# The Geography of Solar Module Manufacturing: A Model for Serving the U.S. Market

Don Schjeldahl, Vice President Director
Renewable Energy Strategies
The Austin Company
6095 Parkland Boulevard
Cleveland, Ohio 44124
440-544-2617 Office
330-283-6931 Cell
Don.schjeldahl@theaustin.com

The large geographic expanse and consumptive power of the United States have long challenged corporate strategists on how best capture market share. This is further complicated, in the case of solar, by a volatile landscape of technologic change, immature supply chain, regulatory complexity and the sometimes corrupting influence of development incentives.

One thing is certain, expected rapid growth of the U.S. market for solar products will require significant investment in new factories and logistics facilities. And like industries that have gone before, solar will produce winners and losers as companies wrestle with location dynamics.

Where should factories be located? How many factories are needed? How big should they be? The answers to these questions lay at the center of solar's path to maturity. While solar's future is still being written, increasing clarity about markets, technologies and supply chain now make it possible to map investment strategies with greater certainty. This article outlines a solar supply chain location model for serving the U.S.

## Market Growth Requires New Rules for Location

When PV modules are as common as power lines the vision that solar is America's next 100 year mega-industry will be reality. And with year on year growth of over 20% it won't take long. Grid parity, the triggering mechanism that brings markets into play, is ever closer in virtually all corners of the United States. Giant leaps in smart grid deployment and policy initiatives are accelerating solar adoption. The artificial demand now created by government subsidies and mandated portfolio standards is certain to retreat as the powers of a competitive market are unleashed.

> Grid parity grows ever closer as PV's cost per watt continues its downward slide and the cost of electric power generation from conventional sources continues to rise:
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> **Ohio Coal-fired Power Plant Scrapped** (November 26, 2009, The Associated Press)
> COLUMBUS, Ohio -- American Municipal Power Inc. has scrapped plans to build a coal-fired power plant in Southern Ohio because construction costs jumped from $3.3 billion to $4 billion, officials said. The 1,000-megawatt coal plant, which would have provided electricity to parts of Michigan, Pennsylvania, West Virginia and Virginia, had been the target of environmental groups since its announcement six years ago. AMP insisted in a statement Wednesday, however, that the opposition had nothing to do with its decision.

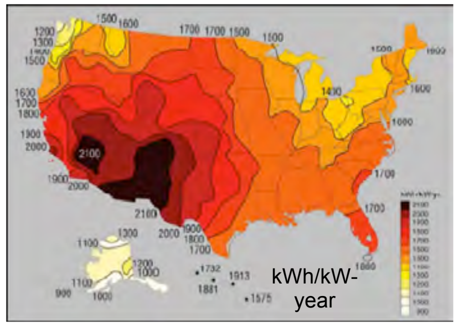



Figure 1 -
Lure of the U.S. Market:

Ample sunlight, large market (pop. 310,000,000), significant disposable income, thirst for electricity, emerging culture focused on sustainability.

Driven by competition, every industry eventually yields to rules that sort efficient producers from those who are careless. Solar has entered a new rule making phase and the U.S. market is a centerpiece in the debate.

Until now location decisions by solar module manufacturers and suppliers on how to serve the U.S. market have not always been logical. With the industry buoyed by strong demand and supply shortages, profit margins have been forgiving when it comes to value chain management. In addition, lucrative government incentives aimed at seeding solar industrial clusters have influenced decisions in often un-advisable directions relative to long term corporate strategy.

Not surprisingly, patterns of investment over the past decade have been more reactive than strategic. For example, sourcing of glass and supplying modules to the market, both logistically demanding, have shown little regard for supply chain efficiency. Intercontinental shipments are common place, led by the German market absorbing a large portion of world production. More recently Solyndra's decision to manufacture in the San Francisco area, a notoriously expense operating environment, is puzzling given the rising specter of competitive pricing.

**Supply Chain Must Drive Location**

Behind the need to develop new location rules for solar are lower module prices which are on a steady downward glide averaging 5% per year. As prices fall a mass market will emerge and the industry will circle around commoditized products. As this occurs profit margins shrink and producer survival will require careful management of costs.

The argument that U.S. based manufacturing is a mute point due to advantages of low cost countries is losing steam. Asian factories, lifted primarily by low cost labor, it is argued, can supply competitively priced modules to the world. A careful analysis of geographically variable production costs shows, however, that Asian production affords only a narrow cost advantage over North American production once overseas shipping, carrying costs, exchange rates, breakage, customer service costs, and other operating factors are considered. Domestic content will also erode the logic behind an Asia dominant production strategy.

While modules produced in low cost countries will capture some of the U.S. market, solar manufacturing is coming to the U.S. in a big way. Chinese producers recognize this and are adjusting their strategies accordingly. In November Suntech announced its first U.S. manufacturing plant would be located in the Greater Phoenix, Arizona area. The plant will have an initial production capacity of 30 megawatts (MW) and is expected to begin production in the third quarter of 2010. Wanxiang Solar announced last March plans to produce modules in Rockford, Illinois.

Stabilization of raw materials supplies, particularly for silicon, stands behind approximately a third of the decline in module pricing. The remaining two thirds can be attributed to economies of scale, increased competition, and supply chain efficiency. Interpreted by companies at each level of the supply chain, these industry shaping forces will dictate best strategies for serving the U.S. market.

<u>Scale Economies</u>: Factory size has steadily increased over the years. Plants producing 25MW of modules, a common capacity a few years ago, have given way to plants with capacity of 100MW, 250MW, or more. At the core of plant output decisions are long recognized benefits of scale economies where the cost per unit decreases through operational efficiencies that come from production increases. Determining the optimal production size has many variables including levels of automation, cost of capital, corporate ability, and reliability of sales projections.

The optimal scale and configuration of factories also varies by product technology. Thin-film PV plants, which are technically complex and capital intensive, tend to be larger and have more demanding operating requirements. A challenge for thin-film factories is maintaining production efficiency and product quality, in turn making production stops and starts more difficult. Thin film factories in the 250MW to 500MW range appear to be emerging as a model for the industry. At these output levels factories must be located to efficiently serve a large customer base, likely at a national or super regional market scale.

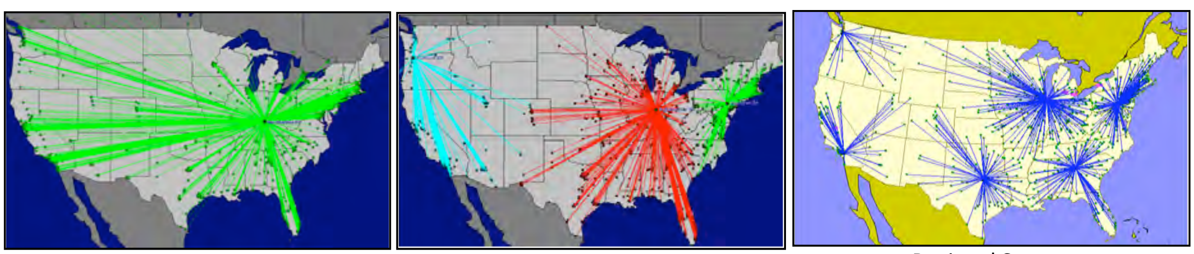
In contrast to thin-film, crystalline module assembly factories, using contract cell suppliers, have modest capital requirements even with automation. Building requirements are likewise simple. Production lines can be switched on and off with relative ease in response to market fluctuations and these factories are easily scalable. Crystalline assembly factories in 50MW to 100MW range appear a likely model for serving regional markets.

<u>Competition</u>: With each tick downward in the cost of PV grid-parity, solar's Holy Grail, gets tantalizingly closer. To say module manufacturers are frantically working to develop downstream sales channels may be an overstatement but not by much. Module producers recognize that explosive market growth just around the corner means positioning for market share today. Aggressive pricing is an outcome as producers look to capture customers. Competition is squeezing the bottom line and attention to supply chain is the answer.

<u>Supply Chain</u>:  To counter price reduction producers are looking to lock-in attractive supplier contracts in order to better manage profit margins.  By definition supply chain is the linked set of resources and processes that begins with the sourcing of raw material and extends through the delivery of finished product to the final customer.  It includes vendors, manufacturing facilities, logistics providers, internal distribution centers, distributors, system integrators, installers and all other entities that lead up to final customer acceptance.

Optimizing supply chain is a blend of art and science.  The goal is to locate to optimally balance labor cost, logistics costs, customer service, utility costs, and taxes.  Incentives should only be viewed as a temporary benefit and not part of a long term location strategy.

North America's large geographic expanse and dispersed population provide ample opportunity to guess wrong when deciding how to supply the market.  To illustrate tradeoffs between logistics and production scale for example, consider alternate models for serving 80% of the U.S. population.  To support each customer with one day service by truck requires 26 distribution points based on how far a truck can travel out and back in one day (roughly 250 one way miles).  By contrast, one facility located to minimize travel to that same U.S. population would be located somewhere between Memphis, Tennessee and Indianapolis, Indiana.  Figure 2 illustrates various service models for the U.S. market.



National Strategy    Super Regional Strategy    Regional Strategy

Figure 2 - Factory Location Strategy:  As profit margins are squeezed and customer service requirements and logistics costs grow in importance more facilities are needed to serve the market

**Location Model for Serving the U.S. Market**

Each company must define a network of suppliers, factories, distribution centers, and service centers that best satisfies its unique requirements.  The prudent approach when developing location strategy for the U.S. market is to incorporate flexibility in the network design.  Shifting customer demand, changing regulations, fluctuating fuel costs, shifting labor markets, competitor actions, and changing tax structure can all throw a network out of balance.

A common approach is to develop a strategy for full market build-out and locate initial facilities with the lowest risk exposure.  As conditions evolve the plan is revisited and the strategy adjusted if warranted.  Trigger points are designed into the strategy to know when the next facility is needed.  Contract manufacturing, third party logistics, remote distribution centers, and cross dock operations are often used as short term hedges in rapidly changing markets.

Each step of the solar value chain has its own best strategy. For example, HSC and REC have both invested heavily in U.S. silicon production facilities. HSC has plants in Michigan and soon in Tennessee, and REC has plants in Washington. Drawn by low cost electricity these facilities play on the global stage sending product to customers around the world. Silicon producers may hedge their location decisions to incorporate political factors, but low cost is the key consideration.

In contrast to silicon's global orientation, inverter manufacturing is becoming sensitive to customer location as PV demand grows. Geographic variability in production and transportation costs for inverters point to a multi-plant strategy in order to cost effectively serve the U.S. market. Germany's SMA recognized this when selecting Denver, Colorado in October for its first U.S. factory. SMA's plan to produce 1GW of inverters for a market largely in the western U.S. leaves the doors open for a second plant in the eastern U.S. as that market develops.

Figure 3 presents a location model for each step of the solar supply chain. The geography for of an optimal location strategy is suggested for each step. The model assumes a minimum of 5GW demand distributed among 12 states in the south, southwest, and northeast U.S. Location strategies are based on an optimal balance of labor costs, logistics costs, customer service requirements, utility costs, and taxes and reflect capital investment requirements.

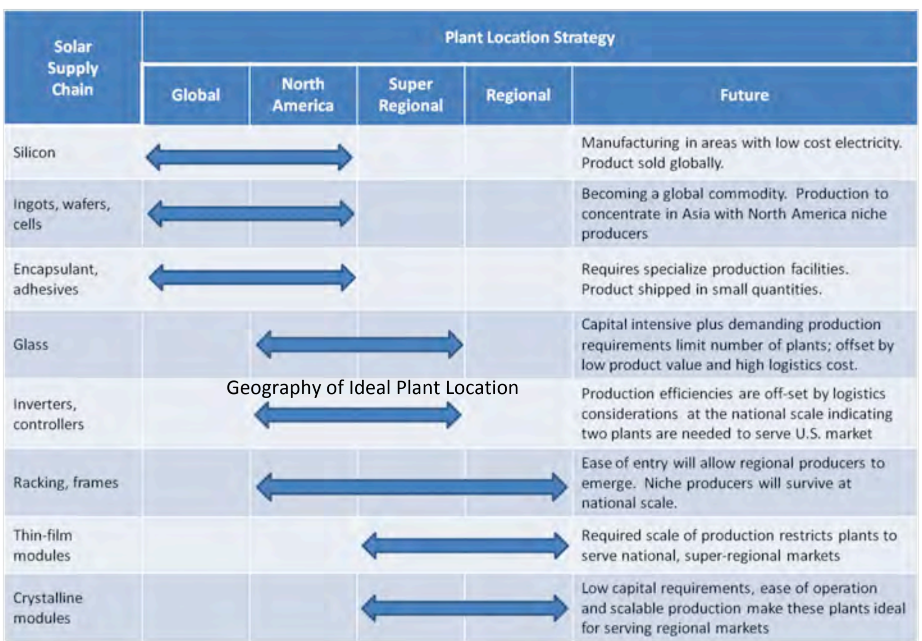


Figure 3: Solar Supply Chain - Factory Location Strategy for Serving the U.S. Market

## Conclusion

With year on year growth of over 20% and grid parity for much of the U.S. nearing, the pace of investment in production facilities and logistics operations is sure to accelerate. Urgency to act is no substitute for careful planning however. Companies that are strategically savvy will enjoy a buffer that softens the impact of disruptive events including swings in the market. Companies that discount strategic acuity are unnecessarily vulnerable to a host of invest eroding forces. Now is the time for the solar supply chain to develop location strategy for a mature U.S. market.