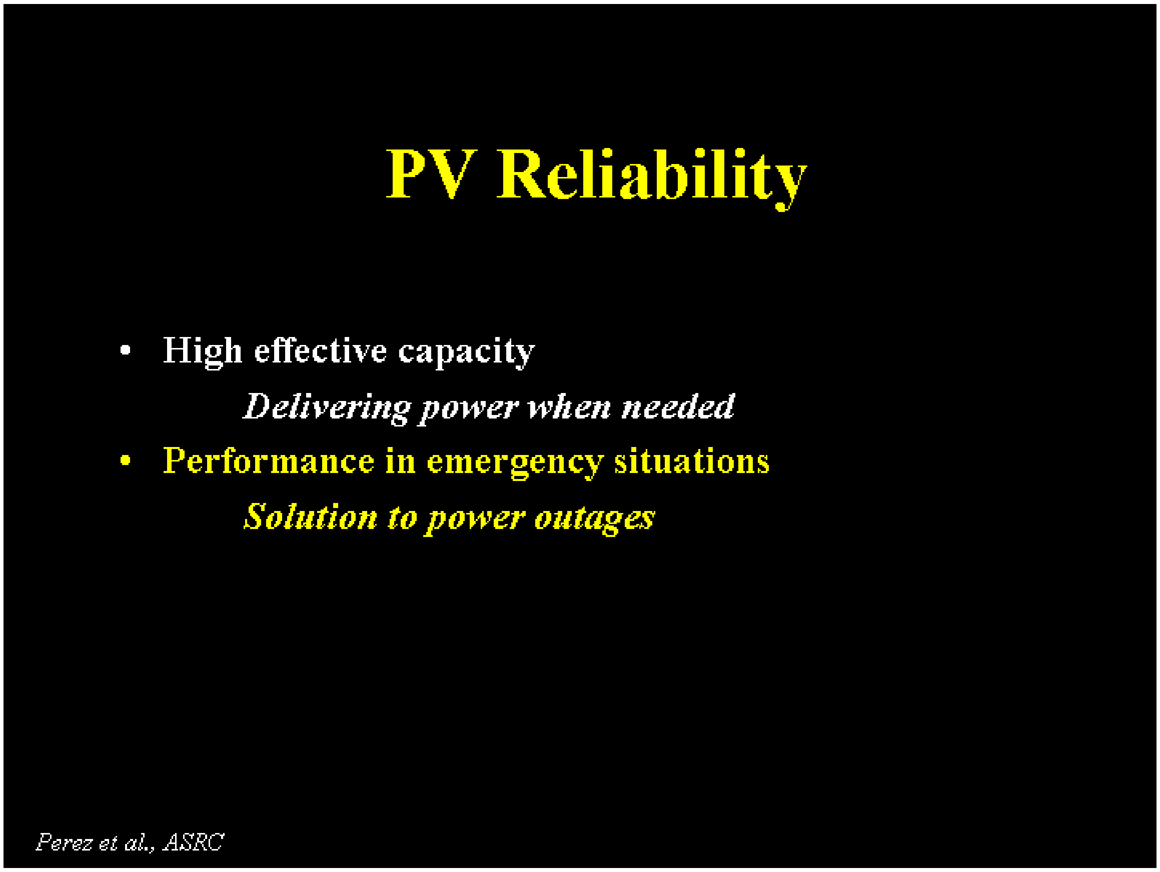
The black columns correspond to the ideal sun-tracking PVs; the gray columns represent the practical fixed PVs; and, the white columns represent the amount of discomfort necessary to accomplish the same peak-shaving job without PVs.

Taking the case of NYC at 10 percent PV penetration (i.e., assuming the 1000 mW top loads in the City are to be met by PV), these results show that it would have taken fewer than 10 degree-hours of discomfort during the entire summer to guarantee the equivalent of 100 percent reliability from the deployed PV installations.

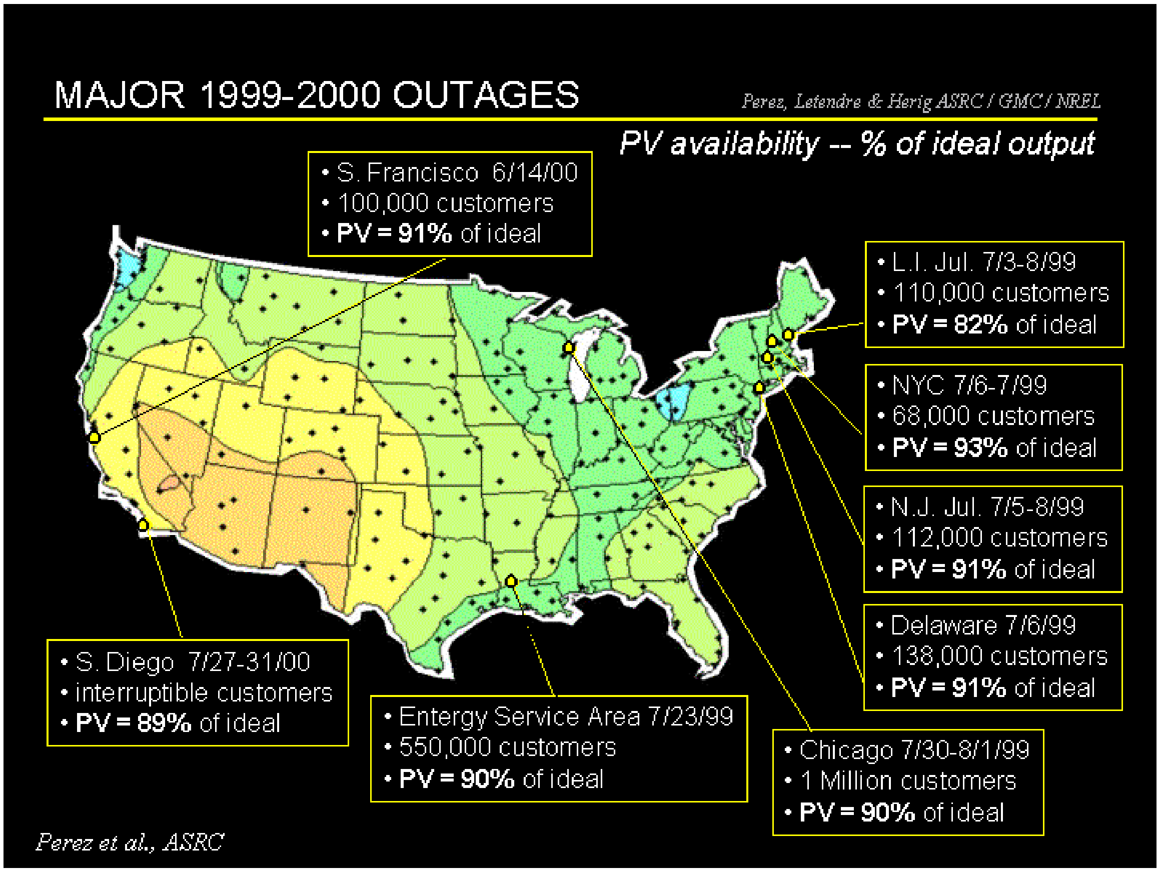


This diagram is an illustration of the most extreme load day in NYC on July 6, 1999. The grid was particularly stressed with heat and high energy transfers on that day, leading to the collapse of localized distribution systems. The top diagram represents the City's load shape on that day. The second diagram shows that the amount of solar resource was almost ideal on that day.

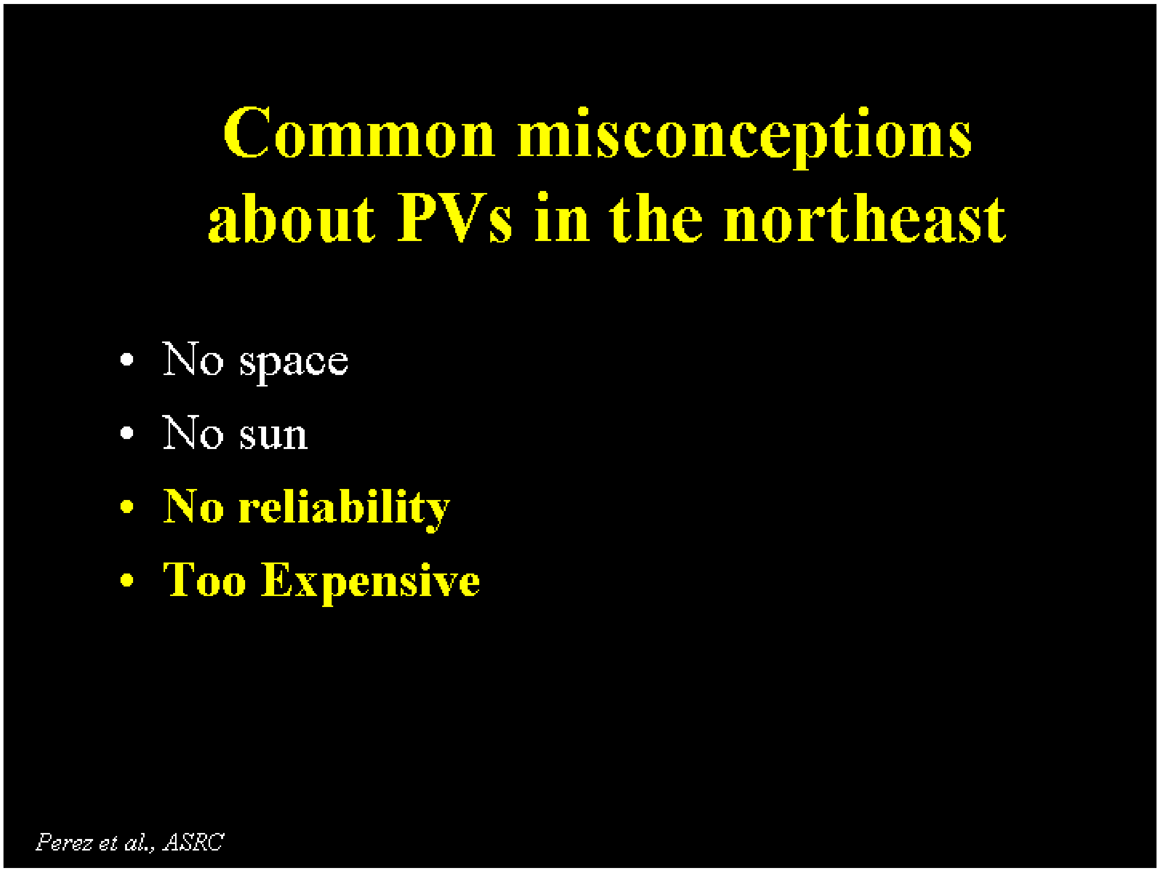
The third and fourth diagrams, respectively, show how much energy back-up, or end-use temperature discomfort would have been necessary to guarantee that the City's load be reduced by 100 percent of the rated PV output. For the considered 5 percent PV penetration level, this could have been achieved with a maximum user discomfort of 0.4 degree Celsius lasting for about 3 hours.



Another measure of PVs' reliability is to take a systematic look at all instances of high grid stress: rolling blackouts or local distribution failure situations.

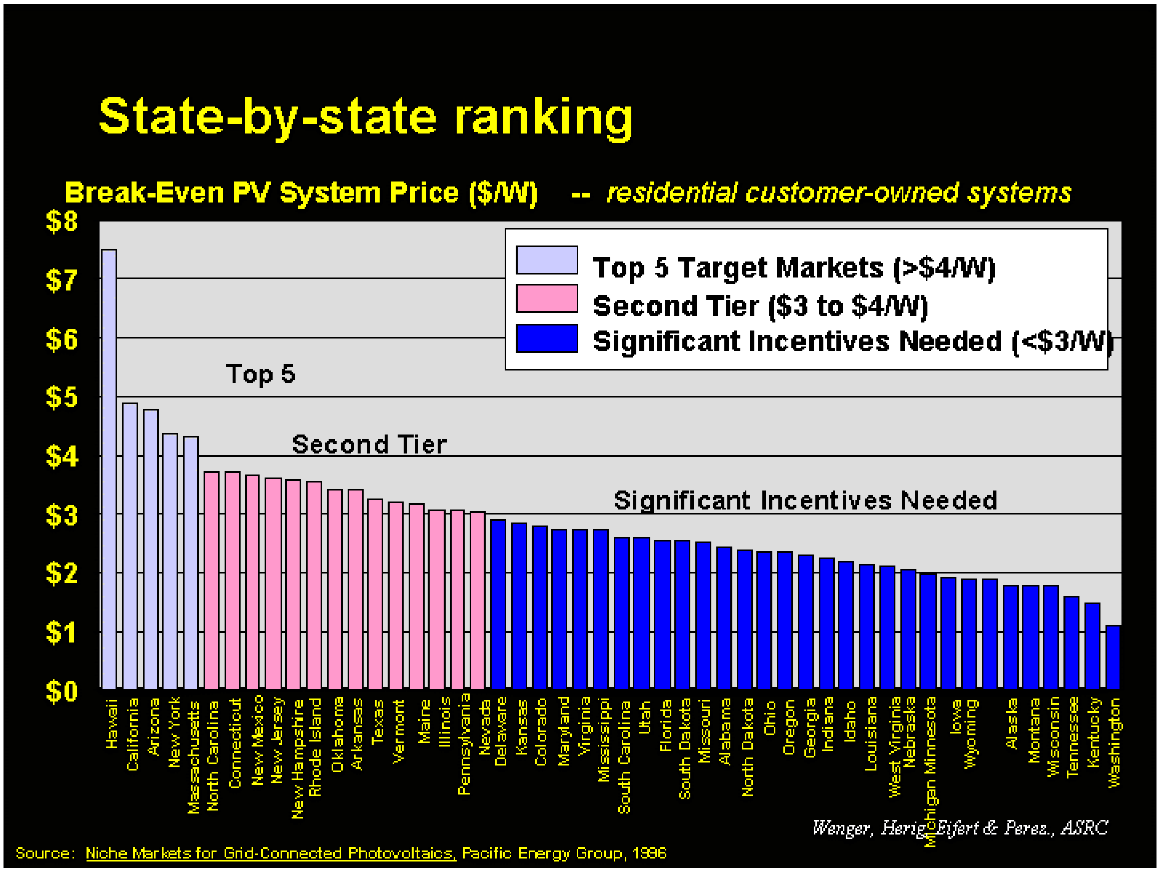


This diagram shows that, during all instances of heat wave-driven grid stress situations in the country, the availability of the solar resource was nearly ideal. The most recent data from 2001 fully confirm this observation (as of 6/20/01).



- TOO EXPENSIVE

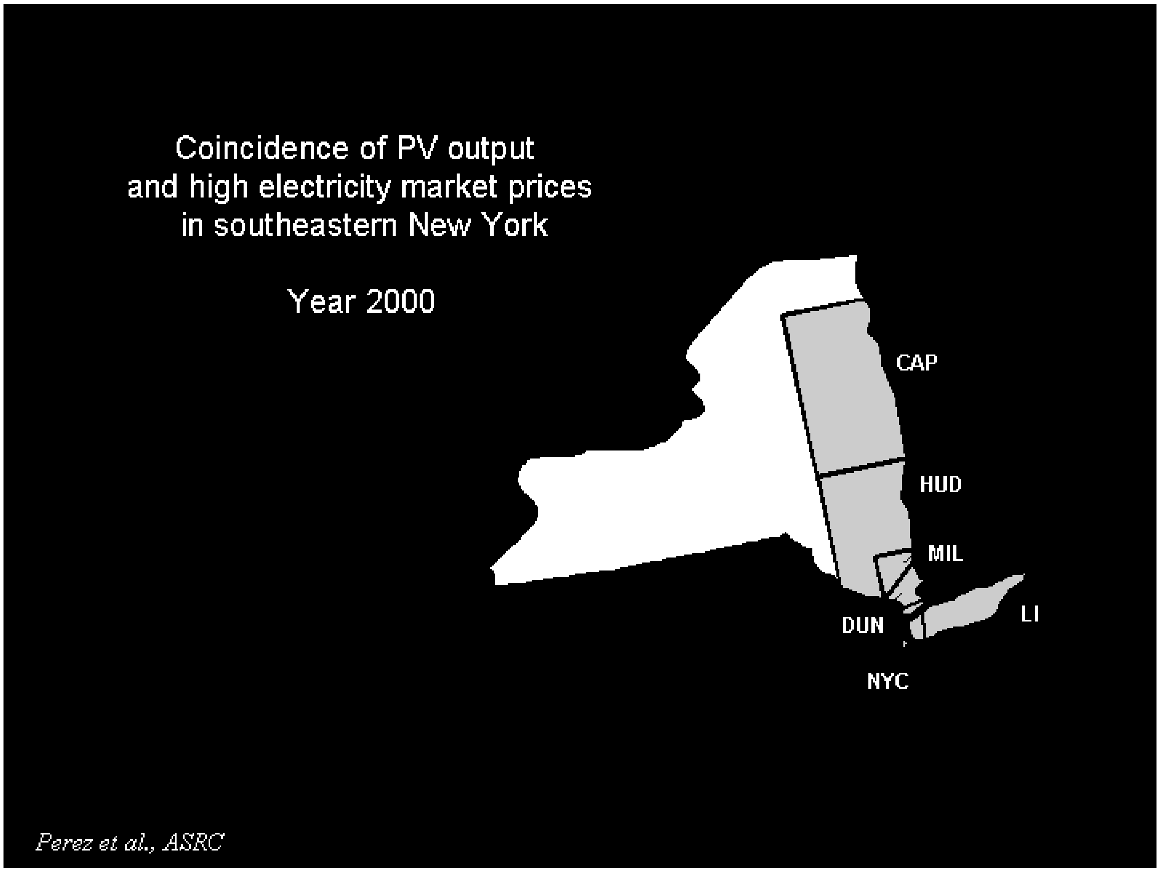
The final common perception about PVs is that the resource is too expensive for New York. Although the resource is expensive in absolute present terms, it may be one of the least expensive long-term options available to us, considering all indirect, still intangible (environmental, fuel depletion, etc.) costs elements. In relative terms, New York offers some of the best economic environments for the deployment of user-sited PVs.



A few years ago, we took a look at the economic feasibility of residential PV installations (http://lunch.asrc.cestm.albany.edu/~perez/niche-market-1/nichepv.pdf). Because of a combination of adequate solar resource and high retail rates, we found that New York ranks among the best states for economic feasibility, on par with California and Arizona.

In fact, today, given available incentives, a downstate residential system, purchased via a mortgage or a home equity loan, would be slightly profitable.

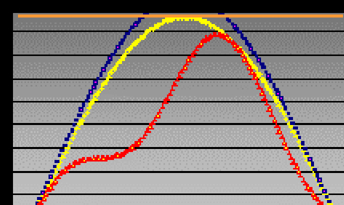
See economic engines at: http://www.sunwize.com/default.htm; or,
http://www.bpsolar.com/4th-Section.html



Another way to assess the value of PV electricity is to look at its availability during instances of high market prices.

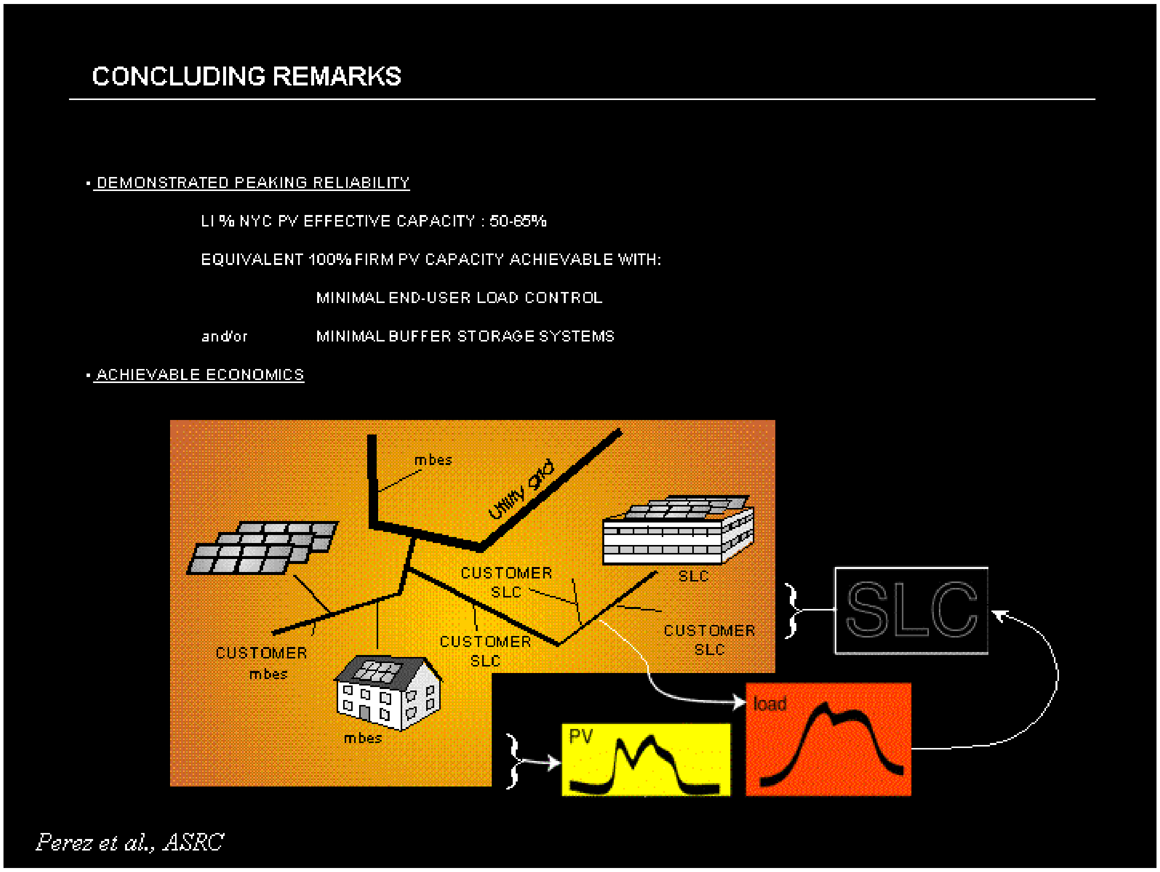
Average PV availability for all day-ahead prices > $150/MWh

	LI	NYC	DUN	MIL	HUD	CAP
%ideal day output	88%	82%	88%	79%	76%	65%
average energy output kW/MW	702	652	694	631	616	513
value PV / value ideal source	73%	66%	72%	67%	59%	47%



Perez et al., ASRC

Every time Independent System Operator (ISO) prices exceeded $150 per mWh during the year 2000, the average output of PV arrays was 88 percent of the maximum possible clear day output on Long Island.



The main message from this presentation is that dispersed PV resource, producing power near or within consumption pockets, can constitute a reliable solution for meeting growing peak loads in downstate New York. Dispersed PVs, assuming many forms (residential, commercial roof tops, parking lots, dedicated field-mounted arrays, etc.) could provide reliable peak time power. Together with a very small amount of backup (battery or other) and/or load management, the grid reliability of PVs could be guaranteed at 100 percent.

The resource is clean, environmentally acceptable, renewable, and is reaching breakeven point economically (for demand-side systems). However, price, regulatory, and infrastructural barriers remain an issue, together with public education. These issues are addressed with much success in Germany and Japan. In the U.S., the Sacramento Municipal Utility District (SMUD) in California has demonstrated large scale deployment of affordable PVs. SMUD has already deployed thousands of PV systems. There is high customer demand for many more systems. One of the ingredients of its success is standardized system deployment.

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