

# Long term trends in solar and wind energy

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\* **Full disclosure:** Akamai Technologies of Cambridge, MA pays me as a statistician and quant, but the opinions and observations expressed here are *just mine*.

## Energy trends ...



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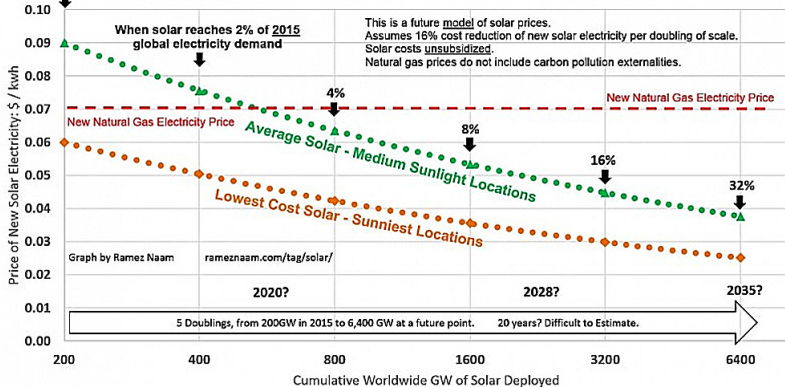




<http://rameznaam.com/2015/10/14/how-cheap-can-energy-storage-get/>

**2015: Solar is 1% of global electricity**

## How Cheap Can Solar Get?



## Suppose I were to say ...

- Instead of paying 24¢/kWh for electricity,
- You could get it for 6¢/kWh for a 20 year lifetime,
- With a financial commitment of only 7 years?
- And that all this cost was *cost of money* ...
- With no recurring costs of generation or distribution for energy? (A very small amount of charge for “transmission”: \$6 per month in our case)

Suppose I were to say ...

Interested?

Suppose I were to say ...

- *But wait, there's more!*

## Suppose I were to say ...

- Suppose you could make money on the deal?
- For “40 quarters of generation” ...
- per [DOER Renewable Energy Portfolio Standard \(225 CMR 14.00\) FAQ](#) 29 July 2014
- Too good to be true?
- What’s the catch?

Suppose I were to say ...

- *Example for a 20 year lifetime of 10 kW 29 panel array ...*
- 16¢/kWh cost-of-money for 7 years ...
- ... and then 0¢/kWh cost-of-money for 13 years ...
- **So**  $\frac{7 \cdot \$0.16 + (20 - 7) \cdot \$0.00}{20} = \$0.056$
- \$56,220 avoided cost of energy over 20 years (if loan paid in 7 years)
- \$31,440 in SREC II 2016 earnings @ \$250/MWh for eligible 10 years (low ball)

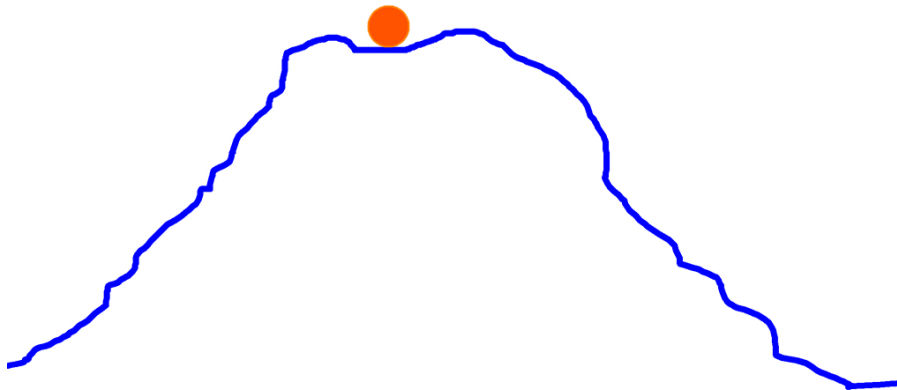
Suppose I were to say ...

Welcome to the energy revolution!

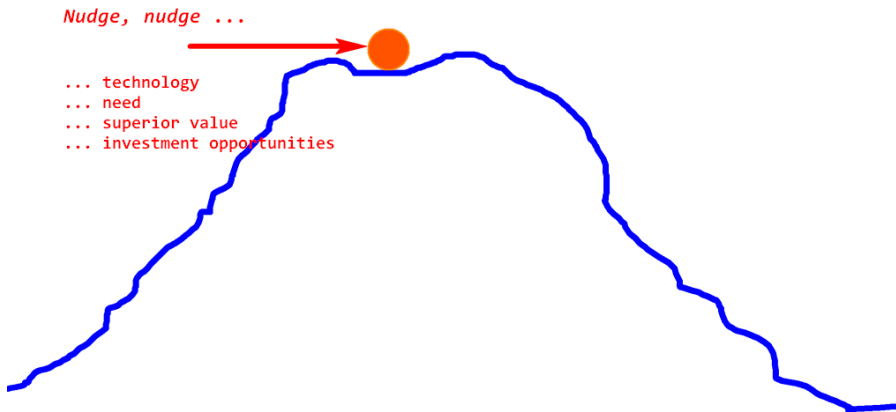
Remember, Solar PV is a *technology*,  
*not* an energy resource.

– Professor Tony Seba, Stanford University

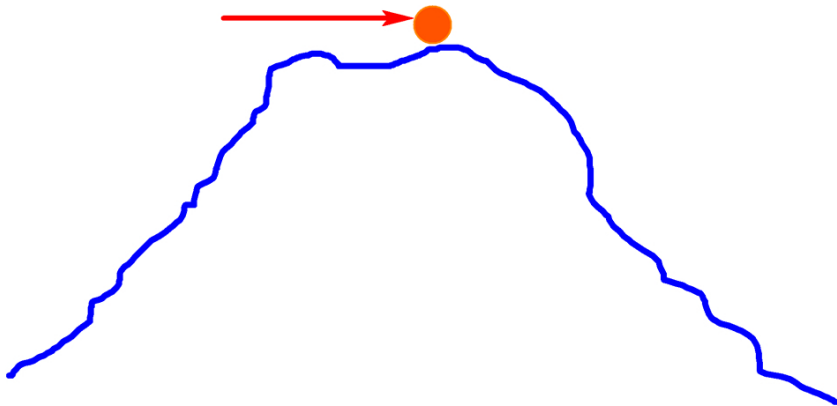
## Ball in a Depression at the Top of a Hill



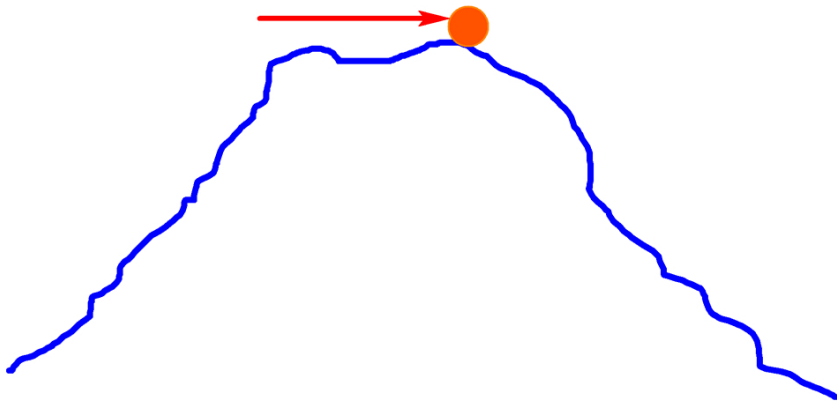
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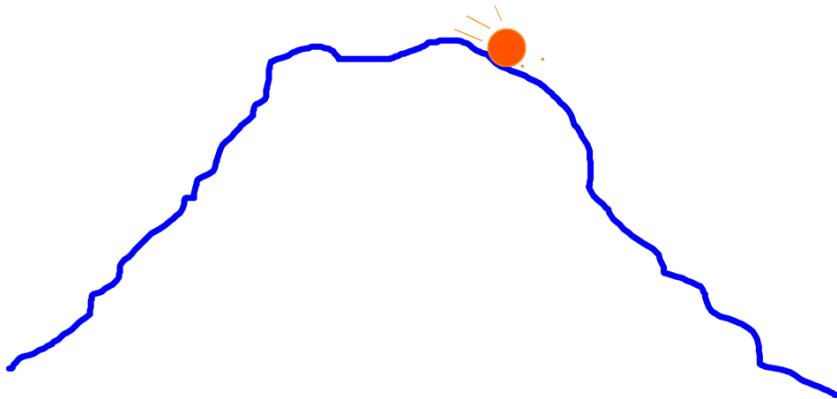
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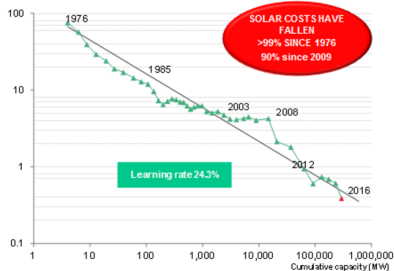


# Experience Curves (or “Learning Curves”)

## WIND AND SOLAR EXPERIENCE CURVES

Bloomberg  
NEW ENERGY FINANCE

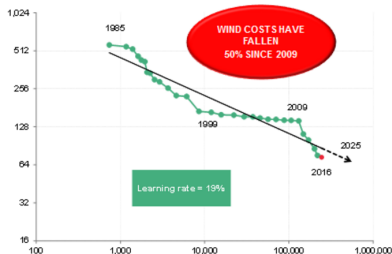
### SOLAR PV MODULE COST (\$/W)



Note: Prices are in real (2015) USD. 'Current price' is \$0.4/W

Source: Bloomberg New Energy Finance, Maybank

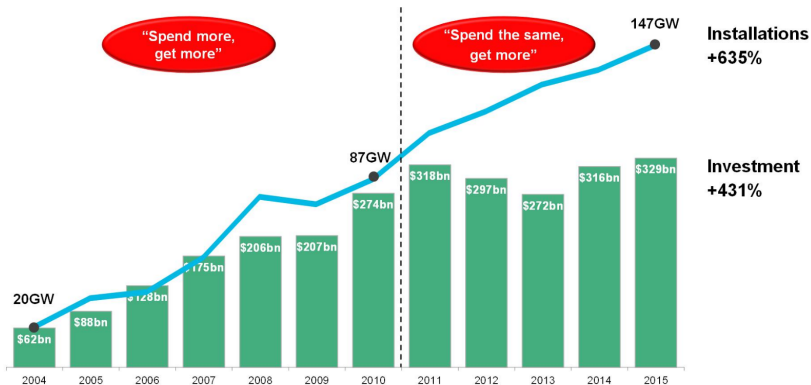
### NORTHERN EUROPE ONSHORE WIND LEVELISED COST (\$/MWH)



Note: Pricing data has been inflation corrected to 2014. We assume the debt ratio of 70%, cost of debt (bps to LIBOR) of 175, cost of equity of 8%

Source: Bloomberg New Energy Finance

# Solar Improves Even Without Additional Research Investment



## Wind and Solar Energy Technology are *different* ...

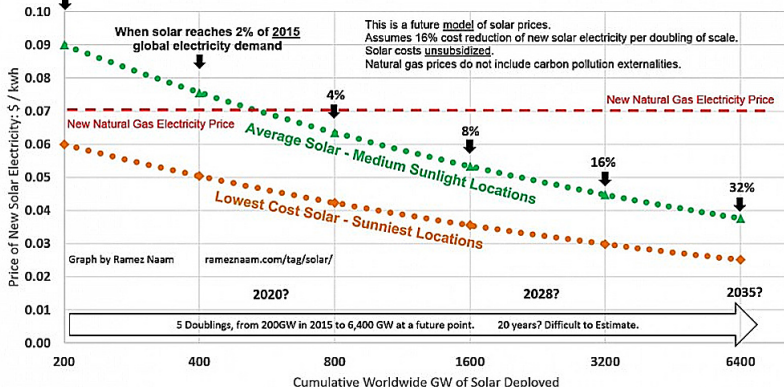
- “But what if the Sun doesn’t shine and the wind doesn’t blow?”
- There’s always a *third* component to consider: *demand*
- While it doesn’t strictly correspond, wind and solar generation line up with peak demands diurnally
- Managing wind and solar means covering that discrepancy
- Conventional energy solutions ignore demand during design, and are built to be always available, at huge capital and other inefficiencies
- These are sometimes called *Sankey inefficiencies*
- Energy storage has an important role to play

# Experience Curve for Solar

<http://rameznaam.com/2015/10/14/how-cheap-can-energy-storage-get/>

## How Cheap Can Solar Get?

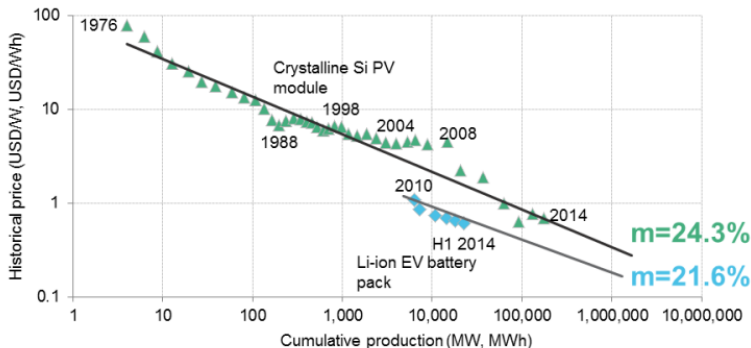
2015: Solar is 1% of global electricity



# Energy Storage

## LITHIUM-ION EV BATTERY EXPERIENCE CURVE COMPARED WITH SOLAR PV EXPERIENCE CURVE

Bloomberg  
NEW ENERGY FINANCE™



Note: Prices are in real (2014) USD.

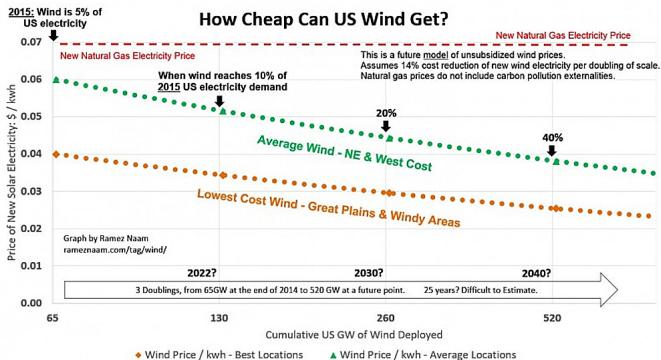
Source: Bloomberg New Energy Finance, Maycock, Battery University, MIT

Michael Liebreich, New York, 14 April 2015

@MLiebreich

#BNEFSummit

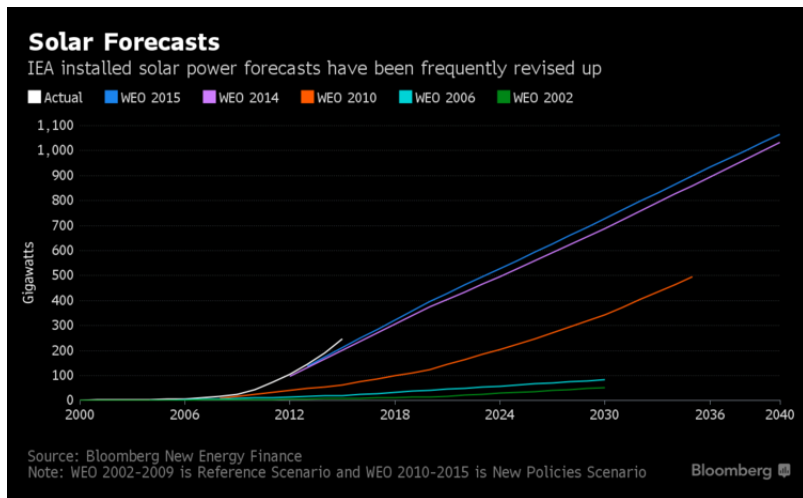
1



This can be important because onshore and especially coastal wind are *anti-correlated* with solar availability.

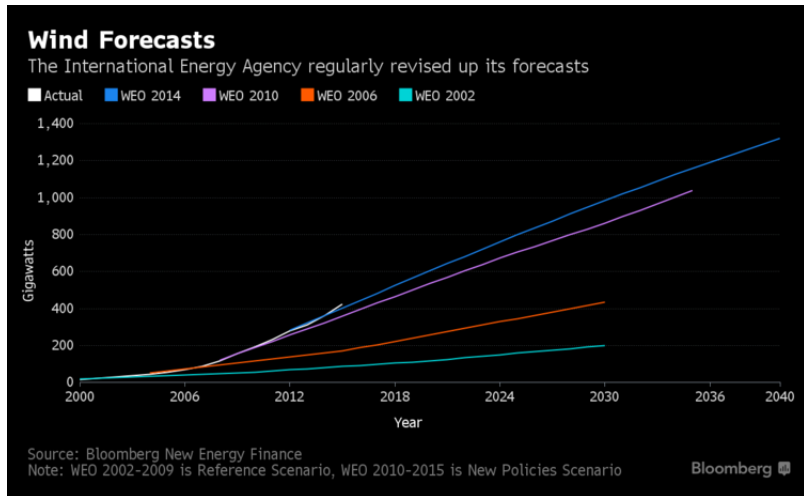
# Systematic *underestimating* of solar adoption

By energy agencies *and* utilities, at national and global levels



## Systematic *underestimating* of wind adoption

By energy agencies *and* utilities, at national and global levels



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- Such parity, expected in *2020*, is equivalent to:
  - Price per barrel of oil less than \$10 (Currently around \$50)
  - Price per 1000 cubic feet of natural gas less than \$5 (Currently \$8 to \$16, and swings widely)
- Oh, and by the way, the parity point against transmission for rooftop solar PV + storage is expected in 2022!

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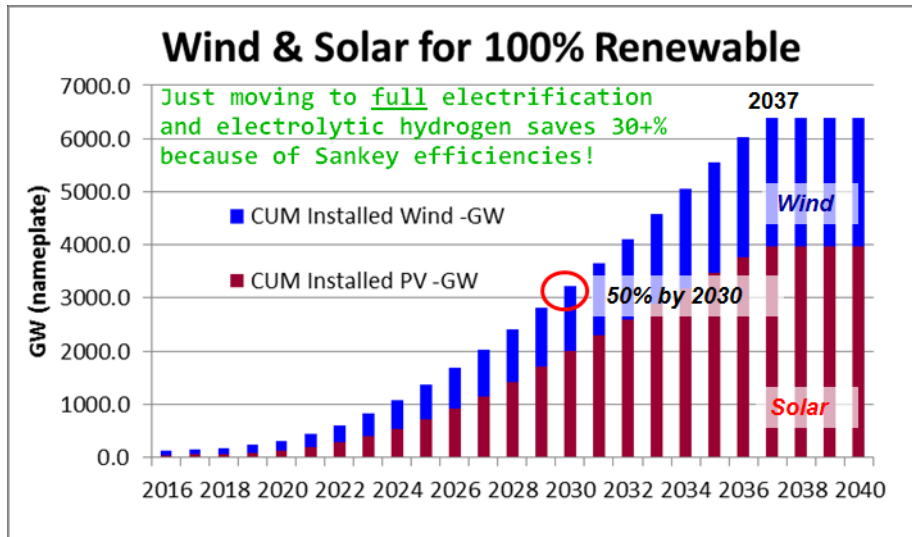
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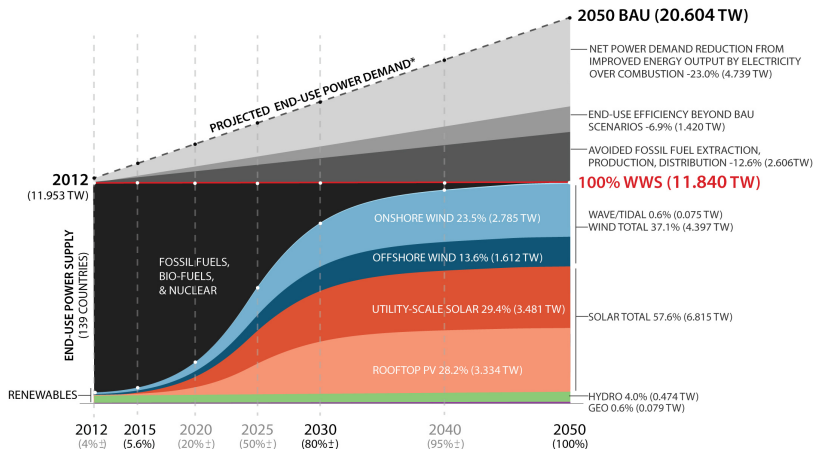
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- In fact, they exist *now*
- <http://www.solpad.com>

What could be, but may not be, at least not by 2030 ...



*For the world ...*



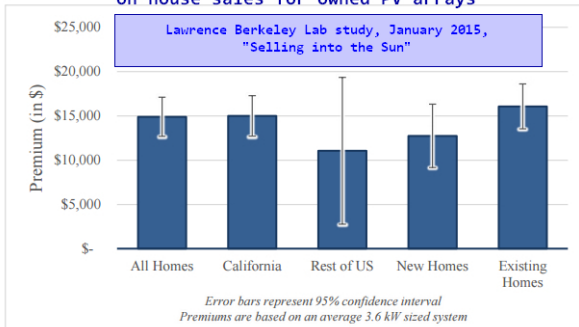
## Projected Energy Supply & Demand, 139 Countries

\*ENERGY FOR ALL USES (INCLUDING ELECTRICITY, HEATING, TRANSPORTATION, INDUSTRY)

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# Thank You!

**Figure 6: Estimated Premiums Based on an Average-Sized 3.6 kW System on house sales for owned PV arrays**



(End)