SOLAR ENERGY

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In the last 30 years, global electricity consumption has more than doubled from around 7,323 Terawatt-hours (TWh) in 1980 to 18,466 TWh in 2010. In the U.S., total electricity consumption grew around 85% from 2,094 ThW to 3,886 TWh in that period. In China, development and industrialization has driven an increase in electricity consumption of a factor of 13 from 261 TWh in 1980 to 3,633 TWh in 2010[1]. Electricity generation by fuel source has also shifted over time and varies by region. In the U.S., electricity generation by fossil fuels has decreased from around 77% in 1980 to 68% in 2011 despite the boom in abundance of low-cost shale gas, generation by nuclear has grown from around 10% to around 20%, hydroelectricity has decreased from over 10% to around 8%, while non-hydro renewables have increased from a negligible share of electricity generation in 1980 to around 4.7% of electricity generation in 2011. In China, the share of electricity generated by fossil fuels has hovered around 80%, hydroelectricity has decreased from around 20% in 1980 and an all-time high of 25% in 1984 to around 15%, nuclear energy has grown from no use to being accountable for around 1.5% of electricity generation in 2011, and renewables have grown from negligible use in 1980 to around 2.5% of electricity generation in 2011[2].

Globally, electricity generation by non-hydro renewables grew by a factor of 25 from around 30 TWh in 1980 to over 750 TWh in 2011[3]. In 2012, global investment in the clean energy sector totaled $269 Billion[4]. As nations' concerns mount over air pollution and the health of their populations, energy security, climate change, and environmental displacement; and as the costs of clean energy technologies continue to decrease, these investments and deployments will continue to rise.

An important sector in renewable energy technology is solar energy. Since 2008 alone, the deployment of solar energy technology has increased almost four fold, from less than 6 GW/year in 2008 to almost 24 GW/year in 2011[5]. Over the same period, the cost and average selling price of solar photovoltaic modules have been decreasing rapidly. Since 2008, the average selling price has decreased from over $3.50/W to under $1/W[6]. This cost reduction has been brought on by the confluence of a number of factors including significant technological innovation and market forces such surging global supply.

For truly widespread adoption of this technology, further cost reduction is required for direct cost-competition with incumbent energy sources in subsidy-free environments in mainstream markets. The U.S. Department of Energy estimates that total system costs of $1/W installed will be required for such widespread adoption, which will necessitate further innovation in solar cells, modules, and systems[7].

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[1] U.S. Energy Information Administration, International Energy Statistics

[2] U.S. Energy Information Administration, International Energy Statistics

[3] U.S. Energy Information Administration, International Energy Statistics

[4] "Who's Winning the Clean Energy Race?" Pew Charitable Trusts, April 2012.

[5] Mints, P.; Donnelly, J. (2011). "Photovoltaic Manufacturer Shipments, Capacity and Competitive Analysis 2010/2011." Report NPS-Supply 6, Navigant Solar Services Program. Palo Alto, CA

[6] Mints, P.; Donnelly, J. (2011). "Photovoltaic Manufacturer Shipments, Capacity and Competitive Analysis 2010/2011." Report NPS-Supply 6, Navigant Solar Services Program. Palo Alto, CA

[7] R. Margolis, G. Barbose, M. Bolinger, G. Brinkman, C. Coggeshall, K. Cory, P. Denholm, E. Drury, A. Ellis, D. Feldman, J. Gary, A. Goodrich, G. Heath, B. Kroposki, T. Mai, M. Mowers, C. Turchi and J. Zuboy, SunShot Vision Study, U.S. Department of Energy, Washington, D.C., 2012. Available at: http://www1.eere.energy.gov/solar/pdfs/47927.pdf (last accessed: March 13, 2013).

Many technological pathways are under pursuit to achieve low-cost solar energy. The predominant technology commercialized today is crystalline silicon that made up 85% of total market share in 2010, while thin films are gaining market share at 13% of the total market in 2010. Crystalline silicon includes polycrystalline and monocrystalline silicon, which made up 48% and 37% of the total market, respectively. Thin film technologies include Cadmium Telluride (CdTe), amorphous silicon (a-Si), and Copper-Indium-Gallium-Selenide or Copper-Indium-Selenide (CIGS/CIS), which made up approximately 8%, 3%, and 2% of the total global market in 2010, respectively.[8]

In this session, leading scientists from academia and industry will outline the current cost drivers of solar energy technology and various innovation pathways under pursuit to achieve the technological advancements that can bring about widespread adoption of subsidy-free solar energy. These pathways present many opportunities for the American and Chinese communities to work together to achieve solar technology that may compete in widespread markets without subsidies.

Dr. Tonio Buonassisi, Professor of Mechanical Engineering at the Massachusetts Institute of Technology will show the current cost drivers of solar energy technology based on crystalline silicon solar cells, the predominant solar technology in production today, through an industry-validated bottoms-up cost model. With the prioritization provided by this model, he will detail several innovations with the potential to be introduced into the solar production industry within the next 1-5 years.

Dr. Qiang Huang, Adjunct Professor and the Director of the State Key Lab of Photovoltaic Science and Technology, China (Trina Solar limited), will provide an overview of the principles of leading mono-crystalline silicon solar cell architectures, characterization methodologies, innovations that have resulted in Trina Solar's 19.7%, and the pathway to Trina Solar's target all back-contact solar cells and film-crystal hetero-junction solar cells with a efficiency > 21% in production. Trina Solar is one of the world's leading solar cell and module suppliers, supplying 5% of global solar cell market.

Dr. Xiaodan Zhang, (Ms.), a Professor and Deputy Director of the Nankai University, will present progress in a thin film amorphous/microcrystalline silicon tandem solar cell structure. Silicon-based thin film solar cells are made up of multiple thin layers of silicon alloy, each tuned to a specific range of the solar spectrum, that can be deposited at low temperatures (<200C). Although currently less efficient than mono-crystalline silicon solar cells, the use of silicon-based thin film solar cells allows for significant reduction of silicon compared to mono-crystalline solar cells, having the potential to reduce the cost of the product. The use of multiple layers allows the device to capture a broad range of the solar spectrum, and the low deposition temperatures also provide the possibility to create solar cells on flexible substrates.

Dr. Homan Yuen, Co-Founder and Vice President of Solar Junction, will then expand on other low-cost thin film solar cell technologies, and high-efficiency concentrating photovoltaic (CPV) technologies. Other thin film technologies will include CdTe, the second most wide-spread solar technology in deployment today after crystalline silicon; CIGS, a thin film technology with higher efficiencies than CdTe or amorphous silicon observed in low-volume production and laboratory settings, but with significant production challenges; and CPV systems that include compound-semiconductor solar cells with efficiencies 2-3 times that of silicon, combined with low-cost mirrors or lenses that focus large areas of light into small areas of solar cells.

[8] K. Adrani, R. Margolis, et al. 2010 Solar Technologies Market Report, National Renewable Energy Laboratory, November 2011. Available at: http://www.nrel.gov/docs/fy12osti/51847.pdf