Re-considering the Economics of Photovoltaic Power

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INTRODUCTION

- Deals with the recent dramatic reductions in the underlying costs and market prices of solar photovoltaic (PV) systems, and their implications for decision-makers.
- To provide a measure of clarity and transparency to discussions regarding the present status and future potential of PV system economics.
- PV technology are receiving growing attention amongst key stakeholders.
- Current PV costs and the associated market and technological shifts witnessed in the industry have not been fully noted by decision-makers.
- Hard to gain a coherent picture of the shifts occurring across the industry value chain around the world.
Reasons:

1. Rapidity of cost and price changes.

2. The complexity of the PV supply chain which involves a large number of manufacturing processes, the balance of system (BOS) and installation costs associated with complete PV systems.

4. Perceived inadequate supply of raw materials.

3. Differences between regional markets within which PV is being deployed.
High costs of PV in comparison with other electricity generation options have until now prevented widespread commercial deployment.

But now the situation is changing because

1. Dramatic reduction in cost of PV modules.
2. Environmental concerns.
3. Increasing costs for some generation alternatives.
4. Large drops in solar module prices have helped spur record levels of deployment, which increased 54 percent over the previous year to 28.7 GW in 2011. This is ten times the new build level of 2007.
Confusion in economics of PV arise because of the way the PV prices are perceived.

Primarily, this has been done using three related metrics, namely:

1. The price-per-watt (peak).
2. Capital cost of PV modules.
3. The levelized cost of electricity (LCOE).
4. The concept of ‘grid parity’.
DRAMATIC SHIFT IN COST

- Price of PV modules used to be very high during the initial stages but reduced to a certain level by 2004.
- From 2004 to Q3 2008, the price of PV modules remained approximately flat at $3.50-$4.00/W.
- The 18 largest quoted solar companies followed by Bloomberg made average operating margins of 14.6%-16.3% from 2005 to Q3 2008.
- By the end of 2008, the production capacity of solar power plants increased more than the demand resulting in the increase in competition in pricing.
- As a result, price of the PV module fell rapidly from $4.00/W in 2008 to $2.00/W in 2009.
This reduction was possible due to the technological advancements in the previous four years such as:

1. Advances in wafer, cell and module manufacturing processes.
2. Better cell efficiencies.
3. Lower electrical conversion losses.
4. Lower installation and maintenance cost.
5. Falling BOS costs.
Regardless of the subsidy situation, there is at least 50 GW of cell and module capacity globally, and an estimated 26-35 GW of demand, for 2012.

Due to the less demand, some of the companies have reduced or completely shutdown their production.

For the first time, in late 2011, factory-gate prices for crystalline-silicon (c-Si) PV modules fell below the $1.00/W mark.

This is often regarded as marking the achievement of grid parity in PV systems.

Technological advancements, process improvements, and changes in the structure of the industry suggest that further price reductions are likely to occur in coming years.
The most fundamental metric for considering the costs of PV is the price-per-watt of the modules.

As of April 2012, the factory-gate selling price (ex-VAT) of modules from “tier 1” manufacturers was $0.85/W for Chinese multi-crystalline silicon modules, $1.01/W for non-Chinese mono-crystalline silicon modules, with thin film modules and those from less known suppliers are even cheaper.

Depending on the market, distributors of these modules can take a considerable margin, buying at the factory-gate price and selling at the highest price the market can support (Value based pricing).
Figure 1: PV module experience curve 1976-2011 (BNEF, 2012a).
Figure 2: Chinese c-Si PV module prices ($/W): Note the change in the slope of the curve since 2008.
Silicon costs, making up about 20% of the total module cost today, have had a significant impact on PV cost declines as they dropped from temporary highs of more than $450/kg in 2008 to currently (Q1, 2012) less than $27/kg.

On average, prices of wafers dropped from just below $1.00/W in 2009 to $0.35/W in Q1 2012, and those of cells declined from $1.30/W in 2009 to $0.55/W in Q1 2012.

The price of BOS’s single largest component, the inverter, dropped from an average of $0.29/W in 2007 to under $0.20/W in some cases in Q1 2012.
The average cost of BOS (including installation) in 2010 ranged from $1.6/W for a ground-mounted system to $1.85/W for a rooftop system.

The BOS cost for a 10 MW, fixed tilt, multi c-Si project in the US is reported to be $1.43/W and for a 10 MW, fixed tilt, CdTe project, it was $1.54/W.

Thus, we have observed that there has been a significant drop in the PV modules from 2008 to present.
The Levelized Cost Of Electricity (LCOE) is most commonly used by policy makers as a long term guide to the competitiveness of technologies.

The LCOE for PV c-Si has declined by nearly 50% from an average of $0.32/kWh early 2009 to $0.17/kWh early 2012.

Under a range of financing assumptions and locations, the U.S. DOE estimated a PV LCOE of approximately $0.10/kWh to $0.18/kWh for utility-scale, $0.16/kWh-$0.31/kWh for commercial systems and $0.16/kWh-$0.25/kWh for residential PV systems (NREL, 2009).

BNEF identify the most important determining factors of the levelized cost as being capital costs, capacity factor, cost of equity, and cost of debt.
It is difficult to directly compare levelized cost of electricity due to the discrepancies in the economies of different power generating technologies.

Example: Emirates Solar Industry Association (ESIA, 2012) show that based on current market rates, the LCOE from solar PV in typical MENA climates is estimated to be $0.15/kWh.

At this level, PV is cheaper on a simple LCOE basis than open-cycle peaking units at gas prices.

PV has, in fact, already replaced some peaking plants.

Example: California.

The key challenge lies in establishing the underlying place of different technologies within the power dispatch curve.
Even at comparable levelized costs and with commercially proven technologies, differing risk profiles of different technologies also have a large impact on the viability of the project.

- Depends on the amount of capital needed to finance the project.
- Uncertainty in future fuel and electricity prices impacts differently on the profitability of different technologies.
- Example: For gas and solar.
A new wave of discussions about grid parity has been set off by the recent non-linear price drops.

Depending on the scale of the PV project, grid parity normally refers to the LCOE of PV by comparison with alternative means of wholesale electricity provision.

For small-scale domestic or commercial PV systems, the appropriate alternative should be the purchase of electricity at a relevant residential or commercial tariff.

Such PV applications are not competing against wholesale generation but, instead, the delivered price of electricity through the grid.
Contrary to the view that the arrival of grid parity is still decades away, numerous studies have concluded that solar PV grid parity has already been achieved in a number of countries/regions.

It does not take into account the value of solar PV to the broader electrical industry.

BNEF (2011) concludes that falling costs in PV technology mean that solar power is already a viable option for electricity generation in the Persian Gulf Region, where it can generate good economic returns by replacing the burning of oil for electricity generation.

Similarly, power produced from PV in India is already competitive with power obtained by burning diesel.

PV is rapidly becoming competitive with alternative power generation technologies.
CONCLUSIONS

- The PV industry has seen unprecedented declines in module prices since the second half of 2008.
- Awareness of the current economics of solar power lags among many commentators, policy makers, energy users and even utilities.
- LCOE metrics in the PV industry can be misleading and should therefore be applied with caution as they require careful interpretation and transparency.
- Furthermore the term „grid parity“, the long-sought goal of the PV industry, has become outdated and is generally misleading.
- The challenge is to elegantly transition PV from a highly promising and previously expensive option, to a highly competitive player in electricity industries around the world.
?? QUESTIONS ??