Projecting the Likely Success of Startup Companies Bringing New Clean Energy Technologies to Market

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ABSTRACT

Young companies with innovative clean energy technologies often need financing to enable them to survive their developmental years while they struggle to achieve profitability. If such financing, either from private industry or the government, is difficult to obtain, it's bound to slow down the development of such technologies. Yet the years 2008 to 2012 marked a tightening of such credit. Reasons for such tightening included both the Solyndra loan scandal as well as investor disillusionment with the sector.

To help manage risk for both government and private investors, the author developed a simple framework to gain insight into the likely success of young companies with new technologies in the clean energy sector. This framework was based on research done by Harvard Business School.

The utility of the framework was illustrated by its application to four case studies of actual companies. Two case studies investigated companies that had failed, including a developer of an energy-efficient microprocessor chip and a manufacturer of a residential heat pump designed to operate at extremely cold outdoor temperatures. The other two case studies investigated companies whose ultimate fate is still unknown: a manufacturer of panels designed to replace light shelves in daylighting systems and an over-the-Internet service to manage programmable thermostats.

In all these case studies, the framework was useful for providing insight into the factors that either led to failure or potential. By helping both lenders and entrepreneurs avoid some common but costly mistakes, the framework has the potential to reduce risk for these parties.

Why an Insight Framework Would Be Helpful

The years 2008 through 2012 were troubling ones for investments in young companies bringing new clean energy technologies to market. The first signs of trouble appeared in the venture capital sector. In the years 2007 and 2008, funding for the earliest stages of venture investment in startup cleantech companies (a category that includes energy efficiency and renewable energy) peaked, and then declined in subsequent years (Freed & Stevens 2011; Nordan 2011). The 2008 financial collapse was a key motivator for this trend, both in driving down overall investment as well as causing investors to seek the safer havens of later-stage companies (Eilperin 2012). Other factors, at least in the clean energy sector, included the belated discovery by venture capitalists that this sector features greater technological risk, longer time between initial investment and exit, and higher required funding amounts than are typical for other sectors (Eilperin 2012; Ghosh & Nanda 2010).

Just as venture capitalist appetite for investing in the earliest stages of clean energy technology development began to wane, a much bigger investor came onto the scene: the U.S. federal government. The U.S. Department of Energy [DOE] ramped up a loan program that provided loans and loan guarantees to mostly, but not exclusively, companies involved in renewable electricity generation and electric vehicles. Some of the program's recipients were well-established companies, but many were startups with new technologies.

The loan program was managed by the DOE's Loan Programs Office [LPO] and came to be well known to a broad swath of the American public. The LPO managed a portfolio of nearly $25 billion in loans and loan guarantees provided over a two-year period, beginning September 2009, to nearly 40 projects. According to the LPO's web site, such projects included the first two all-electric vehicle manufacturing facilities in the U.S. and the world's largest wind farm. Despite these achievements, the program's best-known project by far was a loan guarantee to a startup photovoltaic panel manufacturer named Solyndra (LPO 2012).

Founded in 2005, Solyndra boasted a novel design, featuring a matrix of glass cylinders coated with a mix of copper, indium, gallium, and selenium. By the end of 2008, the company had raised $600 million in venture capital, set up a factory, hired over 500 employees, and taken over a billion dollars worth of orders. With the contraction of the venture capital market, the company was fortunate to be the first recipient of a loan guarantee from the LPO. The $535 million loan guarantee turned out to be not enough when the company's efforts to scale up production stalled, and global prices for conventional silicon photovoltaic modules plummeted. In August 2011, the company filed for bankruptcy (Eilperin 2012, *The New York Times* 2011).

Solyndra's failure became a huge embarrassment for the Obama administration. It was the subject of countless articles in the popular media and several congressional investigations. To supporters of the loan program, this criticism seemed unfair given that the entire point of the program was to provide loans that were riskier than what private industry would support. Furthermore, the LPO's losses were small compared to the $10 billion Congress had appropriated for defaults (DOE 2011). Such protestations did little to diminish the political storm.

In late 2011, the White House assigned an independent consultant to review the LPO's loan portfolio management. The consultant determined that the LPO could benefit from more meticulous financial management as well as higher performance standards for the participating companies (Allison 2012). Indeed, there is some evidence that such higher standards were implemented. In February 2012, both Bright Automotive and Chrysler withdrew their loan applications from the DOE claiming the terms available had become too onerous (Ramsey 2012). The Solyndra debacle also did little to whet the appetite of venture capital firms to return to the clean energy sector.

This tightening of credit for investments in new clean energy technologies presents a serious challenge for clean energy advocates. Young companies with innovative technologies often need financing to enable them to survive their developmental years while they struggle to achieve profitability. If such financing, either from private industry or the government, is too difficult to obtain, it's bound to slow down the development of such technologies.

As a means to improve the success rate of both public and private investors in this sector, the author proposes a framework to help investors improve their understanding of some of the major factors that influence the success of startup companies bringing new clean energy technologies to market. The framework is not a fortune-telling tool, nor is it an infallible predictor. Instead, it is a guide to help investors think about how to improve the prospects of young companies with new technologies. It has the potential to help early-stage investors and entrepreneurs in the clean energy sector avoid several widely observed but avoidable mistakes. If these parties are more likely to focus their efforts on successful ventures, and avoid costly mistakes, that can only help advance the development of clean energy technology.

Basis of the Framework

The theories of Harvard Business School professor Clayton Christensen are widely applied by strategists in the business world (MacFarquhar 2012). To develop this body of work, Christensen drew inspiration from geneticists who study fruit flies. Just as geneticists study these tiny animals because their short lifetimes enable rapid observation of numerous generations, Christensen studied disk drive manufacturers, which at the time were coming into and going out of business in droves (Christensen 1997).

Christensen assembled a database that contained the specifications of every model of disk drive released during the time period 1975 to 1994. Christensen then analyzed this database to make observations about which firms led product introductions, and to reveal how new technologies diffused through the disk drive industry over time. By analyzing the history of each technological innovation, Christensen drew conclusions about which innovations were associated with success for the organizations that released them, and which led to the failures of established market leaders (Christensen 1997).

Over the course of this study, Christensen found that new companies were unlikely to succeed when they competed directly with well-established companies. When new companies attempted to manufacture products similar to those produced by the market leaders, and sell those products to the same customers served by the market leaders, Christensen concluded that those new companies succeeded only 6 percent of the time. Instead, new companies that avoided competition with market leaders by selling less-expensive, lower-quality products to entirely new classes of customers (at least to start with), succeeded 33 percent of the time. According to Christensen, the reason for such a difference in outcomes was due to the superior resources that market leaders had at their disposal. He found that the market leaders often overwhelmed new companies that attempted to compete with them directly (Christensen 1997).

To facilitate the application of Christensen's theories to young companies with new clean energy technologies, the author boiled down this body of work into a framework consisting of two deceptively simple questions. The term "clean energy" is used to refer to technologies that are widely associated (regardless of whether those associations are based in fact) with reducing the environmental consequences of energy consumption and include energy-efficiency, renewable energy, fuel cell, electric transportation, and cogeneration technologies. The results obtained from applying this framework are not absolute indicators of success or failure. For example, a company that the framework tags for success may still fail because it doesn't have a sound management team, isn't adequately capitalized, or its technology isn't viable. Offerings passing the framework are, based on Christensen's work, simply more likely to succeed than those that don't.

The two questions of the framework must be answered in the affirmative to indicate likely success. The first such question is "Is the new offering less expensive than similar offerings from the market leaders?" In other words, is the startup company charging less for its offering than well-established companies selling products with similar functions? According to Christensen, startup companies can avoid competition with market leaders when they pursue the low ends of their markets with business models that allow them to make money at discount prices. He cites Walmart, Dell, and Nucor as examples of companies that succeeded with such a strategy. Low prices enable startup companies to sell to customers that aren't served by the market leaders, thus allowing startups to avoid bruising competition before they are ready.

Furthermore, new companies have many obstacles to overcome to attract customers. The lower the price, the more likely it is customers will be attracted by their offerings (Christensen 2002).

The second question is "Is the new company marketing its offers to undemanding customers?" Undemanding customers are those who do not expect high levels of quality and reliability. There are several reasons why new companies need undemanding customers to succeed, at least at first. Even startup companies that feature accomplished management teams with much quality control experience are bound to struggle with product quality and reliability at first. New technologies almost always pose problems that are impossible to anticipate. Market leaders simply have more resources to deal with such problems than startup companies. Furthermore, market-leading companies have already been through their early product shakeout years.

Startup companies can avoid the demands of customers conditioned by their experience of doing business with the market leaders by selling to new customers not served by the market leaders. Finding such customers requires startups to exercise a great deal of creativity. For example, for many years, some solar panel manufacturers focused on selling into off-grid markets as a way to avoid competition with electric utilities. Alternatively, startup companies can bring to market new technologies in areas lacking strong market leaders with high quality standards. To be clear, even for undemanding customers, quality is still relevant. It's just that by seeking out undemanding customers, the new company need not match the product quality provided by the market leader (Christensen 2002).

On the surface, these questions may appear to be too elementary and obvious to be of value. In practice, the principles they are based on are frequently violated. To illustrate the application of this framework, we investigated how it could be applied to companies that manufactured high-efficiency computer chips, heat pumps designed to operate at low ambient temperatures, light distribution matrices for daylighting systems, and over-the-web management services for Internet-connected thermostats. The first two technologies were chosen to investigate how the framework could provide insight into well known and studied failures. The latter two technologies were chosen to determine if the framework could provide insight into the likely performance of companies whose outcome is yet to be determined. These case studies were chosen specifically because the author was familiar with their facts and because they offered a variety of situations in which to illustrate the application of the framework.

Case Study #1: The Transmeta Corporation

Founded in 1995 by former employees of Sun Microsystems and other California high-tech manufacturers, the Transmeta Corporation developed and sold energy-efficient microprocessor chips for laptop computers. Transmeta's first product, dubbed the Crusoe chip, cleverly relied on two tricks to boost energy performance. First, whereas conventional microprocessors use hardware—transistors embedded in their silicon substrate—to order the execution of digital instructions, the Crusoe chip used software to accomplish the same task. As a result, Transmeta claimed to be able to get by with one-fourth the transistors of its competitors, avoiding the cost and energy losses associated with the avoided transistors. Second, Transmeta microprocessors monitored computing operations as they were being performed, and sped up and down as required. For example, a Crusoe microprocessor might operate at low speed when doing word processing but shift into high gear when photograph-editing software was started up. The lower the speed, the lower the chip's energy consumption. Whether or not Transmeta's chips were more energy efficient than competing microprocessors was never clear, but the company claimed to be able to double battery life (Transmeta 2001).

In its early years, Transmeta achieved impressive and intoxicating success. Not only did the company raise a hundred million dollars before it went public, but it also launched the last great initial public offering [IPO] of the dot-com boom, in which it raised hundreds of millions of dollars more (Transmeta 2001). The IPO turned out to be the high point for Transmeta, as the company went into competition with an incumbent long before it was ready. At the time Transmeta went public with its product, and even until the present, the leading manufacturer of microprocessor chips for laptop computers was the Intel Corporation.

The inventor of the computer microprocessor, the Intel Corporation has seen its fortunes rise and fall with the personal computer industry. The company, which first broke into the Fortune 500 in 1979, also has a reputation for being a fierce competitor (Intel 2012). Over the years, numerous companies have attempted to compete with Intel for the computer microprocessor market, and all but one of them, the hapless Advanced Micro Devices [AMD], have failed. A startup company would be hard-pressed to pick a more intimidating competitor.

When Transmeta announced that for all practical purposes it was going into competition with Intel, the latter already had annual revenues in excess of $30 billion. Few laptop computer manufacturers were willing to risk alienating such a powerful supplier. Intel, to its credit, took Transmeta's threat seriously and quickly brought out a more efficient chip of its own. Whether or not those chips were as efficient as Transmeta's chip was never clear, but it didn't matter. Transmeta, which was already well on its way down the classic startup failure trajectory, began to suffer from a host of performance, quality control, and supply chain problems.

Once Transmeta called out Intel as its competitor, buyers naturally compared the performance of Transmeta's product to Intel's. This was bound to be a losing game for Transmeta given the huge gulf of resources and experience between the two companies. When the Sony VAIO PictureBook computer was released (it was the first product to bear a Transmeta Crusoe microprocessor), the *PC World* Test Center tested two PictureBooks, one with a Transmeta chip and one with an Intel chip. These tests revealed that the Transmeta computer exhibited nearly fifty percent longer battery life, but that advantage came at the cost of nearly twenty percent slower performance (Mainelli 2000). Transmeta released its own tests but was never able to overcome market perception that its products couldn't perform on the same level as Intel's.

Transmeta might have been able to limp along with such a reputation had it not been for a string of quality control and supply chain failures. The coup de grace that ended this string occurred when Transmeta attempted to switch suppliers.

Transmeta didn't actually manufacture its chips. It designed them and then farmed out their manufacture to foundries that rent out capacity in their fabrication plants to produce chips for others. Transmeta's original foundry was IBM, which by all accounts maintained high-quality standards, but also charged high prices and occasionally missed delivery dates. In a misguided attempt to cut costs, Transmeta qualified the Taiwan Semiconductor Manufacturing Company [TSMC] to produce its next-generation chip. The complexity of that chip proved to be beyond TSMC's capabilities. It took so long for TSMC to learn to produce Transmeta's microprocessors at the required quality and quantities that most of Transmeta's customers gave up and walked away (*Technology Review* 2005).

By the end of 2005, Transmeta had cumulative losses of $655 million and the company had to face up to the fact that it was continually losing money on its chip sales business

(Transmeta 2006). Management decided to exit that business and reinvent the company as an intellectual-property vendor, licensing chip manufacturers to use its power management technologies. Transmeta slashed costs by laying off hundreds of employees, but it wasn't enough. The company continued to lose money. In January 2009, Transmeta's assets were purchased by a digital video processor manufacturer, which went out of business itself later that year (Nauman 2008).

To apply the first question from above, were Transmeta's offerings less expensive than the incumbents' offerings? The answer is clearly no. Transmeta was so heavily capitalized right from the start that it wasn't able to sell at discounted prices, satisfy its investors' demands for returns, and make a profit (Kanellos & Konrad 2001).

To apply the second question from above, did Transmeta market its products to undemanding customers? Again, the answer is no. For the most part, Transmeta sold its products to customers who were also marketed to by the likes of Intel and AMD. These customers were extremely demanding. In the end, because Transmeta could not possibly meet the expectations of such customers, the company was undone.

It was silly to expect a small startup like Transmeta to compete with a giant like Intel on the basis of quality, price, and performance. Why did the company even try to do so? Because it had spent nearly $100 million and 5 years developing its product, it had to achieve enormous revenues just to stay afloat. The only plausible story Transmeta's managers could tell their investors, their employees, and ultimately themselves, was that they were going to capture some portion of Intel's $30 billion of annual sales.

Can we apply the framework to suggest what Transmeta might have done differently? The company would probably have done better had it spent less money up front and developed a simpler, less-expensive energy-efficient microprocessor chip, which it then marketed for applications that Intel did not pursue. Examples of such applications include smartphones, tablets, digital cameras, and disk drives. Indeed, ARM Holdings, which was founded only five years before Transmeta, succeeded with such a strategy. ARM first established its chips as the standard for a wide variety of non computer devices and is only now starting to challenge Intel (Winkler 2011).

Case Study #2: Hallowell International

Hallowell International was founded in 2005, in Bangor, Maine, by a young entrepreneur named Duane Hallowell. The company's product was a heat pump, originally sold under the trade name All Climate Heat Pump, but later rebranded the Arcadia. Regardless of the trade name it was sold under, the Hallowell product was designed to heat homes in climates with extremely low outdoor temperatures with greater capacity and effectiveness than conventional air-source heat pumps (i.e. split-system units, 5-tons and under, typically sold to residential customers). Unlike conventional heat pumps, the Hallowell product was designed so that it would rarely, if ever, require backup heating. It was also capable of providing air conditioning in the summer. One of the main selling features of the product was that it improved the feasibility of using air-source heat pumping in northern climates, where such heating units currently enjoy little market share. Heat pumps that replaced electric resistance heaters held the potential to reduce heating energy consumption by at least a factor of two (Stein 2005).

The company quickly achieved a series of successes and accolades. The Arcadia heat pump won an Innovation Award at the 2008 International Air-Conditioning, Heating, and

Refrigerating Exposition (Arnold 2008). In 2009, Hallowell won the Maine Governor's Award for Business Excellence. By 2008, the company reportedly employed 40 people and sold 1600 units (*Mainebiz* News Staff 2008).

By 2010, things started to quickly unravel for Hallowell. The company became overwhelmed by complaining homeowners fuming about high utility bills and unit failures. By early 2011, it ceased operations, and in June 2011, all of Hallowell International's assets were sold at auction (Russell 2011).

To apply the first question, were the heat pumps sold by Hallowell less expensive than standard heat pumps? The answer is no. Hallowell heat pumps were about four times as expensive as standard heat pumps on an installed-cost basis (Criscione 2006).

To apply the second question, did Hallowell market its products to undemanding customers? Again, the answer is no. The end users of the company's heat pumps were mostly homeowners and tenants who expected thermal comfort year-round, even on the coldest night of the year. They expected the same thermal comfort they would have obtained had their heat pumps been made by Carrier, Trane, Lennox, or York. It was extremely unlikely that a small startup company like Hallowell could have succeeded with such a product.

Unlike ARM Holdings in the previous case study, it wouldn't have been possible for Hallowell to come up with a less expensive product that it sold to customers outside the sphere of the major heating and air-conditioning manufacturers. For one thing, it's not clear how Hallowell could have implemented its innovation in a low cost product. For another, the heating and air-conditioning business is different from the microprocessor industry. New applications arise frequently for microprocessors, whereas the market for residential heat pumps remains static. There weren't a lot of new customers underserved by the incumbents that Hallowell could have marketed its innovations to.

Instead of manufacturing heat pumps, a better strategy for Hallowell would have been to license its designs to one or more of the major heat pump manufacturers. That strategy is being pursued by Eckhard Groll, a professor at Indiana University. Groll claims to know what the flaws were in Hallowell's product that led to the company's failure, and has a patent on his own design. He is reportedly in the process of preparing tests for units based on that design. If they succeed, he has arranged for Trane, a leading manufacturer of heating and air-conditioning equipment, to bring the product to market (*Coastal Contractor Online* 2011).

Case Study #3: LightLouver

Founded in 2004 near Boulder, Colorado, LightLouver produces panels of aluminized reflecting slats designed to replace light shelves in daylighting systems. These panels are also marketed under the trade name LightLouver. According to the company, its panels reflect sunlight deeper into buildings than light shelves do, thus allowing electric lights to be dimmed more frequently and to a greater extent. As a result, using LightLouvers instead of light shelves should yield greater energy savings. The company also claims that its LightLouver panels enable higher-quality daylighting with less glare and better solar control than is achievable using light shelves (LightLouver 2012). The company's energy performance claims have yet to be verified by independent analyses.

So far, the company has achieved some notable distinctions. It won an Innovation Award at the 2010 LightFair Convention held in Las Vegas (*LEDs Magazine* 2010). Its products were selected for installation in the National Renewable Energy Laboratory's Research Support

Facility, an award-winning net-zero building intended to serve as a showcase for energy efficiency and renewable energy technologies.

To apply the first question, is LightLouver's product less expensive than light shelves? The answer is a qualified yes. The manufacturer claims that its product is about half the cost of light shelves. This claim has yet to be verified by independent sources.

To apply the second question, is LightLouver marketed to undemanding customers? Here, the answer is an unqualified yes. Light shelves are often assembled in the field by contractors on a custom basis. As a result, their effectiveness and quality are highly variable. Furthermore, few customers with daylighting systems have sufficient monitoring and analysis capabilities to evaluate the energy savings achieved by such systems. As a result, competing with light shelves on the basis of quality and reliability seems to be a manageable goal for LightLouvers. Assuming that the market for daylighting stays stable or grows, that the company has a business model that allows it to be profitable at such volumes, that the company builds credibility via independent verification of its claims, and that the company isn't undercut by a low-cost competitor, it's likely that the company will succeed with the LightLouver product.

Case Study #4: EcoFactor

Founded in 2006 and based in Redwood City, California, EcoFactor provides an over-the-Internet service that uses data from residential two-way communicating thermostats, as well as data from local weather stations, to continually calculate optimum thermostat settings. EcoFactor doesn't manufacture thermostats. It manages Internet-connected thermostats made by other companies. By continually monitoring and adjusting such thermostats, the company claims to be able to reduce energy consumption associated with heating, ventilating, and air-conditioning (HVAC) energy, with little involvement or discomfort for occupants. The company claims that in utility tests its service reduced the energy consumption of residential HVAC systems by 17 percent, but it has not released the original underlying energy-savings analyses (Fehrenbacher 2011).

So far, the company has racked up some notable successes. In 2009, it won the CleanTech Open business plan competition (Garthwaite 2009). That same year it also executed a three-year agreement with Oncor, the largest utility in Texas, to provide that company with demand response savings. The company obtained $2.4 million in financing from Claremont Creek Ventures and $3.5 million from RockPort Capital Partners (Fehrenbacher 2010). In February 2012, EcoFactor announced that it had come to an agreement with Comcast to offer to its service to all of Comcast's Xfinity Home customers (Fehrenbacher 2012).

To apply the first question to EcoFactor, is the company's service inexpensive? The answer is a qualified no. As there are no other companies that provide the same service as EcoFactor, the price of the service can't be compared to competitors. Instead, to judge the cost of EcoFactor's service, the relevant comparison is the cost of the energy that the service saves. Given that published articles report a price of nearly $9 per month (Slater 2010), at a savings rate of 15 percent of overall HVAC costs, homeowners would need to have average annual heating and cooling bills of $720. Certainly there are many customers with costs that exceed this amount, but for EcoFactor to be attractive to a mass market, it is going to have to lower its price.

To apply the second question, we ask does EcoFactor market to undemanding customers? Here, the answer is clearly yes. In terms of quality and reliability, the company needs only to improve on the performance of setback thermostats, and that performance is demonstrably poor.

In an encyclopedic work, Peffer et al. (2011) reference a multitude of studies documenting widespread dissatisfaction with setback thermostats. In several of the studies, numerous participants report that they don't use the thermostats to achieve energy savings. Many other studies document the main reason why programmable thermostats are underutilized: They are too complicated for many people to use. The usability and utilization of programmable thermostats are so low that EcoFactor, which requires minimal effort and sacrifice from occupants, is well on its way to meeting this challenge.

Based on this framework, it appears that EcoFactor has the potential to succeed. The company has three main challenges. The first is to build credibility by releasing the results of independent studies that support its energy-savings claims. The second is to drive down its price and build scale. The third is to develop a business model that enables it to achieve these goals while remaining profitable and fulfilling the expectations of its financiers.

Conclusion

The framework was useful for gaining insight into the failure of two startup companies bringing new clean energy technologies to market. The framework was also useful for evaluating the prospects of two young companies whose prospects remain to be determined. Four case studies is too small a sample to validate the accuracy of the framework, but it does appear to be a useful tool to help investors to analyze young companies with new technologies. More research is still required to establish the value of the framework and the underlying theory that supports it.

At least one trend is evident from making a comparison between the companies that failed and the companies for which the framework predicts qualified success. In essence, the companies that failed went into competition far too early with market leaders. In both cases, the startup companies were not able to meet the quality and reliability standards of the incumbents. In the case of the companies for which the framework predicted potential, but qualified, success, they both entered markets in which there was no strong market leader. Indeed, in both markets, the products these latter companies sought to either displace or enhance exhibited significant quality shortcomings.

Why do so many clean energy entrepreneurs rush into competition with market leaders? Judging from the first two case studies, there seem to be two reasons. The first is that they are drawn to the sheer size of the market leaders' customer bases. Entrepreneurs need only convince their investors that they can capture a small amount of market share from market leaders in order to project large revenues. The second is that entrepreneurs like to see themselves as Davids, mitigating the environmental consequences caused by the products of the market leader Goliaths. It's far less appealing to sell clean energy products to customers who weren't really going to buy from the market leaders. Entrepreneurs who can avoid these pitfalls would seem to be able to improve the likelihood of their success.

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