The Advocate's Dilemma: Applying Clayton Christensen's Work to Speed the Diffusion of Energy Efficiency Technologies

Jay Stein, E SOURCE

ABSTRACT

When theories about "disruptive" technologies became popular in the late 1990s, advocates were quick to apply the term to energy efficiency technologies. Based on such theories, efficiency advocates hailed the ultimate dominance of their favored technologies over current conventional energy technologies. These disruptive technology theories were largely popularized by Clayton M. Christensen, a professor at Harvard Business School, and the author of the best-selling business book *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. This book, which was released in 1997, defined disruptive technologies as those that upset existing business value networks, and in many instances, led to the downfall of large and powerful organizations.

Christensen's ideas about disruptive technologies, however, were widely misunderstood by efficiency advocates. Successful energy efficiency technologies are almost never disruptive. Furthermore, Christensen's work predicts that the techniques favored by efficiency advocates, such as paying incentives and augmenting codes and standards, are inappropriate for disruptive technologies. Advocates can enhance their likelihood of success by limiting their advocacy work to technologies that are not disruptive. Advocates who choose to focus on disruptive technologies anyway will find their best opportunities by seeking out disdained customer classes who can use the disruptive technology to obtain an amenity they desire, but previously could not obtain access to.

Introduction to Clayton Christensen's Work

Clayton M. Christensen is a professor at Harvard Business School. His best known publication is undoubtedly the book *The Innovator's Dilemma*, *When New Technologies Cause Great Firms to Fail*, which won the 1997 Financial Times/Booz-Allen & Hamilton Global Business Book Award. This book detailed Christensen's theories about how large organizations manage technological change and how new technologies find markets. His theories were subsequently elaborated on in numerous other publications including magazine articles and two more books, many of which Christensen coauthored with others (Christensen 1997).

In *The Innovator's Dilemma*, Christensen explained the observation that led to the development of his theories. A friend of his noted that geneticists study fruit flies, because these diminutive animals "are conceived, born, and die within a single day." According to Christensen, this same friend suggested that for those who would study the business world, disk drive companies are analogous to fruit flies (Christensen 1997).

Inspired by this observation, 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. Key to understanding this work is to understand the two principal distinctions Christensen used to describe new technologies: sustaining and disruptive (Christensen 1997).

Sustaining Technologies

Christensen defined sustaining technologies as those that sustain their industry's rate of improvement in product performance. In his lexicon, these technologies are designed to provide demanding, high-end customers with better performance than what those customers could previously obtain. Furthermore, such better performance often comes at the expense of higher first cost. Lastly, Christensen found that the development and commercialization of these technologies was almost always led by established market leaders. Indeed, he concluded that in literally 100 percent of the cases he studied, the adoption of sustaining technologies was led by such companies (Christensen 2002).

The T-8 lamp is an exemplary sustaining technology. Although initially more expensive then the dominant (at the time) T-12 lamp, when combined with a high-frequency electronic ballast, the T-8 lamp enabled commercial building owners to enjoy better quality light with lower operating costs. Furthermore, the manufacture of such lamps was ultimately dominated by market incumbents such as General Electric, Osram Sylvania, and Panasonic.

Disruptive Technologies

Technologies labeled "disruptive" were so distinguished because, according to Christensen, they disrupted value networks. He defined such networks as being "the context within which a firm establishes a cost structure and operating processes and works with suppliers and channel partners in order to respond profitably to the common needs of a class of customers." Successful disruptive technologies differ from their sustaining counterparts in two important ways: they are more accessible (i.e. they are typically simpler, more convenient, and less expensive), and they are also designed to appeal to new or less-demanding customers. In general, disruptive technologies that succeed are those that enable less skilled or less wealthy customers to do for themselves things that only the wealthy or skilled customers could previously do (Christensen & Raynor 2003).

Christensen concluded that disruptive technologies were virtually the exclusive domain of new market entrants. Indeed, Christensen concluded that by focusing on disruptive technologies, new market entrants could greatly improve the odds of their success. He found that of the products contained in his database, new market entrants succeeded only 6% of the time when they offered sustaining technologies, but succeeded 33% of the time when they offered disruptive technologies. This may seem counterintuitive, given the extremely risky nature of disruptive technologies, but because new market entrants are also extremely risky ventures, there seems to be a synergy between the two concepts. Not only did offering disruptive technologies improve the likelihood of success for new market entrants, but as a corollary to that success, disruptive technologies enabled these companies to dethrone the incumbent market leaders (Christensen 2002).

Christensen described the process by which disruptive technologies led to the downfall of dominant firms as starting when a disruptive technology gained a foothold in new or low-end markets. He wrote: "… the (disruptive) technology eventually improves enough to intersect with the needs of more demanding customers. When that happens, the disruptors are on a path that will ultimately crush the incumbents (Christensen & Raynor 2003)."

One example of a disruptive technology is the Sony transistor radio. In the early 1950s, radios contained vacuum tubes and were sold by appliance stores that made most of their profit replacing burned-out tubes. The major radio manufacturers of the time, including RCA, investigated the new solid state transistors, but decided that their quality wasn't good enough for contemporary radio consumers. Sony didn't try to pursue those customers with its product. Instead, Sony found a new market for radios: teenagers, most of whom couldn't afford expensive vacuum-tube radios. The transistor radio offered teenagers the opportunity to listen to rock-and-roll music in locations their parents didn't control. This new customer class was delighted, despite the poor sound quality of early transistor radios, because its alternative was no rock and roll music at all (Christensen & Raynor 2003).

Sony also had to find a new distribution channel. The existing radio retailers weren't interested in a product that didn't contain tubes. Instead, Sony marketed its product through a new distribution channel: the discount retailer. These new stores, such as Korvette's and Kmart, lacked the sophisticated staff required to replace tubes, but they did know how to sell to teenagers (Christensen & Raynor 2003).

From such undistinguished beginnings, transistor radio technology improved to the point that it became good enough to compete with vacuum tube products. At that time, the incumbent radio manufacturers, which included RCA, tuned-out. Today, virtually all consumer radios contain transistors (Christensen & Raynor 2003).

The Sony transistor radio enjoyed many of the attributes that distinguish successful disruptive technologies: it was less expensive than the incumbent technology; it was marketed to a customer group that was ignored by the incumbent's distribution channel; it enabled that customer group to accomplish something that it yearned to do but previously couldn't because it couldn't afford the incumbent technology; it was manufactured and distributed by new market entrants; it took root without the incumbent technology's value network taking notice of it; and ultimately, it displaced the incumbent technology, putting much of the incumbent's value network out of business.

How Christensen's Work Was Interpreted by Efficiency Advocates

The conclusions the energy-efficiency advocacy community generally drew from Christensen's work are typified by Lovins et al (2005). In this study, the authors identify a set of strategies, technologies, and public policies which they identify as being "fundamentally disruptive to current business models." This set includes: doubling the efficiency of oil consuming technology; superefficient light vehicles, heavy trucks, and airplanes; biofuels; and using efficiency techniques to save natural gas. The authors then go on to invoke Christensen's theory of disruptive innovation:

"In *The Innovator's Dilemma*, Harvard Business School professor Clayton Christensen explained why industry leaders often get blindsided by disruptive innovations—technological gamechangers—because they focus too much on today's most profitable customers and businesses, ignoring the needs of the future. Firms that are quick to adopt innovative technologies and business models will be the winners of the 21st century; those that deny and resist change will join the dead from the last millennium."

The logic is clear to the reader: Efficiency and renewable energy technologies are disruptive. Disruptive technologies lead to the fall of dominant businesses. Therefore, efficiency and renewable energy technologies will lead to the fall of dominant businesses.

Such ideas are not exclusive to Lovins and his collaborators. EPRI (2001) wrote that "PV (photovoltaics) possesses many of the attributes of a disruptive technology." Drawing on Christensen's work, but more tenuous in his approach than Lovins et al, EPRI (2001) merely asserted that "It is possible—though certainly not assured—that PV could emerge in a reordered energy arena as an enabler of benefits and structure that are as-yet only dimly articulated." Horning, Seville, and Waddington (2002) declared that "DG (distributed generation) is a new and disruptive technology," and went on to assert that "Energy providers (will) shift from selling kWh through capital intensive transmission and distribution systems to selling on-site energy services and solutions."

The logic sequence asserted by Lovins et al fails in several ways. First, efficiency and renewable energy technologies are not necessarily disruptive. Indeed, the vast majority of such technologies have been deployed using sustaining strategies. Second, disruptive technologies don't necessarily lead to the fall of dominant businesses. According to Christensen, not only do most disruptive technologies fail, but they are even more likely to fail if they are not brought to market in a certain manner. Third, the tools favored by efficiency advocates, such as paying incentives and augmenting building codes, are inappropriate for disruptive technologies.

Lessons from Christensen's Work for Efficiency Advocates

If efficiency advocates are to take one lesson away from Christensen's work, it's that the chances for a technology to succeed are at their highest when strategy, distribution channel, and customer are consistent with the technology type. For example, a sustaining technology is most likely to succeed when it is brought to market with a sustaining strategy, manufactured and distributed by incumbent market players, and sold to customers valued by those incumbents. A disruptive technology is most likely to succeed when it is brought to market with a disruptive strategy, manufactured and distributed by new entrants, and sold to customers underserved by the incumbents. To choose between these two models of technological innovation, it's also essential that advocates clearly understand which technologies are truly sustaining, and which are disruptive.

Efficiency Technologies Are Rarely Disruptive

Christensen & Anthony (2003) wrote "Few technologies are inherently sustaining or disruptive. Shaping an innovation into a disruptive-growth business is a strategic choice." In other words, any given technology may well be either sustaining or disrupting, depending on how it is deployed in the marketplace. Indeed, most efficiency and renewable energy technologies have been deployed following a sustaining strategy. According to Christensen, such a strategy consists of targeting "demanding, high-end customers with better performance than what was previously available (Christensen & Raynor 2003)." In contrast, a disruptive strategy is one that "offers a product or service to people who would otherwise be left out entirely or poorly served by existing products (Hart and Christensen 2002)."

Few successful energy efficiency technologies have been brought to market utilizing a disruptive strategy. Campbell et al. (2001) identified three exemplary efficiency technologies whose success was apparently sped along by government sponsored research, incentive programs, and building and equipment standards and codes: more efficient refrigerators, electronic ballasts, and low-e windows. All three of these technologies were brought to market as sustaining technologies. Each offered better energy performance and other amenities at the expense of higher first cost. In addition, all were ultimately manufactured by the same companies that dominated the industry before these products came along.

It's certainly possible for efficiency technologies to be deployed following a disruptive strategy. The ultimate example of a disruptive efficiency technology is the Boulton-Watt steam engine, which took advantage of a four-fold increase in efficiency over predecessor coal-fired engines to displace virtually all the dominant drivepower technologies of its day.

Boulton and Watt originally attempted to market their product as a sustaining innovation, promising energy savings to coal mine operators for their water pumps. This approach failed, as the coal miners asserted that they already had plenty of coal and weren't willing to change pump suppliers simply to obtain energy savings. Boulton and Watt then switched strategy and marketed their product to the copper miners of Cornwall, who were underserved by the existing technology of the day. The copper miners were importing their coal by sea at great expense, and were frustrated by the limitations in mine depth posed by the incumbent technology. Not only did Boulton and Watt's product mitigate both of these problems, but in addition, Matthew Boulton developed an innovative financing scheme that enabled the entrepreneurs to sell their product at a lower first cost than the incumbent technology. This strategy was successful, and the Boulton-Watt steam engine took root among the copper miners of Cornwall.

Few efficiency technologies are brought to market following the pattern established by Boulton and Watt. A far more common strategy employed by efficiency technology vendors is to target customers who are already well served by contemporary technologies with products that cost more initially, but promise lower operating costs over their lifetime.

Techniques Favored by Efficiency Advocates Won't Work with Disruptive Technologies

It's a good thing that efficiency and renewable energy advocates rarely encounter truly disruptive technologies, because the three most popular techniques used by advocates to accelerate technological diffusion are unlikely to succeed when applied to disruptive technologies. Such techniques include incentive programs, code and standard provisions, and government funded research

Incentive programs are based on the theory that higher first cost is a key barrier to the diffusion of efficiency technologies. To overcome this barrier, the incentive-paying entity, typically a utility or government agency, offers potential buyers either the full difference in cost between the efficiency technology and its conventional counterpart, or some portion of that cost. In the case of disruptive technologies, at least initially, cost is a relatively minor barrier to the technology's acceptance.

A far more potent barrier is that the target audience for the incentive program is likely to be dominated by customers who are already well-served by the incumbent technology. Such customers are unlikely to switch to an unusual and suspicious technology simply to gain energy savings. Furthermore, because the disruptive technology is typically banned from the incumbent technology's distribution network, the disruptive technology is disadvantaged in three ways: The customer is unlikely to even know about the existence of the disruptive technology. Should the customer find out, he or she will be informed by the incumbent's distribution network about the shortcomings of the disruptive technology. Lastly, the customer knows that he or she would have to rely on a new and unproven distribution network to install and service the disruptive technology. Because of these barriers, customers who are already well served by the incumbent technology are unlikely to adopt a disruptive one no matter how much less expensive it is than the incumbent.

Incorporating requirements into building codes and equipment standards that require the use of disruptive technologies is also unlikely to work. As soon as the market incumbents find out that such a code change is in the works, they will use their superior economic and political power to quash such requirements. Government-funded research and development efforts are also susceptible to similar pressure. In addition, government scientists are unlikely to understand the under-served customer classes that disruptive technologies are initially targeted for. The government bureaucrats that approve such research are unlikely to get excited about research intended to benefit such customers. The key lesson for advocates is to clearly distinguish between sustaining and disruptive products, and apply the traditional policies of incentives, standards, and research only to sustaining products.

How to Succeed at Bringing Disruptive Technologies to Market

Christensen's most salient advice to those who would seek to promote disruptive technologies is: "Forcing a potentially disruptive innovation into a sustaining business model—thereby putting it on a collision course with incumbents—will only ensure its early demise." To avoid such a collision, Christensen recommends "…such technologies must be incubated and refined where they can be profitably deployed through disruptive strategies, in markets where they do not compete against established systems (Hart & Christensen 2002)." In other words, Christensen recommends that disruptive players do all they can to stay below the radar of incumbent competitors. This overarching recommendation leads to several specific recommendations for strategy, distribution channel, and customer class.

For strategy, Christensen recommends "competing against nonconsumption (Hart & Christensen 2002)." In other words, he suggests vendors use more efficient technology to craft products that enable customers who currently can't afford a given amenity to gain access to that amenity. Not only does the disruptive technology avoid bruising competition, but it also doesn't have to be as good as the incumbent technology. Customers are delighted by the disruptive technology, even if it doesn't work especially well, because their alternative was to go without the amenity altogether. For example, as discussed above, the teenagers who bought the early Sony transistor radios were so delighted that they could finally listen to rock-and-roll music with their friends, they were willing to accept poor sound quality.

The problem for efficiency advocates is that this strategy does not produce energy savings in the short run. It may well lead to an increase in energy consumption as customers who otherwise would have gone without a given amenity start to consume energy to obtain it. Efficiency advocates may well argue that in later stages, when the new technology begins to displace the incumbent technology in mainstream markets, energy savings will be achieved.

To reach that point, however, requires the cultivation of a new distribution channel, just as the Sony radio was marketed by discount retailers. Christensen uses an expansive concept of distribution channel: "The term channel as it is commonly used in business refers to the wholesale and retail companies that distribute and sell products. We assign a broader meaning to this word, however: A company's channel includes not just wholesale distributors and retail stores, but any entity that adds value to or creates value around the company's product as it wends its way toward the hands of the end user (Christensen & Raynor 2003)."

Lastly, the targeted customer class should be one that is disdained by the incumbent distribution channel, much as the Sony transistor radio took root with teenagers. However, such a disdained customer class is not likely to have much purchasing power, so products offered to it must be relatively inexpensive.

Although there are undoubtedly many advocates who are capable of carrying out such tactics, it's not likely many would choose to do so. Just as the incumbent value networks disdain both disruptive technologies and customer classes, so do many policy makers, especially as their prospects for achieving energy savings lay entirely in the long-term future. Instead, the development of disruptive technologies is probably best left to entrepreneurs who have an intimate understanding of both the technology as well as the disdained customer class.

Case Study: Photovoltaics

To the author's knowledge, Christensen has never written extensively about a particular energy efficiency technology, but he has written many times about a renewable energy technology: photovoltaics. In this work, Christensen lamented the small market share achieved by the solar electric industry, and criticized it for attempting to disrupt the electric utility industry by offering a sustaining product. He also described how the photovoltaics industry might advance itself by developing a disruptive product.

In Christensen & Raynor (2003) the authors write regarding solar electricity: "It defies profitable commercialization despite billions of dollars invested to make the technology viable. This is indeed daunting when the business plan is to compete against conventional sources of electricity in developed countries." What they mean by this is that in the developed world, the electric utility industry thoroughly dominates the electricity sector, to a large extent because it controls a "well-developed, sunk-cost grid system." According to Christensen's theory, it's difficult to disrupt such a powerful incumbent, and virtually impossible if one employs a sustaining strategy. Selling photovoltaic panels to customers already hooked up to the electric grid is a thoroughly sustaining strategy.

Instead, Christensen suggests that the photovoltaic industry look to the less developed world as fertile ground for a disruptive photovoltaic technology to take root. He notes that in such countries, there are large rural areas in which no electric grid system yet exists, and probably won't for many decades. For customers in such areas Christensen theorizes that "Pioneering companies will have to optimize a new technology… and develop production, sales, service, and microfinancing packages that enable nonconsumers to gain access (Hart & Christensen 2002)."

Christensen doesn't expect that such companies would offer the same solar panels designed for use in developed countries. As an alternative, he proposes that such products be made by depositing thin films on flexible substrates using roll-to-roll processes. Although he doesn't say so explicitly, he would likely advise entrepreneurs to avoid the expensive batteries and power electronics used in wealthy countries to provide electricity at night and during cloudy days, by suggesting that developing country products need only be better than no electricity at all.

Another thing that Christensen doesn't explicitly write but hints at is skepticism that such systems could be developed and brought to market by the companies that currently dominate the photovoltaic industry. These companies are heavily invested in manufacturing products designed to enable developed world customers to garner government subsidies. In Christensen & Raynor (2003) the authors conclude that "If history is any guide, the commercially viable innovations in clean energy will not come from government-financed research projects designed to make solar energy a preferred source of power in developed markets. Rather, the successful innovations will emerge from companies who carve disruptive footholds by targeting nonconsumption and moving up-market with better products only after they have started simple and small."

Case Study: Low Energy Cooling Technologies

In *The Innovators Dilemma* Christensen devoted a chapter to describing how he might apply his theories to bring a disruptive technology to market. He speculated about a variety of actions he might take if he were tasked with marketing an electric vehicle. To illustrate what an efficiency advocate might do to stimulate the diffusion of a disruptive energy technology, this section speculates how its author might approach such a challenge for low energy cooling technologies.

The low energy cooling label comprises a wide variety of technologies that provide thermal comfort for buildings but consume less energy than the market dominating refrigeration-based technologies. Examples of low-energy systems include those that make use of water evaporation, passive air flows, and desiccants. Although numerous public agencies have tried for decades to increase the market penetration of such technologies, these efforts have been relatively unsuccessful. Typical reasons given for such failures are the: the dominance of the refrigeration-based air conditioning industry, a lack of information among potential buyers, and concerns about the quality of low-energy technologies. All of these are classic barriers faced by disruptive technologies.

It's only logical that low-energy cooling systems should face such barriers given that they are disruptive technologies. The manufacturers, distributors, and installers of these technologies are, for the most part, different than those who inhabit the incumbent technology's value network. Because low energy cooling technologies are disruptive, Christensen's analysis predicts that their market positions would not be improved by the classic techniques employed by energy efficiency advocates.

Were the author to attempt to bring such a technology to market, the first step would be to find a disdained customer class to market to. I would do research to understand the market for non-air-conditioned buildings. Furthermore, I would attempt to learn what portion of this market would like to have air conditioning, but can't afford current refrigerated systems.

Next, I would work with technologists to design a low energy cooling system that enabled these customers to obtain comfort cooling at a much lower first cost than refrigerated systems. Lower first cost would be a much higher priority than lower operating costs. I wouldn't bother trying to design a system that offered the same level of comfort and convenience as refrigerated systems. My low energy cooling system would only need to be better than no air conditioning at all.

Once such a system were designed, I would attempt to find a distribution network that already had a relationship with the customers I identified, and was capable of manufacturing, marketing, selling, installing, and servicing my low-energy cooler. Such a network would probably be made up of multiple companies, none of whom would be in the refrigerated cooling business. I would contact the key players within this network and encourage them to get into the low-energy cooling business. I would probably offer them some sort of inducement, like subsidized market research, marketing, and training. I wouldn't offer these players incentives to reduce their capital costs. I would expect them to take ownership of their product and to bring to market a product inexpensive enough to appeal to their potential customers.

I would hope that my low energy cooling technology would catch on with these customers, and that eventually this distribution network would improve its capabilities to move upmarket. Surely, this would be a risky strategy, but any strategy involving disruptive technologies is. Furthermore, it wouldn't save any energy at first, since the early adopters would be people who had no intention of purchasing a refrigerated air-conditioning system. Instead, I would hope that the entrepreneurs I encouraged would ultimately bring to market a product that could disrupt the incumbent air-conditioning industry.

Conclusions

Disruptive technology theories developed by Clayton Christensen have been widely misinterpreted by energy efficiency advocates. These theories do not predict the ultimate dominance of energy efficiency technologies. Instead, they suggest that successful energy efficiency technologies are rarely disruptive and the techniques widely favored by advocates are unlikely to succeed when applied to disruptive technologies. Advocates would probably find it easier to restrict their efforts to sustaining technologies. Advocates who decide they want to stimulate the market diffusion of disruptive technologies anyway can improve their chances for success by competing with nonconsumption. This strategy would include identifying a customer class disdained by the incumbent technology, and encouraging the emergence of a new value network to serve these customers.

References

Campbell, Richard et al. 2001. *Energy Research at DOE, Was it Worth It?* National Academy of Sciences.

Christensen, Clayton M. 1997. *The Innovators Dilemma*. Boston, Mass.: Harvard Business School Press.

______. 2002. "The Rules of Innovation." *Technology Review*. June.

Christensen, Clayton M. and Scott D. Anthony. 2003. "Solving the Dilemmas of Growth." *Strategy & Innovation*. July-August.

Christensen, Clayton M. and Michael E. Raynor. 2003. *The Innovator's Solution: Creating and Sustaining Successful Growth*. Boston, Mass.: Harvard Business School Press.

EPRI. 2002. "Is PV the PC of the 21st Century? Photovoltaics as a Disruptive Technology." *EPRI Journal* (October 22).

Hart, Stuart L. and Clayton M. Christensen. 2002. "The Great Leap, Driving Innovation From the Base of the Pyramid." *MIT Sloan Management Review*. Fall.

Horning, Andrew, Don Seville, and Ryan Waddington. 2002. "Commercializing Distributed Generation: A Customer-Based Collaborative Learning Project." A research briefing to the Sustainability Consortium of the Society for Organizational Learning (March 26).

Lovins, Amory et al. 2005. *Winning the Oil Endgame*. Snowmass, Co.: Rocky Mountain Institute.