

Case Study: A123 Systems

Local Markets and Competitiveness

A Value Chain Analysis

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None of the opinions or comments expressed in this study are endorsed by the companies mentioned or individuals interviewed. Errors of fact or interpretation remain exclusively with the authors. We welcome comments and suggestions.

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Executive summary

In an era when many U.S. companies are sending jobs overseas, battery maker A123 Systems, Inc. represents an unusual twist to the familiar outsourcing story. This U.S. company established operations in Asia in recent years to manufacture batteries for consumer use. Incorporated in 2001, A123 Systems originally supplied batteries to Black & Decker for consumer products. Subsequently the company shifted its focus to advanced batteries for motor vehicles, and now it is aggressively expanding production in the United States.

A123 Systems to date has excelled by producing a battery with a 10-year life span that emphasizes safety and durability, which has enabled the company to win contracts despite competing with larger, more established players. Its automotive customers already include BAE, Eaton, Fisker, Navistar, and Shanghai Automotive Industry Corporation (SAIC). The company continues to accelerate battery performance while bringing down production costs, and it is emerging as a technological leader in the field.

In making its international location decisions, A123 Systems, like many clean energy firms, faces a complex set of factors that can be described as “push” (favoring production offshore) and “pull” (favoring production in the United States). Our analysis of A123 Systems’ location decisions yields the following key findings:

1. **The primary drivers of offshore locations for A123 have been low labor costs, ease of setting up facilities, and 20 years of experience by Asian countries in manufacturing lithium-ion batteries for consumer electronics.** Another key factor is a consistent lack of financial commitment from the U.S. investment community, which is accustomed to funding technology ventures instead of establishing plants in the United States.
2. **Strategic support in the form of \$249 million from the U.S. Department of Energy (DOE) and an additional \$125 million in incentives from the state of Michigan were major pull factors that enabled A123 to establish new manufacturing capabilities in the United States.** Other important pull factors for the United States include: a large established automotive industry; one of the world’s top markets for vehicles; preeminent research facilities such as universities and national laboratories; and the presence of significant niche markets, including military, medical, and aerospace applications.
3. **A123 Systems’ competitive advantages include its core competency in li-ion batteries, its proprietary nanophosphate technology, and its product diversification.** While many new battery entrants are larger firms seeking to create internal divisions,

A123 has lithium-ion batteries as its core competency. It has developed a superior nanophosphate electrode design that distinguishes its product from other advanced batteries. And it has targeted the full range of electric vehicles, such as hybrids (including buses), plug-in hybrids, and fully electric models. These characteristics give A123 Systems important advantages over many of its competitors.

4. **To compete against Asian competitors, A123 and other U.S.-based battery firms will need to focus on lowering production costs and offering superior products.** Asian firms have low-cost labor and many years of battery production experience. U.S.-based manufactures can confront these factors head-on through high-level automation in their production processes, and by offering batteries that are superior in the key areas of quality, safety and durability.

Global lithium-ion battery industry

In the manufacture of lithium-ion batteries for hybrid and electric vehicles, the leading countries are China, Japan, South Korea, France, and the United States.

Largely thanks to the well-established battery industry for consumer electronics, Asia claims an overwhelming market share in lithium-ion batteries. In 2007, Japan held 57% of the market, while Korea had 17%, and China had 13% (METI, 2010). As for the United States, only one company appears in the top 14 firms (see Figure 1).

A123 Systems, Inc. has a 1% world market share, which situates it as the world's 14th largest lithium-ion battery manufacturer (NEDO, 2009).

Figure 1. World share of lithium-ion batteries for consumer use

1. Sanyo (Japan)	23%
2. Samsung (Korea)	15%
3. Sony (Japan)	14%
4. BYD (China)	8.3%
5. LG Chem (Korea)	7.4%
6. BAK (China)	6.6%
7. Panasonic (Japan)	6.0%
8. Hitachi Maxell (Japan)	5.3%
9. ATL (China)	3.8%
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14. A123 Systems (U.S.)	1%

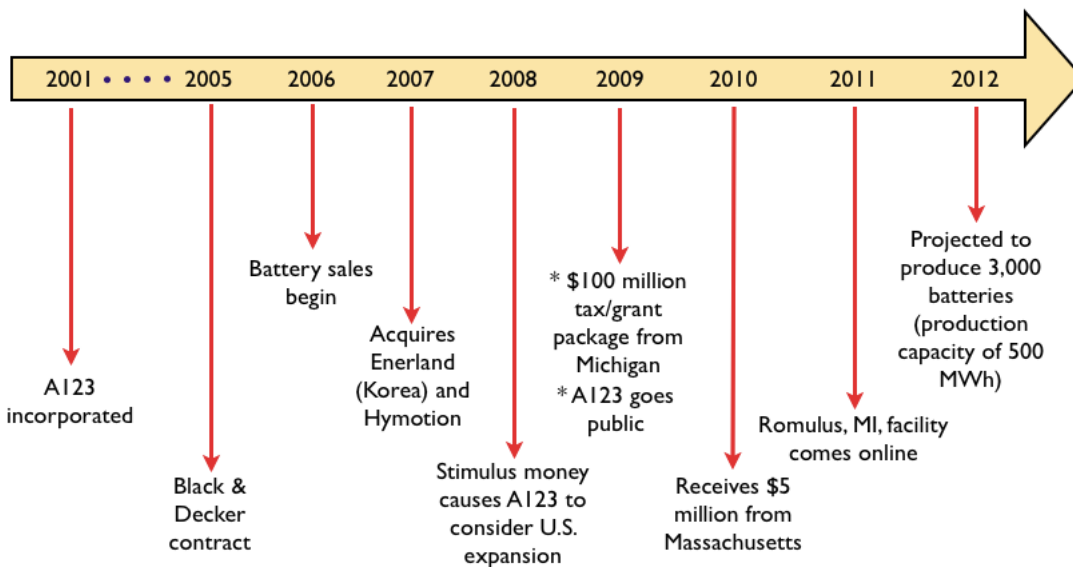
Source: (NEDO, 2009)

The total lithium-ion battery market is projected to reach \$66 billion by 2020. By then, according to one estimate, 17% of automobile sales could be hybrid-electric vehicles (HEVs), plug-in hybrid-electric vehicles (PHEVs), and full battery-electric vehicles (BEVs), up from 1% today. Other estimates put electric vehicles' market share by 2020 as high as 50% (PRTM, 2010). Due to the growth in demand for lithium-ion batteries, A123 is projected to earn \$2.1 billion per year in revenue by 2014, solely from automotive applications (Deutsche Bank, 2009). The United States is projected to become the largest producer of electric vehicles by 2015 (Nishino, 2010).

A123 Systems company profile

A123 Systems is a lithium-ion battery maker based in Watertown, Massachusetts. Incorporated in 2001, the company uses proprietary nanophosphate technology built on materials initially developed at the Massachusetts Institute of Technology (MIT). A timeline of the company's development is found in Figure 2. A123 initially sold its batteries through lucrative contracts, primarily with Black & Decker, a large toolmaker, and with BAE Systems, a defense contractor. In 2005, when Black & Decker selected the company as its supplier, A123's batteries had four times the power and ten times the life span of the incumbent Japanese supplier's products (Deutsche Bank, 2009). The relationship with Black & Decker subsequently declined, as A123 moved to diversify into other products and clients. Revenue from Black & Decker diminished from 66% in 2007, to 44% in 2008, to 14% in 2009 (Kanellos, 2010b). A123's new supplier agreements included Chrysler and Fisker Automotive, in which A123 invested \$35 million in 2007. By the end of 2009, business had shifted from consumer-based products to grid storage and automotive applications (Dunn, 2010).

Figure 2. A123 Systems timeline



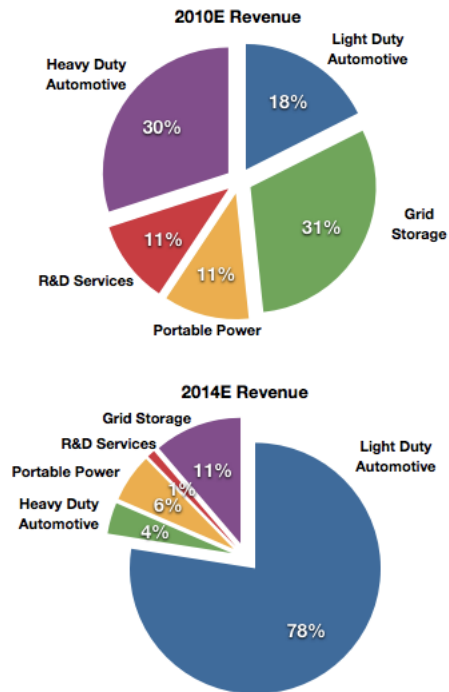
Source: CGGC

A123 is quite vertically integrated, encompassing research and development (R&D), design, manufacturing, and sales of rechargeable lithium-ion batteries and battery systems. To date, the company has operated at a net loss, despite a vaunted 2009 IPO. Sales are nevertheless growing quickly, and the company is expanding production capacity for automotive batteries in three locations in Michigan. Several of A123's automotive customers are poised to move into full

production, including SAIC Motor Co. Ltd (a leading automaker in China) and Fisker Automotive (a “green” sports car maker in the United States).

The company has three main product markets: automotive, electric grid services, and consumer electronics. A123 will largely focus on automotive applications in the coming years, but there is potential for synergies in the renewable energy sector if A123 gets further involved in grid systems, including, for example, load management. As Figure 3 demonstrates, revenue for A123 will shift predominantly to light-duty automotive applications in the coming few years (Deutsche Bank, 2009).

Figure 3. Projected revenue for A123 Systems in 2010 and 2015, by sector



A123 currently has a capacity of 169 MWh, which is approximately equal to 7,000 EV battery packs, or 85,000 hybrid battery packs (Deutsche Bank, 2009). By 2012, the company hopes to have a production capacity of 500 MWh. Shipments are advancing steadily toward this goal. In 2009, the company shipped 66.5 MWh worth of batteries, up from 44.9 million in 2008 (Kanellos, 2010b). A123 aims to produce 1,000 batteries by 2011, and 3,000 by 2012.

According to company statements, net losses for 2009 were \$85.8 million, up from \$80.5 million in the previous year. Revenue continued to grow to \$91 million in 2009, a 33% increase from the previous year (see Table 1). The company had 1,819 employees as of June 1, 2009, with 227 in R&D, 1,440 in manufacturing, 31 in sales, and 121 in administration. About 317 employees were located in the United States, and 1,502 abroad, overwhelmingly in China (Kanellos, 2009).

Table 1. A123 Systems revenue and employees, 2006-2009

Year	Revenue (millions)	Employees
2005	\$0.7	
2006	\$34.3	
2007	\$41.3	
2008	\$68.5	1,819
2009	\$91.0	1,700

Source: Hoovers.com and (Kanellos, 2009)

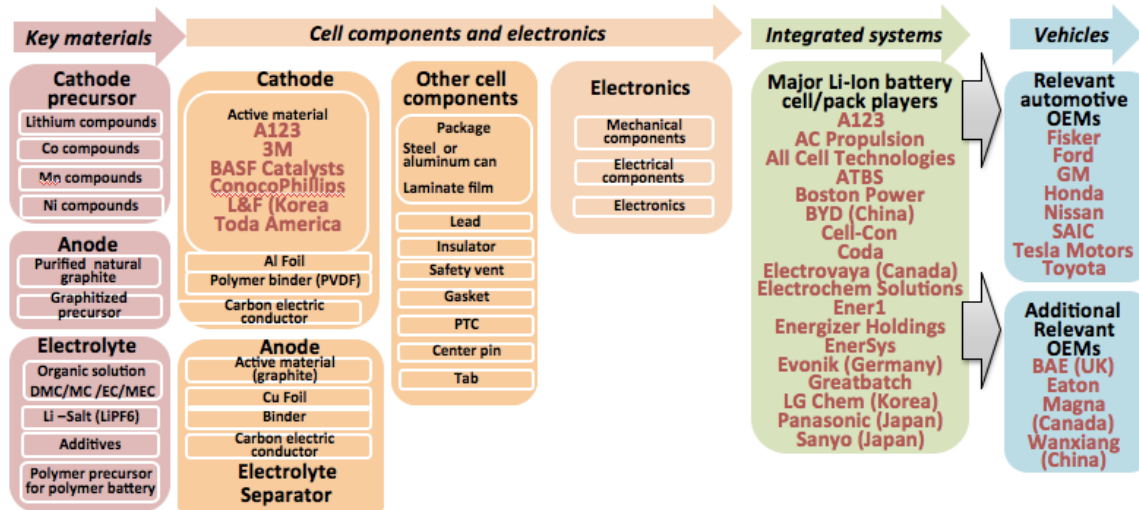
A123's headquarters and research labs are all in the United States. Manufacturing capacity is currently located in Asia, except for module design and pack assembly for grid storage, which take place in Hopkinton, MA. A123 is focusing its sales and marketing work in Europe and the United States, where it can capitalize on heightened interest in order to develop domestic battery-manufacturing capacity. One contract resulting from this strategy is Continental (a German automotive manufacturer), which will include A123 cells in its battery packs. A123 has five factories in Changzhou, China, and sales offices in various locations throughout the United States, Asia, and Europe. In 2007, A123 acquired Korean subsidiary Enerland, which makes prismatic cells. The company's facilities in Changzhou, China, by contrast, make cylindrical cells. As A123 moves ahead, it appears to be shifting part of its manufacturing base to the United States, where its research and development (R&D) hubs are primarily located.

Value chain dynamics

A general depiction of the value chain for the lithium-ion vehicle battery industry is found in Figure 4. The flow of activities begins with key materials and precursors, and moves on through cell components and electronics, to integrated systems, and finally to the relevant original equipment manufacturers (OEMs), which make vehicles using battery systems.

In the popular press, one oft-cited worry for the supply chain is a potential shortage of the raw material, lithium. However, research indicates that this concern is overblown. First, the quantity of lithium required to make an electric car battery is very small; one battery maker estimates that existing lithium resources could supply 33 billion full hybrid-electric vehicles (Compact Power, 2010). Second, while much of the world's supply of lithium is concentrated in South America (Chile, Argentina and politically unstable Bolivia), large deposits are also found elsewhere, including in China, Afghanistan, and Australia. A number of new lithium mining companies are appearing across the globe (Wright, 2010). In our interviews with battery firms, no respondents expressed concern about lithium supply.

Figure 4. Value chain of lithium-ion batteries for electric vehicles



Source: CGGC

A123 Systems holds an important position in two crucial parts of the value chain, as a major battery cell/pack player and a leader in cell components. The heart of the battery is the cell, which is composed of four major components: anodes, cathodes, separators, and electrolyte solution. Among the four most popular chemistries for the cathode, A123 has carved out a niche in lithium phosphate. This proprietary battery design, rooted in nanotechnology, currently has less energy and power density than other types, but it has a major advantage in that it is considered much safer, with a lower potential incidence of “thermal runaway reactions” (Kanellos, 2010a).

Based on A123’s impressive ability to win contracts, despite competing with larger, more established players, the company is well positioned to grow and become a leader in the automotive battery industry. Its automotive customers already include BAE, Eaton, Fisker, Navistar, and Shanghai Automotive Industry Corporation (SAIC) (A123 Systems, 2010). According to Deutsche Bank, A123 could potentially capture a 10% market share of the lithium-ion battery market (Deutsche Bank, 2009).

A123 Systems’ competitive edge

A major competitive advantage of A123 Systems is the fact that lithium-ion batteries are its core competency. In order to enter this potentially lucrative market, many larger companies are seeking to create internal divisions, often specializing in only limited portions of the value chain. A123 has developed a superior nanophosphate electrode design that distinguishes its product

from other advanced batteries. As the field grows with less experienced entrants, A123's core competencies and established performance in cell technology will give it a needed edge.

Deutsche Bank has identified three areas in which A123 excels: geographic, vehicular, and product diversification. A123 is uniquely positioned to serve several geographic markets, including Asia, North America, and Europe. The company has not limited itself to any single vehicular or product application, targeting all types of electric vehicles, including HEVs, PHEVs, and BEVs, as well as hybrid buses (Deutsche Bank, 2009). In fact, A123 supplies batteries and battery systems to BAE Systems for the best-selling hybrid bus in the world (Orion Bus), to Daimler for the Citaro Bus (used in New York City's bus fleet), and to Magna for Volvo's 7700 bus. In total, these give A123 a near-50% market share of all HEV buses in the world (Deutsche Bank, 2009). A123 demonstrated further commitment to diversification when it bought Toronto-based Hymotion in 2007, the nation's top seller of HEV-to-PHEV conversion kits.

China's largest domestic automaker, Shanghai Automotive Industrial Corporation (SAIC), selected A123 to supply batteries for the hybrid version of its Roewe 750. A mild hybrid model is expected to launch in late 2010, with a plug-in hybrid to come out in 2012 (Pure Green Cars, 2010). Typifying China's push to become a major electric vehicle manufacturer, SAIC is moving ahead with EVs and PHEVs in 2012 and 2013. The fact that SAIC selected A123 as its battery supplier puts A123 in a favorable position for winning future contracts (Deutsche Bank, 2009).

International location decisions

When A123 first looked for investment capital to build domestically, it met with incredulity from Wall Street and Silicon Valley, since nearly all battery manufacturing was already performed in Asia. As a region, Asia offered distinct advantages, including faster set-up of plants, easier access to supplies and equipment, and local personnel with the know-how needed to establish a battery plant (Lee, 2010). In an interview with the Los Angeles Times, company co-founder Dr. Yet-Ming Chiang explained that A123 preferred to establish its manufacturing base in the United States because of the U.S. roots of the co-founders, employees, and technology (much of the innovation grew out of MIT labs) (Lee, 2010).

However, A123 did indeed establish manufacturing capabilities in China—eventually building five plants there—so that it could begin delivering on future contracts. The major factors that influenced A123's decisions to locate in China include lower labor costs, ease of setting up production, and the U.S. investment community's reluctance to prioritize domestic production facilities.

Since 2009, the company has moved quickly and aggressively to expand manufacturing capacity in the United States. In our conversations with A123, it became clear that the \$249 million in stimulus funds that the company received from the DOE was the reason for choosing the United

States for the company's domestic manufacturing expansion. The state of Michigan provided further incentives totaling \$125 million (A123 Systems, 2010). A123 initially considered Florida and Arizona, among others, but Michigan became most attractive for several key reasons:

- High unemployment
- Large automotive clients
- A \$100-million grant and tax subsidy from the state
- A highly-trained workforce with automotive skills
- Reasonable labor rates
- Extremely attractive real estate market
- Brand new facilities that were never used because of automotive downturn

Three locations in Michigan will be the focus of A123's expansion plans: Romulus, Livonia, and Brownstown. The Romulus plant will focus on coatings (A123 Systems, 2010). The Livonia facility, which opened in September 2010, is considered the largest lithium-ion automotive battery production facility in North America. It will involve the whole production process, including R&D, fabrication of prismatic cells and modules, and final assembly of battery packs (A123 Systems, 2010). By the end of 2011, A123 aims to have two of the plants operational and employing 400 people. Plans include employing a further 1,600 workers, for a total of 2,000 employees able to manufacture roughly 30,000 batteries per year (Lee, 2010).

A123 also received \$5 million in 2010 from the state of Massachusetts to expand operations, with the goal of creating 250 jobs by 2014 (Ailworth, 2010). A123 has its headquarters in Watertown, MA, and also maintains a manufacturing site in Hopkinton, MA. The new activity in Massachusetts is seen as an effort by the state to keep at least part of A123 in the area. In addition, A123 has expressed a desire to stay near a highly-skilled workforce and have access to top-tier universities (Ailworth, 2010).

Push and pull factors

Our interviews with A123 Systems indicated that the decision to manufacture in China was a difficult judgment call. Like all technology companies, A123 is concerned about protecting its intellectual property (IP). It took specific measures to try to protect IP, such as parsing the manufacturing operations into isolated steps. Still, by locating in China, the company did lose a share of its intellectual property, and in essence, its competitive advantage, since it now faces direct competition from Chinese firms that are using its technology. At the same time, in its new facilities in Michigan, A123 will be able to use manufacturing practices learned

“No automaker wants to depend on a supplier in a distant land, especially one whose loyalties lie with a competitor. Take Ford: it purchased nickel-metal-hydride battery packs for its Escape Hybrid SUV from Japan’s Sanyo Electric Co., which had developed them for Toyota. But if battery supplies get tight, Sanyo’s ties to Toyota surely will outweigh Ford’s needs”

--John Voelcker, auto industry journalist (Voelcker, 2007).

in its China locations. Thus, A123's experience is a twist on the usual outsourcing story: the company now stands to benefit, in part, from valuable manufacturing experience in China that it can apply to the manufacture of lithium-ion batteries in the United States.

The factors surrounding A123 Systems' location decisions, and those of many clean energy firms, are of a multifaceted "push/pull" nature. Table 2 summarizes the way in which such factors provided a complex backdrop to A123's decision to locate in the United States versus China. "Pull" factors refer to conditions that make U.S.-based manufacturing attractive, while "push" factors refer to forces that favor production outside the United States. We divided these factors into five categories: local demand; government as a key actor; the private sector as a key actor; the role of R&D and intellectual property; and labor, including costs and availability of needed skills.

Clearly, the \$249 million in DOE funding and the additional \$125 million in incentives from the state of Michigan were major pull factors that enabled A123 to establish new manufacturing capabilities in the United States. Added pull factors for the United States included a large, established automotive industry and major market for vehicles, preeminent research facilities such as universities and national laboratories; and the presence of significant niche markets, including military, medical, and aerospace applications. Important factors that in general act as a push to China include: quicker set-up of facilities in China; lack of financial commitment from the U.S. investment community; and 20 years of experience by Asian countries in manufacturing lithium-ion batteries for consumer electronics.

Now that A123 has committed to this ramp-up of its U.S. manufacturing, validation of its technology and manufacturing equipment will be important to establish the company as a leader in advanced vehicle batteries. Given the need to compete with China's low labor costs, high-speed automation will play an important role. According to our interviews with industry sources, as A123 and other U.S.-based manufacturers strive to beat Asian competitors and build their customer base, they will need to offer such key advantages as battery reliability and solid designs, with no quality issues or need for re-work.

Table 2. Push/Pull factors for U.S. manufacture of lithium-ion batteries

<p>1 – Local demand - Including short and long term; high-value versus low-value markets</p> <p>Push</p> <ul style="list-style-type: none"> * Asia offers higher short-term demand for low-value products * China is setting aggressive future targets for electric vehicles <p>Pull</p> <ul style="list-style-type: none"> * U.S. companies have access to high-value niches including medical, aerospace (e.g., NASA), and military applications; the United States conducts two-thirds of the world’s military R&D spending * The United States is projected to become the world’s leading manufacturer of EVs using lithium-ion batteries by 2020, significant for U.S. battery makers because automakers want loyal suppliers nearby * Shipping costs are high for batteries (which weigh on average 400-600 pounds and are subject to hazardous materials regulations), a further incentive for end-use markets to have battery manufacture nearby
<p>2 – Government as key actor - Including all levels of government; incentives to companies, regulatory environment, and support for R&D</p> <p>Push</p> <ul style="list-style-type: none"> * In China it took only nine months to get a lithium-ion battery factory up and running, compared to 27 months in the United States. China’s pre-existing battery manufacturing eases access to equipment and shortens set-up time * China often provides zero-financing and facilities to foreign companies <p>Pull</p> <ul style="list-style-type: none"> * DOE support (funding and technical) directly contributed to A123’s expansion in the United States, and specifically, in Michigan vs. Asian locations * State funding and support (MI and MA in this case) are cited by companies as crucial pull factors
<p>3 – Private sector as key actor - Investment patterns, relevant trends affecting location decisions</p> <p>Push</p> <ul style="list-style-type: none"> * The U.S. investment community is accustomed to funding technology ventures instead of establishing plants in the United States and shows a continued lack of long-term financial commitment to domestic manufacturing <p>Pull</p> <ul style="list-style-type: none"> * The jumpstart provided by U.S. federal stimulus funds and state incentives to battery firms may help attract private capital
<p>4 – Role of R&D and intellectual property - Including technology issues directly relevant to location decisions, e.g., availability of raw materials, patents, proprietary concerns</p> <p>Push</p> <ul style="list-style-type: none"> * Rapidly-growing battery expertise in Asia, especially in South Korea, is attractive to new U.S. players <p>Pull</p> <ul style="list-style-type: none"> * A123 and other U.S. firms often have a technological edge and thus hesitate to put proprietary technology at risk in overseas plants. This is why A123 was concerned about relocating to Asia in the first place, where Chinese competitors now use A123’s technology
<p>5 – Labor - Including costs and availability of needed skills</p> <p>Push</p> <ul style="list-style-type: none"> * Average wage for relevant labor in Changzhou, China (A123’s manufacturing hub) is \$2.70 per hour, while the equivalent in Michigan is \$13.50 per hour * Asian workers have previous battery manufacturing experience <p>Pull</p> <ul style="list-style-type: none"> * A123 can access higher-skilled labor in the United States. Company is now using operational lessons learned from Asia in their future plants in Michigan * Potential automation in battery manufacturing process favors domestic U.S. production in the long run

Conclusion

We have analyzed the factors contributing to A123 Systems' international location decisions. In the short term, several push factors initially drove A123 to Asia, including low labor costs and ease of setting up facilities in order to deliver on contracts. Since 2009, the company has pursued an aggressive expansion strategy in the United States, opening, in September 2010, the largest lithium-ion automotive battery production facility in North America.

According to our conversations with industry experts, it is very likely that A123 would not have chosen to focus on domestic manufacturing in the United States if not for the \$249 million the company received in DOE funding and incentives totaling \$125 million from the state of Michigan. A123 was the second largest grantee in an investment of \$2.4 billion in stimulus funding to establish the U.S.-based battery industry. Since automakers show a strong preference for having loyal battery suppliers nearby, and the United States is projected to be the largest producer of electric vehicles, this early momentum will help U.S.-based firms challenge their Asian competitors and take advantage of the benefits of proximity.

A123 specializes in the durability and reliability of lithium-ion batteries with a 10-year life, an early advantage in competing with China. However, as lithium-ion batteries near commoditization, they will likely be mass-produced in China. It will be important for U.S.-based firms to recognize this push factor and focus on producing safe, high-quality batteries at home. U.S. firms entering the industry will need to capitalize in the coming few years on the head start provided by stimulus funding. By 2017, the market will have stabilized, making it more difficult for new companies to enter. If A123 is to break into the top-10 list of global lithium-ion battery manufacturers, it will need to meet the lower production costs in Asia head-on, through high-level automation and a sustained focus on quality, safety and durability.

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