

## Chapter 24

# How Is the Marketplace Changing for Chemical Engineering?

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### **Where Are Chemical Engineers Currently Working?**

*Maria Burka, Gary Patterson, and Freeman Self*

In the U.S., chemical engineering hiring exhibits a long-term average growth of about 1%-2% per year. Short-term swings in growth rate are common, including the recent upswing in primarily petrochemical hiring. On average (and with significant variability) over the last 25 years, only approximately 60% of graduating bachelor chemical engineers are hired into industry and government. Those graduates going into industry are hired throughout a broad range of sectors, but a majority of them (60% on average) join companies in the petrochemical field.

According to the 1995 National Science Foundation (NSF) data, only 62,000 or 28% of all persons with chemical engineering degrees worked as chemical engineers. Others were either retired or worked in other fields including a large percentage in management and allied fields, Figure 1.

In 2000, there were approximately 200,000 working chemical engineers in the U.S. An additional 20% had been estimated not to work, based on 1995 NSF data. (See Figures 1 and 2.)

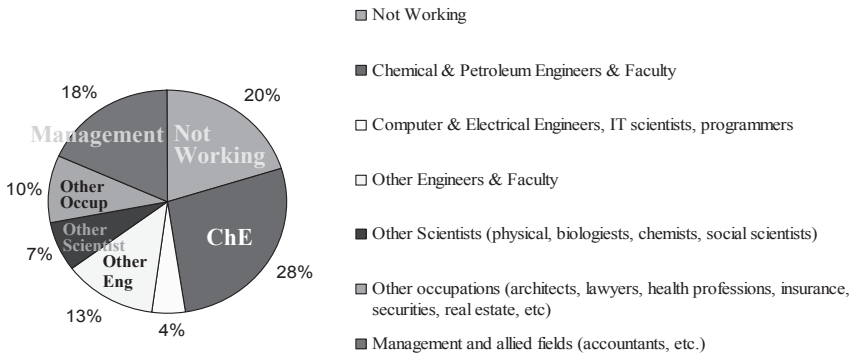


Figure 1. Fields of Employment of Chemical Engineers. Source: NSF.

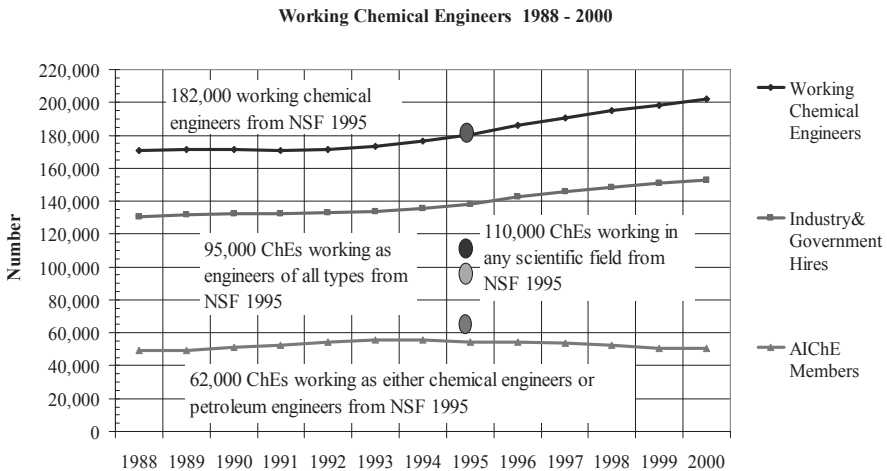


Figure 2. Working ChEs and Industry Hires Excluding Those Returned to the U.S. Source: AICHe and AAESO.

The total number of graduates fluctuates each year, but there were approximately 8,000 in 2000, Figures 3 and 4.

Although chemical engineers have been and continue to be hired throughout a broad range of industries, most new graduates are hired in the petrochemical fields, Figure 5. B.S. graduates hired in the

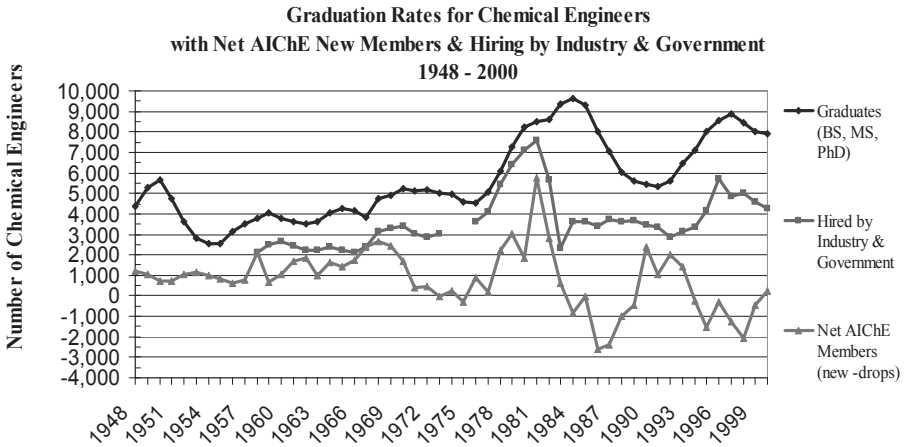


Figure 3. Source: AIChE for data on members and hires 1976-2000 and AES for number of graduates 1948-2000 and hires 1958-1972.

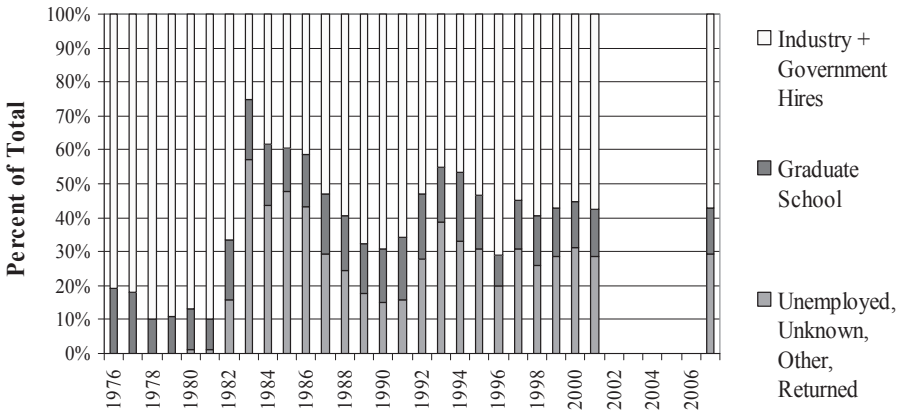


Figure 4. Graduation Plans of B.S. Chemical Engineers: 1976 – 2006.

petrochemical industry (chemicals, fuels, engineering, construction, environmental and R&D) increased from 40% in 1985 to 50% in 2001, with a spike in the early 1990s. Industrial hiring was more diversified in the 1990s, but less so in the 1980s. Figure 5 is based on the AIChE Initial Placement Surveys.

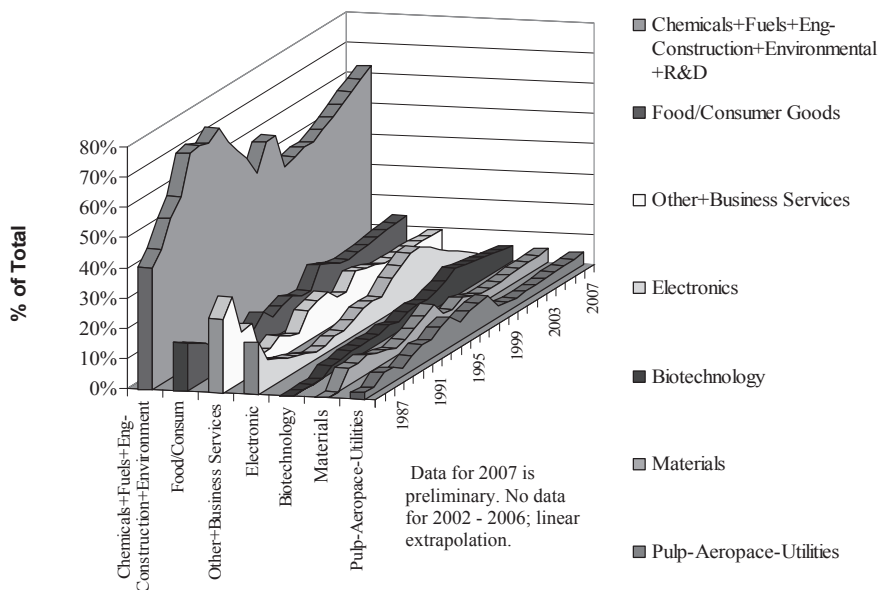


Figure 5. Industrial Hiring of US Chemical Engineers with B.S. Degree: 1986- 2007.

Hiring in other fields rises and ebbs over time. The electronic industry was a popular employer in the 1980s, an insignificant one in the early 1990s, and regained its popularity in the early 2000s only to lose it in the middle 2000s. However, the U.S. data is mixed for BS graduates. The 2001 AIChE data shows 16% of them going to the electronics field while the preliminary results from the 2006-2007 AIChE Initial Placement Survey show that 0.5% of the graduates are hired into electronics. World Chemical Engineering Council data show only 1%.

The number of chemical engineers actually working as chemical engineers track the number of AIChE members, Figure 2. Likewise,

the graduates hired by industry and government also track the net new AIChE members, Figures 3 and 5. This is probably more than a coincidence, although many working as chemical engineers do not join AIChE. The U.S. Bureau of Labor Statistics predicts that chemical engineering employment will grow approximately 1% per year from 2004 to 2014.

As shown in Figure 6, China, Japan and the U.S. are the largest producers of B.S. ChE, followed by India and South Korea.

Based on a 2004 World Chemical Engineering Congress (WCEC) survey for international chemical engineers graduating around 2001, most of the graduates held jobs by 2004. Additionally, this survey provides data on the time to find the first job. Hiring of graduates worldwide mirrors that of the U.S., based on a WCEC survey reflecting hiring around 2001. More graduates of universities in other countries tend to go into petrochemical fields than U.S. counterparts. Additionally, this survey shows close agreement in trend with AIChE, except for those hired in the electronic industries, Figure 7.

AIChE is the only broad and long-term source for graduation data. Therefore, it is important that AIChE continue to collect the data from universities on a regular and consistent basis.

### **What Roles Do Chemical Engineers Play?**

*Calvin Cobb and Greg Stephanopoulos*

Over the recent decades, the roles that chemical engineers take following graduation have been varying widely. It is a commonly held belief that our educational process uniquely trains chemical engineers to be able to accept and successfully perform in these roles. The departure from industrial chemistry over 100 years ago has developed a professional discipline that differs from all other engineering disciplines. Key to this distinct nature of chemical engineering is its foundation on all three sciences (physics, chemistry and biology) in contrast to the dominance of physics and applied mathematics in all other engineering fields. The close contact with science has been a constant source of innovation and

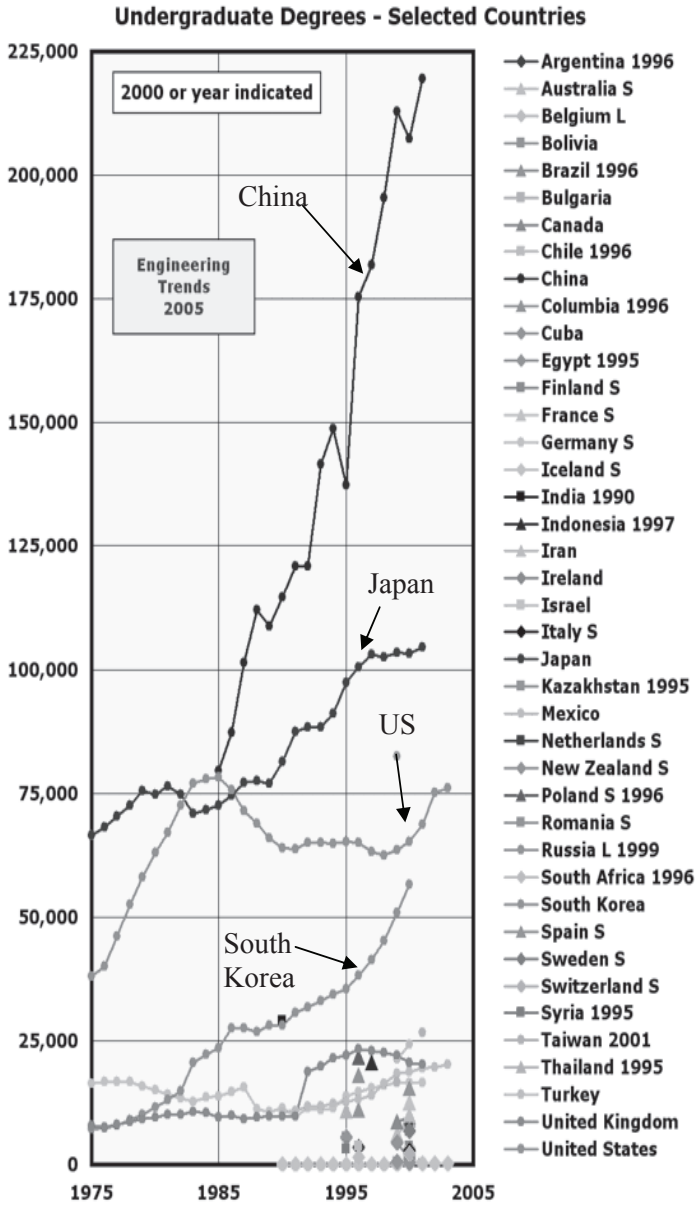


Figure 6. Engineering Trends Report 0405A

“An International Study of Undergraduate Engineering Degrees.”

Source: NSF “Science and Engineering Indicators 2004” except U.S. from AAES.

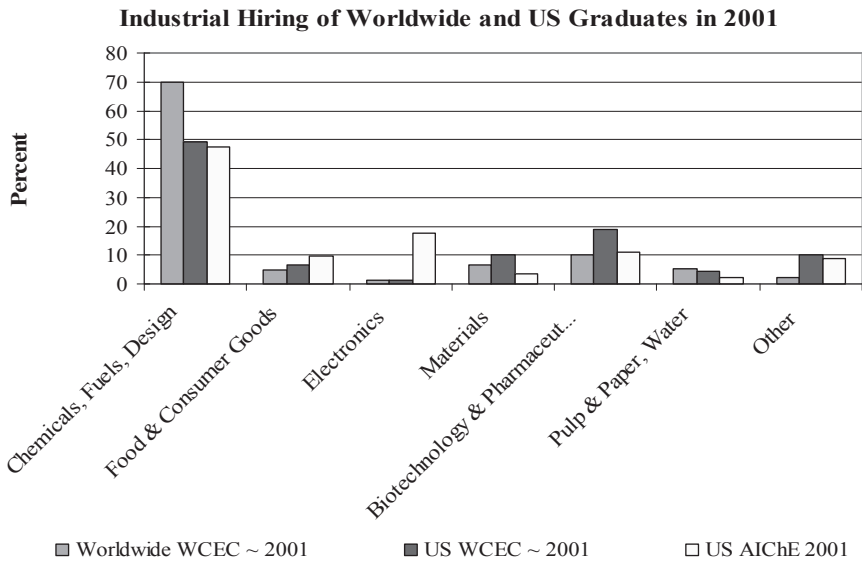


Figure 7. Source: 2001 AICHe Initial Placement Survey and 2004 WCEC Survey.

renewal for chemical engineering, the most recent evidence being its evolution into the arena of biological engineering. Evidence of this is that most companies in the process industries are led by chemical engineers.

The leading process industry companies have hired chemical engineers in large numbers. They are run primarily by chemical engineers who support our profession vigorously. Beginning at least 40 years ago, however, with the development of the “Expanding Domain of the Chemical Engineer,” there has been a clear recognition that a significant number of new graduates begin their careers in a wide variety of companies outside the traditional and mature chemical companies. Based on recent graduation data from AICHe Initial Placement Surveys (see above), at least eight new categories of companies consisting of two groups have been identified. One includes the nonchemical manufacturing company having significant chemically related processes, such as an electronic chip producer. The second includes the company in an emerging industrial sector producing a new chemically related product, such as a biorefinery and an artificial organ producer. Thus,

the categories of employers of chemical engineers have been stratified into mature chemical producers, existing nonchemical manufacturers, and emerging chemically and biologically related industries. Changes in employment patterns are subtle, and hiring for a particular new industry fluctuates over time, possibly due to the business cycle.

A new dimension of change in the role of the U.S. chemical engineer derives from the de-industrialization of the U.S. In a 2005 article in *Technology in Society*, Prof. James Wei notes the “decreased demand from manufacturing industries for new engineering graduates, and layoffs and early retirements” of experienced engineers. He also states, “Rising numbers of engineering graduates have taken jobs in the service sector—medicine, health care, law, business management, consulting, financial engineering, entrepreneurship, environment and safety. . . . They believe they acquired a number of positive attributes that are useful outside of a career in manufacturing . . . , such as a rigorous discipline, a general knowledge of science and technology, the habit of collecting relevant information followed by quantitative analysis of data to construct conclusions and recommendations, teamwork, and strong oral and written communication skills.” Employers value engineers, especially for their ability to “manage systems with multiple objectives and criteria.”

The implications of this trend on the profession and AIChE are profound. It affects not only the job and career situation, but also the direction a number of chemical engineering departments have taken to include biology in their programs. However, the continued educational focus on fundamentals and broad applicability of our core have enabled the broad employment of chemical engineers. It is a tribute to our profession that chemical engineers are finding jobs at record starting salaries. A recent AIChE Salary Survey shows that starting salaries are significantly higher for the hydrocarbon processing industry, which hires approximately 60% of chemical engineers on average over several decades. Our graduates also work at Amgen and Intel because these companies like our core. Wei points out, for example, “courses could be jointly developed with the cooperation of thoughtful engineers in the service sector to teach concepts and tools that are unique to the service sector.”

### *Traditional Roles*

Over the past 40 years, chemical engineers have been employed in companies run by chemical engineers and have taken many roles across the entire range of job functions. Web sites offering information on “Career Roles of Chemical Engineers” abound on the internet including: R&D and technology; process engineering and process design; engineering and engineering management; product discovery and design; production engineering and management; sales and marketing; support services management; business unit management; and executive management.

The unique education of chemical engineers that engrains chemistry (and more recently biology) and trains graduates in systems analysis, systems integration across technologies and disciplines, and problem solving enable chemical engineers to pursue any career roles and paths. However, there is one overall observation that can be made compared to other disciplines. Fewer chemical engineers are business owners compared to other engineering disciplines. This trend can be observed by analyzing the top performing graduates from engineering schools. Civil engineers, for example, tend to have a significant number of business owners in their graduate ranks.

### *Changed Roles*

Changes to chemical engineering as a profession are affected by the following factors:

- One is the trend that companies outside the traditional chemical processing sector are hiring chemical engineers.
- Many chemical engineering departments are incorporating biotech in their names and programs. Others are integrating materials science into programs and some are considering a closer alignment with chemistry. There is, however, a need to take more pro-active approach to make these programs more successful.
- The traditional process industry companies are becoming gradually more global with new major projects being built outside the U.S. in Asia/Pacific and the Middle East.
- Flattening of the world (Tom Friedman’s “The world is flat”) is a major force leveling the playing field worldwide and creates new

challenges to the traditional corporation. As a result, many new businesses are created where chemical engineers will play a very different role, that of an owner.

- The trend to disperse central R&D operations (but not reduction of R&D budgets) favors small firms pursuing most of the contractual and open-ended research, instead of the corporation. It will benefit entrepreneurial individuals who take the initiative to start their own businesses.
- There is a very high short-term demand currently for engineers to execute an increasing number of global projects in the energy and chemical sectors.

### *New Educational Direction*

Academia is faced with the challenge of first seeing what future requirements will evolve and then developing new curricula to reshape chemical engineering education. We seem to be in the early stages where most chemical engineering departments are striving to develop the next era of chemical engineering education. The two biggest driving forces are: (1) which industries will hire chemical engineers (2) what research topics will government and industry fund on campus? Both of these forces will shape chemical engineering departments and the curriculum over a longer period of time.

There is another viewpoint that emphasizes the critical nature of the changes required in chemical engineering education. Academia have been rather slow in responding to the emergence of biology as an enabling science of promising future interest to chemical engineers. This unique opportunity to lead the rest of engineering into the “bio” era should be utilized at an accelerated speed. After all, chemical engineers are the best qualified of all of engineering to meet these challenges.

Nevertheless, if the basic chemical engineering curriculum continues to consist of chemistry and biology, systems analysis, technology integration, and comprehensive problem solving, chemical engineering graduates will come into the marketplace equipped with the same skills as their predecessors.

*Future Roles of Chemical Engineers*

Given both the fundamental changes in the marketplace of leading companies hiring chemical engineers and evolving changes in chemical engineering education, the marketplace is changing for chemical engineers. Chemical engineers will work for a wider array of companies than in the past, and the nature of their work will differ from that in the traditional companies like chemicals and petroleum refining. Process engineering for these emerging companies will not have the same content as a chemical plant. Not all process engineers will be designing distillation columns, for example. It is recommended that AIChE regularly survey members, leaders of AIChE divisions, and faculties of chemical engineering departments to determine the broadening roles chemical engineers have in these emerging areas. It is anticipated that in response to the new ABET criteria the faculties will be gradually adjusting their curricula to prepare their graduates for any changing roles seen by their customers.

Historically, chemical engineers have been leaders and executives in the process industries. While many of the companies chemical engineers join today are not led by chemical engineers, one could expect them to rise to leadership and executive levels because of the inherent skills they possess as a result of their education.

As mentioned before, chemical engineers will continue to be hired by companies that are not considered in the traditional process industry. Their roles will not change fundamentally, but they will be required to learn about these new industries. The fact that future chemical engineers will be hired by increasingly more diverse industries can have tremendous implications for AIChE. It has to continuously seek new innovative means of retaining those chemical engineers employed in diverse industries, such as the Society of Biological Engineering and the Institute for Sustainability.

## Career Paths for Chemical Engineers

*Al Wechsler and Alan Zagoria*

There is clearly no one typical career path for chemical engineers, even for those in a single age group and industry. While generally one must gain experience in specific functions such as design, development, research, technical service, sales or marketing before taking on management responsibilities, there are many lateral moves one can continue to make as one's career evolves, as well as "jumping" directly into management by getting an MBA. It is well understood that typical career paths will span several employers, but it is not well understood how much of this switch is by choice or involuntary. Nor is it understood what the long-term career/financial impact is of "job hopping" for increased salary and job responsibility.

A number of trends in the marketplace impact the relationship of engineer to employer and the required skills to survive and succeed.

### *Advanced Degrees*

About 60% of chemical engineers with B.S. degrees do not go to graduate schools, Figure 8. Approximately 13% of chemical engineers get an advanced business degree, while some others in biotechnology, bioinformatics, medicine, biomedical engineering enter MD or PhD programs in the related fields. Some PhD engineers move into business and management roles (about 2%) after earning business degrees. While the data in Figure 9 may not be statistically significant and some of the job titles may be misleading, they indicate that a PhD plus a management degree is an effective route to top management positions. The trend that many foreign graduate students return to their home countries may lead to a shortfall of graduate-degreed chemical engineers in U.S. industry. This may provide incentive for practicing B.S./M.S. engineers with a bent for research to go back to school.

### *Business/Management Positions*

Approximately half of the degreed chemical engineers working in business or management positions have advanced business degrees which more managers at the top level have than technical and "other"

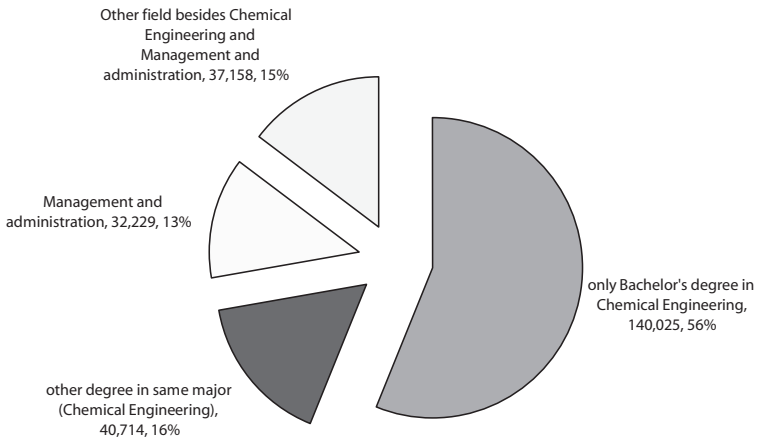


Figure 8. Highest Degree Earned after a B.S. Degree in Chemical Engineering.

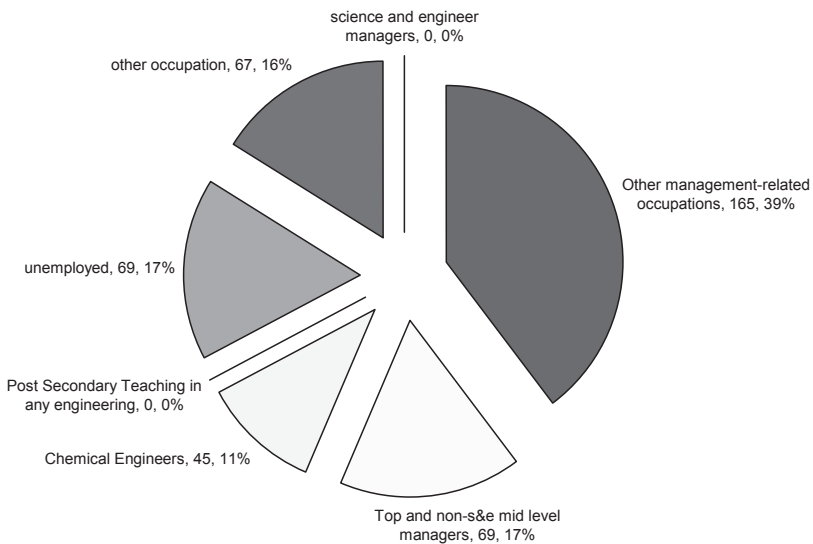


Figure 9. PhDs with Business Degree

managers, Figure 10. The percentages in Figure 10 represent a proportion of the entire B.S. chemical engineering population. Chemical engineers with advanced business degrees are 10-15%, out of which the group who graduated in 1971-1985 holds the most business degrees. The percentage falls off after that. Business degrees are typically obtained 5 to 10 years

after the engineering degree. There is no significant difference in salary between all B.S. chemical engineers and those who also hold advanced management degrees.

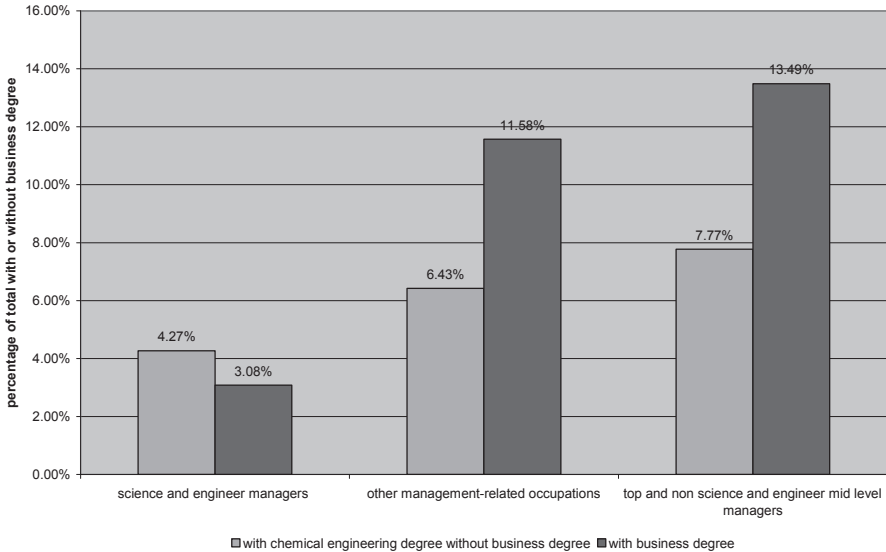


Figure 10. Percentage of Those in Management with/without a Management Degree

### Employment Longevity

Indications are that most engineers today will have 2–4 employers during their career. There appears to be an increase in the number of jobs an engineer can expect to hold, and a decrease in long-term commitment (loyalty) on the part of both employers and employees. Employees not expected to be around long enough to get seniority or vesting are more likely to switch jobs for a salary increase. Due to serious salary compression in this field, at least in the short term, it is much easier to increase salary by changing jobs. As a result, chemical engineers may seek employment outside after a number of years with a company, rather than transfer to another position within the company.

Because of the nature of global industry, as well as buyouts, takeovers or spin-offs, engineers are expected to relocate more now. On the other

hand, they could be less willing to relocate than before, due to personal priorities, dual income families, and split families.

### *Employers*

There appears to be a direct relationship between the size of a company and median salaries. The median salary for those working for large companies is about \$12,000/year greater than for those working for small companies. It is more and more likely that employees will see major changes to their employer, buying other companies, merging, being bought out, added to a conglomerate, spun off, and so forth. This affects the stability of employment, and requires greater flexibility and adaptability to survive/succeed. Global competition and offshoring are clearly changing the employment landscape. Traditional employers (chemicals, petrochemicals, refining, E&C) will continue to dominate the job market. There is no clear upward trend in jobs in the bio/pharmaceuticals area at this time. There appears to be a small, but growing, demand in the financial sector for chemical engineers. Many engineers, particularly those who work in E&C, regularly move among the petrochemical, pharmaceutical and chemical industries. Many basic roles such as process design, controls, specialty equipment, and sales are relatively portable from one industry to another. R&D, tech service, and operations are relatively less portable.

### *Type of Work*

There will be more service-type work and less production engineering (both in design and in operations) in the U.S.. Unique services and skills are most likely to stay here. Additionally, with the trend to outsourcing (domestic and overseas) it is possible that an engineer working for a large company will do the same work, but employed by a small service company providing that same service (tech service, environmental monitoring, managing cooling water quality, instrument reliability or catalyst performance, project management, etc.) to that same large company. Some experienced engineers choose to start a business of their own after leaving or being dismissed from the industrial sector. The challenges these engineers face and the skills they require differ from the requirements in the corporate sector. To start a business of their own, including publicly offered consultancies, one must hold a professional

engineering license. AIChE has a long-standing policy that encourages all of its members to become licensed. During the past several years the state engineering licensing boards have been working to introduce a modification to the licensing process that would increase the educational requirement for the PE license from a Bachelors degree to a Masters degree. With AIChE's encouragement and assistance, the boards are considering an alternative to the Masters degree—a practice-based 30-credit equivalent.

#### *Relationship to Employer*

Chemical engineers with 15 or more years of experience in one or two companies are concerned about job security. They have a lot to lose, and those over 50 expect it will be difficult to find another employment. Younger engineers do not expect longevity with any given job, because in general employers are willing to invest less in the long-term career development of engineers. It is more difficult for engineers to participate in outside training, attend conferences, etc., as management from the top down takes a much shorter term view of the business.

#### *Career Path: Academia*

People working in academia have little career flexibility—teaching/research or administration. A majority of them begin along one of two paths: (1) research assisted principally by graduate students and post-doctoral fellows, and teaching at a research-oriented university or institute; (2) teaching and some research assisted principally by undergraduate students at a regional university or college. Once tenured and promoted, some faculty members move into administration at the department level or higher. Many senior faculty members consult with and thus form bridges between industry and government. Promotion to associate professor with tenure at the research-oriented university or institute is driven principally by the number of refereed scholarly papers the candidate has published in major journals. Outside funding allows a faculty member to support more students to assist in the research effort, leading to more publications. At other institutions, promotion is driven principally by the quality of teaching (including direction of undergraduate research activities). Several years of outside experience, either in manufacturing or in research before entering academia, is a

valuable component of a young assistant professor's background. For more experienced individuals, however, spending a decade or more outside academia leaves insufficient time to pass through the entry-level positions on campus and few departments, most particularly those at research-oriented universities and institutes, bring such individuals into them. It is rare for an individual to go back and forth between industry and academia on a regular basis, because the cultures and reward structures are so very different.

### *Skills Required*

With the changing business environment and job market of skills most required are shifting. Communications skills are becoming more important, because more engineers work in teams, communicate at long distances, and deal with the customers. It is essential to understand such as your employer's and customers' goals in terms of dollars and technical issues. A greater percentage of the jobs that remain in the U.S. will have a unique skill/technical capability. Having a multicultural background will be an asset, because engineers will be dealing with international customers, vendors, standards, partners and owners. Overseas assignments will be more likely and necessary for career growth. The ability to adapt/reinvent quickly will also be a factor in jobs that stay in the U.S. Leading-edge/high-tech/less-outsourcable jobs may be more multidisciplinary at the boundary of several disciplines.

### *AIChE's Role*

In light of changing employment and business environment, AIChE needs to reevaluate its services to the membership. For example, it must address the shortfall of graduate-level chemical engineers in the U.S, services (such as career placement) for those changing jobs (particularly those over age 59 seeking employment), provide services for engineers relocating domestically and overseas, provide services for those moving into management positions and business ownership, and work together with the state licensing boards to properly define the practice-oriented 30-credit equivalent to the Masters degree requirement for the PE license.

## Globalization

*Bill Schowalter and James Wei*

### *Shifts in Manufacturing*

The U.S. has been the main innovation capital of the world since World War II, inventing and creating new products, developing the processes for them, manufacturing them efficiently into desired products and selling them all over the world. A recent striking trend, however, is the accelerating migration of manufacturing plants abroad, as well as many of the highly valuable technical services described in Thomas Friedman's "The World Is Flat." For example, most of the goods sold by Wal-Mart are made in China, and telecommunication has enabled Indians to read our X-ray photos for diagnosis, to prepare our income tax returns, and to coach our school children in mathematics. The U.S. has not built a new [oil] refinery for 35 years, and most of our pharmaceuticals are manufactured in Asia, Ireland, and other places.

Thus, it could be projected that U.S. chemical manufacturing may be decreasing in the future. But like all projections some foresee less downturn than others. In the refinery sector, for example, according to U.S. Energy Information Agency (EIA), the crude distillation capacity (not crude charge) in the U.S. increased 12% from the low in 1986 through 2007. This capacity increased due to "creep," rather than from new grass roots facilities. One of the reasons for this was the effort made on "ream outs" and debottleneckings that were possible to expand refining capacity at existing U.S. refineries and chemical facilities. Another reason for the lack of new U.S. refineries is the excess capacity that remained after the refining subsidies were removed in 1981. Further excess capacity is still a worry. As Exxon's CEO, Rex Tillerson, has stated, the demand for refined products in the U.S. will peak around 2015. Nevertheless, Motiva has announced that they are building "a new refinery" which will double the capacity of their 300 MBPD (thousand barrels per day) Port Arthur Refinery.

### *Shifts in Research and Education*

The U.S. has had the best education system in science and engineering, and our universities have led the world in research and education.

Certainly, in the face of potential decline in chemical manufacturing, the U.S. can retain its excellence in research and education, thus leading to innovations and design of new products and processes, as well as high-level technical services. Technical service laboratories and centers will follow the locations of new major manufacturing plants and markets. It should be cautioned, though, that in recent years, the rest of the world has been catching up in these areas.

One of the consequences of the globalization of manufacturing is the possibility that a smaller number of graduates will be needed to manufacture products in the U.S. to be shipped abroad. Accordingly, an increasing number of U.S. graduates will be expected to work closely with the manufacturing facilities and technical service laboratories and centers that move overseas. Internationally based firms already are hiring graduates from U.S. engineering schools, e.g., BP, Total, Shell, Glaxo Smith Kline, Mittal, BMW, Toyota, and Daimler Chrysler.

Another consequence of globalization is the rapid rise of research universities and research centers in the rest of the world, some of the latter being corporate laboratories serving worldwide needs of U.S. firms. Coupled with this is the increasing number, now also above 50%, of research papers in *AIChE Journal* that originate from universities abroad. We can predict with confidence, though, that the world of 2050 will have many centers of excellence around the globe in engineering inventions and manufacturing.

Coupled with this, we will also experience the globalization of universities. For example, Georgia Tech has opened a campus, Georgia Tech-Lorraine in Metz, France, which offers graduate programs in a number of engineering disciplines. It has become a truly international university and can be a model for what others are trying around the globe. Another example is the large proportion of international doctoral students in our research universities, which has been above 50% for many years. Not surprisingly, the largest percentage increase comes from universities in Asia. Many of these students return to their homes after graduation although, according to the Initial Placement Surveys, the number of graduates returning to their home country immediately after

graduation appears to be decreasing in recent years. Many of these may be returning after working in the U.S.

As this trend toward overseas hiring of U.S. graduates continues, to be competitive at these off-shore sites our graduates must become more adept at understanding other civilizations and cultures, unique local market needs, and ethical considerations. The four-year curriculum already is at capacity with important courses, and it is probably not feasible to add required liberal arts and other “softer skill” courses to it. AIChE’s Education and Accreditation Committee will have to address this. Our chemical engineering departments should be encouraged to consider providing opportunities outside of the four-year curriculum to prepare their students for a future globalized world. These opportunities could involve travel abroad as internships – either after the junior year or during the summer; overseas courses and exposures to culture, civilization and foreign languages; and even multi-year assignments working with companies, plants and markets in the Middle East, China, or India. To be effective abroad, students have to learn the likes and dislikes of foreigners as customers, as employees, and as colleagues and business partners.

Our graduates will be expected to keep track of scientific and technical developments outside of the U.S., and how they will play a role in innovations both in the U.S. and abroad. They will participate in the globalization of concepts. For example, environment and safety issues have been increasingly globalized. One specific instance of this is the publication by the American Petroleum Institute of several well-known standards on pressure relief systems. One of their primary standards is API Standard 521-Pressure Relief and Depressuring Systems, which has recently been co-branded as International Standards Organization ISO-23251. Two other major API safety standards are currently in the process of being cobranded.

#### *Shifts in Technical Societies*

Another consequence of these trends is the strengthening of technical and professional societies in countries where the base of engineering activity is increasing in depth and breadth. Simultaneously, the

broadened geographical base of U.S.-trained chemical engineers leads them to desire somewhat different professional services than would be true of a membership based almost solely in the U.S. The professional services needed for an engineer living in the U.S. and outside the U.S. are probably not very different. Those who have done both suggest that e-mail and electronic communications become more critical. Also needed is a good update service about what is happening in the U.S. networks and decision-making bodies. Already, much of this is in place for the U.S. population, and AIChE may need only to make its members aware of this.

AIChE should assume that its members are contributing to a wide bandwidth of the technology spectrum and are doing so all over the globe. Once this assumption is made, the answers to fundamental questions about the *raison d'être* of AIChE take a very different form from those that have served us to this point in our history.

AIChE should have a presence in locations where large numbers of chemical engineers are educated and work. Examples could be Beijing, Shanghai, Mumbai, Dubai, and Kuala Lumpur. Presence can come in different forms and needs to be managed with respect to budget. Presence also must be developed in a way that will complement, not threaten, local professional societies. Everything overseas must be done in partnership with the home community. AIChE will not survive a solo act, even if it hires local people. In developing an international presence AIChE can develop a list of AIChE members living abroad and their contact information and a list of non-AIChE contact people and organizations at major centers. It can also consider joint membership with local societies, sponsor joint technical, social and networking gatherings, strengthen other societies' benefits by making AIChE's advanced benefits like Knovel, etc., available to them, and assist members visiting abroad by developing contacts with the local AIChE chapters, as well as the local professional societies, and making lists of such contacts available for use by visitors. It can also work closely with U.S.-based companies expanding their overseas engineering activities to better understand and serve their technical/training/recruiting and retention/service/continuity needs.

AIChE can publicize the lives and stories of members working abroad with a series of articles in *Chemical Engineering Progress*. These articles should go beyond how you live and how you got there including experiences and advice in starting an office in Shanghai or Bangalore, suggestions on how to do engineering in these countries, and differences between U.S. and foreign firms as to their human resources practices, business models, and so forth.

AIChE should encourage U.S. universities to offer a more global educational experience with courses in global civilizations, histories, cultures, and foreign languages. It should create a task force to examine alternative pathways for universities and companies to provide students with international engineering experience, both in the U.S. (working on international projects) and abroad, using internships, cooperative education assignments and so forth.