What a difference a decade makes. After a 10-year binge of building low-cost production centers in China, some manufacturers reached for the slide rule — and the new math told them to build the next plant in the United States. Seven industry groups are particularly ripe for “reshoring” — the practice of increasing production in the United States by moving jobs back from abroad or building new plants here. All told, these seven industries account for nearly $2 trillion in annual United States consumption of manufactured goods that are essential to modern life: computers and electronics, appliances and electrical equipment, machinery, furniture, fabricated metals, plastics and rubber, and transportation goods. In 2010, the United States imported nearly $200 billion worth of these products from China; they clearly offer a major opportunity for domestic manufacturers. With manufacturing’s share of United States employment down to 9 percent, from 20 percent 10 years ago, some analysts believe a rebound in the factory sector won’t do much to help job growth. But that’s the old math. The real opportunity for American manufacturers
is not just an uptick in basic jobs — as welcome as those jobs would be. The United States also has the potential to become the preferred base for 21st-century manufacturing in a wide range of essential industries. But the United States faces challenges. The foremost is people: manufacturers can’t find enough workers trained in the high-tech systems and problem-solving techniques used in today’s factories. While some companies and community colleges are adapting Germany’s vaunted apprenticeship system of school-to-workforce transition, the United States lacks a consistent, proven model for training highly skilled workers and placing them in jobs. And with fiscal strains at every level of government, who will foot the cost of education and training on a broader basis? While it may take several years for the new manufacturing math to add up for America, things are moving in the right direction as the economy gathers strength. According to Sharmin Mossavar-Rahmani, chief investment officer for wealth management at Goldman Sachs, “the U.S. is regaining its perch as the undisputed economic superpower of the world.”

**POISED FOR LIFTOFF**

Renewed interest in the United States as a manufacturing platform is exhibited by companies of all sizes, said Hal Sirkin, leader of the manufacturing practice at Boston Consulting Group. Sirkin’s team, which identified the seven industries ripe for reshoring, found that 37 percent of companies with revenue over $1 billion are moving production or seriously considering it, while for companies over $10 billion, the figure is above 50 percent. Ultimately, BCG projects that production of 10 to 30 percent of the goods that the United States now imports from China in those seven groups could shift back home before the end of the decade, enough to lower the national unemployment rate by 1.5 to 2 percentage points. High-skill factory jobs could account for 400,000 to 1 million of as many as 3 million jobs in manufacturing and the services that accompany new plants.

Production in these industries is neither destined for low-cost locations, nor anchored by necessity to the United States. What makes these industries prime candidates for moving new production out of China is that factory wages account for a modest share of total production costs for these goods, while logistics — shipping costs, time to market, and the proximity of production lines to engineering and design teams — contribute a large part of total cost. The key drivers of BCG’s projection reflect that contingency: Labor costs in China’s manufacturing-intensive eastern areas are up 19 percent; transportation costs have increased as the average price of a barrel of oil is now $80 to $90, compared with just $25 to $30 in 2000; and companies have recognized the risk of relying on long supply chains that can be disrupted without warning. Finally, companies see that innovation, product development and customer service can all be made more competitive by locating manufacturing closer to customers and the sales and marketing teams.

Some experts believe the changing cost structure means companies could build incremental new manufacturing ca-
pacity in the United States instead of China. But “saying jobs are ‘coming back’ can be misleading,” said Arvind Kaushal, leader of the manufacturing practice at Booz & Company. “It’s not necessarily that companies are uprooting and closing plants. But the key question is where to add capacity.”

Companies involved in electronics manufacturing, one sector identified as ripe for resurgence, released a study last August confirming the two-front rebound. A May 2012 survey of 229 companies with global revenues totaling some $935.3 billion indicated that North American manufacturers are both returning overseas operations to North America and building new operations in the region. “Companies do not have to close and write off the capital of a plant in China, because they need it to keep feeding Chinese demand,” Sirkin said.

But rising costs remain a challenge for American companies operating in the manufacturing-intensive Yangtze River Delta, or Y.R.D., where cost increases are more intense than in other areas of China. According to the American Chamber of Commerce in Shanghai, 49 percent of responding United States companies in the Y.R.D. consider rising costs to be a serious hindrance to their business, compared to 34 percent of firms in China as a whole,” said Kent Kedl, managing director of Greater China and North Asia at Control Risks, a global business and political risk consultancy. Kedl presented the American Chamber of Commerce in Shanghai’s annual China Business Report for 2012 at a conference in Suzhou earlier this year.

For American furniture makers, higher costs are spurring new construction in the United States. With $13 billion of imports from China in the $75 billion American furniture market, producers are replacing economies of scale based on cheap labor with economies of time that enable rapid design changes in response to customer demand. “If you can draw it, you can make it,” said John Akin, a sales manager for C.R. Onsrud, a producer of machine tools in Troutman, N.C. But the flexibility of computer-controlled tools can be lost if goods have to be shipped from overseas, and that’s reinvigorating North Carolina’s attractiveness as a furniture mecca.

A key driver of American competitiveness is the scope and productivity of American manufacturing. Despite a decade of job losses, Boston Consulting Group notes that the United States today manufactures $3.4 trillion worth of goods annually — equal to nearly three-quarters of the goods that Americans consume. Even in industries that suffered extensive outsourcing to China in the past decade, a large share of production remains in the United States — 52 percent of appliances sold domestically, 61 percent of machinery, 70 percent of transportation goods and 71 percent of furniture. America’s impressive productivity gains offset wage rates in China that remain lower on an absolute basis.

The good news for American manufacturing extends beyond the tipping-point industries. The natural gas bonanza makes the United States the location of choice for energy-intensive chemical plants. According to the Energy Information Agency of the Department of Energy, manufacturers from various industries are planning 89 projects worth an estimated $65 billion to start operating by 2018, with 62 of those in chemicals and fertilizer production.

For manufacturers that use a lot of energy, the United States is the place to be. Already the largest-volume natural gas producer, the United States logged the largest production increase in the world in 2011, despite falling prices, and accounted for just over 20 percent of global natural gas production, according to BP’s Statistical Review of World Energy 2012. The United States now has enough natural gas to last at least 100 years, a decisive edge for the chemical industry.

**TRAINING THE NEXT GENERATION**

That delay will give the United States time to redress a critical
shortage — the skilled workers able to operate effectively in today’s team-based, technology-rich manufacturing environment. “We need a high-performance, flexible work force,” said Jennifer McNelly, president of the Manufacturing Institute, the education and research affiliate of the National Association of Manufacturers.

Government has a less direct role in this area than it once did. “I learned core manufacturing skills that could be used anywhere through a Labor Department apprenticeship from 1978 to 1983,” said Jim Filipek. As head of the manufacturing technology program at College of DuPage in west suburban Chicago, Filipek oversees a program that graduates more than 225 students each year with certificates or degrees in manufacturing skills that range from welding to numeric machine control and engineering. Today, those Department of Labor training programs “are long gone,” but Filipek is instrumental in filling industry’s demand for skilled manufacturing workers. In most cases, students don’t need to embark on a job search — demand is so intense for workers trained in certain skills that Filipek estimates College of DuPage could double the size of the manufacturing program and still not meet demand.

Driving that demand is a problem any company would love to have: more business than it can handle. “We have plenty of profitable work lined up,” said Tessa Bergmans, human resources manager at Dynomax Inc. in Wheeling, Ill. Dynomax designs and produces sophisticated parts for aircraft fuselages, wings and other assemblies, which require significant customization and extremely high quality. The company’s growth illustrates the strength of the rebound in American manufacturing. In the past two years Dynomax has grown to more than 220 people, from 70, as orders increased from commercial and government contracts in aviation and aerospace. But expansion has been limited by the lack of talent. “We’re having a hard time getting enough of the skilled people we need,” Bergmans said.

The opportunity cost of lost business can be high. “The skills gap is a big concern; there are definitely slowdowns now,” Kaushal said. He estimates that a skilled manufacturing worker generates average revenue of $500,000, a potential loss of $300 billion if a projected 600,000 new manufacturing jobs can’t be filled. Despite recent efforts to increase the number of trained manufacturing workers, the problem is likely to get worse before it gets better. The percentage of the skilled manufacturing work force that is over the age of 55 has doubled in the last 10 years, Kaushal said, to 20 percent of active workers. And there’s not a deep bench — 50 percent of the active workers are above the age of 45.

LEARNING BY DOING

When it comes to preparing American youth for careers, however, the current approach is falling short. “We have told young people that you essentially have two choices in life,” said Diane Auer Jones, in remarks to an American Enterprise Institute conference on the challenges facing American higher education. The first choice is “a traditional four-year degree at a school that has a really nice pennant or football team or swimming pool.” The second choice is “skid row.” Jones, an assistant secretary of postsecondary education in the second Bush administration, is now vice president for external and regulatory affairs at the Career Education Corp., a for-profit post-secondary education company, and she writes for The Chronicle of Higher Education’s blog, Brainstorm.

Somewhere during America’s climb to global economic ascendency, manufacturing developed an image problem. Today, instead of being seen as a path to secure work and earnings, manufacturing is seen as dirty, dangerous and, worst of all, dead-end. The ability to apply cognitive skills to make things people need was pushed aside by a society that rewarded financial solutions to problems that might be better addressed by scientific or engineering innovation.

One way to fill the jobs gap is through apprenticeships. Apprentices study math, science and engineering while
Although wage increases in China’s factory belt are spurring some manufacturers to build new plants in America, Beijing is working hard to reconfigure its production resources to maintain its competitive position and continue to dominate strategically important industries. The stakes are high. Analysts estimate China needs to create 24 million new jobs annually to keep pace with its population — an 8 percent growth rate — so this year’s slowdown will make it harder for Beijing to satisfy rising expectations.

To offset labor cost increases, China reinvigorated a domestic “Go West” policy, encouraging companies to move lower-skilled jobs to its less-developed interior provinces. China tried a similar initiative before, but companies stayed put, said Kathleen Walsh, associate professor of national security affairs at the United States Naval War College in Newport, R.I., who studies the national security implications of China’s science and technology policy. This time, China built roads, highways, and airports to help companies move west, and “now it’s working.”

China’s leaders know the manufacturing power that drives rising living standards results from advanced technologies and the underlying scientific and engineering research. So, along with infrastructure, China’s leaders are building an innovation ecosystem, encouraging collaboration between the lower levels of national ministries and state-owned enterprises that Walsh calls “stovepipe monopolies.” It’s a lesson that United States policy makers are learning too, Walsh said. “You need manufacturing at the core level in order to have high-end innovation.” Chinese technology development is guided through “innovation clusters” laid out by the Chinese Academy of Sciences, she said.

That doesn’t sound like a nation losing its edge. In fact, China has moved steadily toward leadership of the machine tool industry — the heart and soul of manufacturing. The Shenyang Machine Tool Co. recently opted to “Go West,” moving some production from coastal Shenzen to the western city of Kunming. Already ranked No. 1 by some observers, Shenyang is developing a suite of new machine tools that will include its own control processor, a specialized market now dominated by Siemens. But the strategy of the chairman and CEO, Xiyou Guan, is as much American as Chinese. His plan calls for American marketing acumen — Shenyang began recruiting United States executives in 2012 to sharpen customer-service capabilities and develop a solutions-oriented approach. The blueprint? “Apple has been inspirational to Chinese leaders,” he said. Its tools are already used to build Apple products, and Shenyang will position its new lineup at the forefront of innovation — it’s called i5.

Working under the guidance of an experienced mentor. They’re typically paid, sometimes at a lower rate than full-time employees, and employers often pay the education bill too. Apprentices are usually hired after completing the program, and commit to repay a share of their educational costs if they leave before a specified date.

Apprenticeships give German manufacturers an edge. They’ve used the approach for centuries at home, where it’s called the dual system (see sidebar), and brought the practice with them to the United States. Robert Bosch, a German manufacturer of goods ranging from dishwashers to car chassis, has used apprenticeships to train skilled workers for more than 20 years. In the United States, the company turns to Mitchell Harp, head of the Apprenticeship Office at Trident Technical College in Charleston, S.C., where Bosch’s primary United States operations are based. “We put it together for them,” Harp said. Trident designs and teaches targeted coursework that dovetails with mentored on-the-job training. Classes of up to two dozen apprentices obtain immediate work experience, while Bosch grooms each generation of manufacturing talent without slowing production.

Harp is part of an employment ecosystem that has positioned South Carolina to land more than its share of new manufacturing jobs as the renaissance unfolds; the state even has an agency called Apprenticeship Carolina that oversees incentives. Booz and Boston Consulting Group cited Georgia, North Carolina, Tennessee and Alabama as also having strong job-attraction programs. They share an aggressive approach to bringing jobs to their states, including tax incentives, education credits and apprenticeship offices that connect companies with community colleges and technical or vocational schools to train workers — in effect replacing the recruiting and training functions that so many companies threw overboard when they set sail for low-cost locations a decade ago.

**TED-HEADS**

The National Academy of Sciences is among a chorus of policy voices seeking to revitalize America’s factory talent pipeline, and conferences on the manufacturing renaissance are as hip as TED happenings. A group of think tanks, law firms and...
Made in America, the German Way

Extensive market-focused career preparation that combines specialized classroom study with on-the-job training under the tutelage of experienced mentors — it’s the German way. According to Friedrich Hubert Esser, president of the Federal Institute for Vocational Education and Training, which oversees Germany’s apprenticeship system, “Our goal in Germany is an education system in which vocational and university education are on an equal footing.”

German companies, educational institutions and trade unions work in a cooperative system with roots in medieval guilds; together, they establish specifications for dozens of jobs and careers, and create the dual-track academic and workplace programs to train the employees that employers believe they’ll need each year. The system is governed by German federal laws covering vocational training.

German companies have taken their centuries-old approach around the world. A unit of the German Education Ministry, iMOVE, exports Germany’s expertise in training and regularly conducts workshops and conferences in such key areas as China, India and the Middle East. German companies set up shop in South Carolina 20 years ago and have used apprenticeships to train United States workers. Many are designed by the Apprenticeship Office at Trident Technical College in Charleston, S.C., which develops courses integrated with training by company mentors.

Trident opened its apprenticeship office nearly 15 years ago, when South Carolina was bleeding jobs, as core industries like textiles collapsed in the face of cheap imports. Today, the German way has caught on, and the chief of the Trident apprenticeship effort, Mitchell Harp, spends most of his time educating senior executives about what apprenticeships can and can’t do. “The apprenticeship model is not a quick fix,” Harp said. “I call it an investment model. It allows employers to take control, and it pays off in the long run.” The company can select specific people from its ranks or the schools’ roster; classroom work is tailored to business needs; and apprentices become productive team members within six months.

One key to success is finding the right people to serve as mentors, Harp said. In addition to teaching apprentices specific skills, mentors model workplace behavior. Perhaps the most important function is the least obvious, “There’s practical knowledge that is not in a book,” said Tessa Bergmans, human resources manager at the aerospace manufacturer Dynomax Inc. “Mentors need to show that to someone, so they can continue the work.”

Once senior executives adopt the apprenticeship model for their training needs, they typically stick with it. “I’ve never had a company say they don’t like it,” Harp said. “They say, ‘How can I make it work in my company?’”

lobbys held its second such annual event earlier this year in Washington. Gene B. Sperling, director of the National Economic Council, said the United States is an increasingly attractive manufacturing site in light of the latest thinking on manufacturing costs. “Stop looking at your unit costs over the last 10 years, and start looking at a ‘total cost of production’ approach over the next 10 years,” he said. That view originated with Harry Moser, a former machine-tool CEO who created the Reshoring Initiative, a nonprofit effort dedicated to revitalizing American production. Companies can use the initiative’s software to assess their total cost of production.

Noting the “outsized role that manufacturing plays,” Sperling said the sector “is worthy of a special emphasis.” The White House is pulling several levers. Perhaps most far reaching is the 2013 budget request for a one-time $1 billion payment to create the National Network for Manufacturing Innovation, a new group of up to 15 regional Institutes for Manufacturing Innovation to “revitalize United States manufacturing.” The goal is transformational — N.N.M.I. is intended to spark a quantum improvement in the creation of jobs by leveraging advanced manufacturing techniques.

The President’s Council of Advisors on Science and Technology recommended coordinating the effort among federal agencies working on the same topics. Leading that mission is the nation’s new chief manufacturing officer, Michael F. Molnar, an engineer with 25 years of experience at Cummins and a stint in the Bush White House. Molnar operates from the National Institute of Standards and Technology, a unit of the Commerce Department. During an interview with Briefings at the International Manufacturing Technology Show in Chicago, Molnar zeroed in on the importance of manufacturing: a manufacturing job generates eight additional jobs in the production supply chain and related service work, and more than 85 percent of the value of U.S. exports comes from manufactured goods. “This is how we maintain our standard of living,” Molnar said.

Even though public comments on the N.N.M.I. weren’t due until late October, Sperling began “a pilot demonstration of the N.N.M.I. concept,” the National Additive Manufacturing Innovation Institute, in August. Seeded with $30 million from the Departments of Defense and Energy and NASA, the innovation institute was created by a broad consortium of research universities, private companies, community colleges and economic development agencies in Ohio and Pennsylvania.

There’s no doubt that additive manufacturing — often called 3D printing — is a revolutionary technology. It’s a way to make products by depositing thin layers of material, like powdered metal, one atop another according to a digital blueprint. This process reduces product design time, saves energy and reduces inventory cost for producers and their customers. Deere, Ford and Airbus use additive techniques...
and tools to make parts and subassemblies. According to the Defense Department, the technology could be used on aircraft carriers for making airplane parts that would otherwise need to be flown in. Ford makes transmission parts for its first-stage vehicle testing with machines from ExOne, a Pennsylvania-based company that was a member of the winning NAMII consortium. ExOne’s “digital part materialization” is also used to make artificial hips, prosthetic limbs and most hearing aids. The company is owned by an investor group led by Ken Rockwell, son of the founder of the aerospace giant Rockwell International.

**BUILDING COMMUNITIES**

While printed airliners might someday ferry passengers between printed terminals, United States manufacturers aren’t waiting for Washington’s strategic plan to pay off. Many practical efforts to solve the training problem are under way at the local level, between companies and community colleges, often in states with accommodative labor laws.

The Manufacturing Institute is developing a credentialing system for secondary school students, based on precision-manufacturing skill standards from several trade groups. “This actually gives graduates skills that have labor market value,” McNelly said. The credentialing initiative gave the institute a network worthy of a political campaign. “I know how many certified production technicians there are in Kansas or Texas,” McNelly said. “Do I tell everyone? No. But we talk about it” on visits to other states.

On the shop floor, apprenticeships are making a comeback, and the Labor Department is doing more to explain and promote the concept, for both industrial and service workers. The Labor Department reported that more than 400,000 people were enrolled in registered apprenticeship programs in 2011. And a recent department study found that people who complete such a program can expect to earn some $240,000 more over a 36-year working life than nonparticipants.

To help fill the talent pipeline, Filipek hosted a meeting in November 2011 for 300 high school students to meet with dozens of local manufacturing companies, ranging from fast-growing midsized specialty firms like Dynomax to bedrock giants like Molex Inc., a global leader in electrical connectors. “I don’t think it’s mainstream yet, but parents who have experienced the great recession personally are rethinking manufacturing,” Harp said.

That rethink could be just what’s needed to help the renewed interest in manufacturing work go viral. McNelly said the Institute’s engagement strategy — Dream It, Do It — is designed to “go where the kids are.” Dream It, Do It promotes regional clusters and manufacturing partnerships among the key constituencies that affect decisions about plant location, training, education and economic incentives. Begun nine years ago, programs are now in 20 states. The initiative gives 16- to 26-year-olds — and their parents, teachers and counselors — an up-to-date picture of advanced, high-tech manufacturing as a career path.

Increasingly, the kids are at the plant or on the floor at major technology shows. On one Saturday in September, nearly 40 students from Eisenhower Middle School in Rockford, Ill., were viewing robots and 3-D printers at the International Manufacturing Technology Show. They were the second group to take part in Rockford’s Introduction to Manufacturing Program. Students submit essays to gain admission to the program, which is administered by TechWorks, a local incubator supported by manufacturers in the region, including Sandvik Coromant of Sweden, HAAS Automation of California and Doosan Infracore of Japan. This year’s class was selected from more than 200 applicants — a sharp rise from the 60 who applied the first year.

In the end, McNelly said, there’s no more powerful way to attract recruits than tapping directly into the energy and aspirations of young people and their parents in the places where they live and work. After all, she added, besides all that stuff, “Manufacturing builds communities.”