Harvesting solar energy – Challenges and prospects

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Photovoltaic solar industry has grown exponentially, from global annual installation of a couple hundred MW 10 years ago to close to 30 GW as of today. Solar module efficiency and reliability have been improved while the cost has been reduced significantly. As a result, solar electricity is approaching the level of grid parity in many parts of the world.

The solar power industry faces many of the same challenges as the agricultural industry, including diurnal challenges of day-and-night; seasonal challenges of summer-and-winter; weather challenges of rain-and-snow; vulnerability challenges of pests-and-plagues; fashion challenges of hot-then-not; financing challenges of feast-and-famine; sustainability challenges of good-and-bad.

Harvesting solar energy requires overcoming similar challenges. Solar energy generation varies with the seasons and also with time in a day, as does energy consumption. While diurnal and seasonal variations are highly predictable, weather forecasts are much less reliable, especially at the building level. The efficiency of crystalline silicon based solar cells, at the mass production level, has improved from 13–14% ten years ago to 17–19% today, and will move above 20% in the next 2–3 years. Can the cell efficiency continue to climb? Are there chances for a significant breakthrough without added cost?

By solving these problems, solar is on its way to supply 5%, then 15% of the worldwide demand for electricity. But why only 15%, can it do more? At the same time, the rise of solar and other renewable energy technologies is starting to shake the fundamentals of today's power industry. The intermittent nature of solar and wind power can cause major fluctuations in energy generation and major new requirements for the responsiveness of electricity supply, with implications for technologies and for the traditional electricity infrastructure. The daytime generation of solar electricity can significantly reduce the peak hour income of conventional power generators. Meanwhile, distributed generation of solar electricity and self-consumption will negatively impact the power grid operators, just like the impact of internet on the post office systems. Amazingly, the current structure of electricity grid is only 100 years old. And even 100 years ago, it was a toss-up between distributed dc championed by Edison against the centralized ac invented by Tesla. We might be seeing the same battle again, with solar panels on your rooftop directly powering dc appliances, while energy storage and smart local grid manage the generation and load. In a word, we might see the "war of current" between Edison and Tesla refought, and who knows, Edison might win this round …