Membership Profiles in the International Council of Academies of Engineering and Technological Sciences

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Abstract— Election or appointment to the position of Fellow in an academy of engineering is a significant career honour. Typically, the appointment is based on submission of a nomination by a current fellow or fellows, vetting of the nomination at the committee level, followed by acceptance or endorsement by the members of the academy at large. Individuals elected to fellowship are recognized at the most senior levels of their engineering community, are well established in their discipline and have a made a contribution which, in some way, sets them apart. Women are, increasingly, reaching this level of recognition internationally. The presence of women within fourteen international academies is discussed, including the date of first female appointment, the average age of the male and female fellows, the percent of female fellows overall and observations on recent changes in appointment level. The distribution of the women by discipline area within the academies is also examined and compared to a large population of fellows in the National Academy of Engineering of the United States. In an increasingly global economy, those participating in engineering education, retention, support, and advancement of women may find the information on the status of women within the community of international academies useful in the development of related domestic and international policies and programs.

Introduction

The International Council of Academies of Engineering and Technological Sciences (CAETS) is an independent, non-political, non-governmental, international organization incorporated in the District of Columbia in the United States. CAETS has a number of objectives with respect to technical considerations and policy issues. Its mission includes the words, "to foster effective engineering and technological progress for the benefit of all societies of all countries." CAETS has twenty-four active member academies that are assigned to one of three levels for fee assessment (US$1000, US$3000, US$6000) depending on the ability of the member academy to participate. Those academies in $1000 group are typically in countries with a smaller population. Their academies tend to be relatively young and have limited funding. Those countries assessed $3000 have somewhat larger populations and levels of funding but relatively small, although established, academies. Those countries with the highest fees of $6000 typically have large populations and the academies have high funding and are very well established.

As it approaches its twentieth anniversary, the Canadian Academy of Engineering (CAE) is benchmarking its position within CAETS and examining best practices in other academies, particularly, but not limited too, those academies in the same $3000 fee category and those academies whose members pay dues associated with the honour of being appointed to the rank of fellow. The author, a volunteer during her sabbatical, undertook the benchmarking exercise which included the four broad areas of governance, finance, membership and outreach. In the

membership area, the CAE was interested in the originating background of the fellows; i.e., academic or nonacademic; the average age of the membership; the application of membership dues; the participation of women; and the visual impression of the first page of the academy website.

During the benchmarking exercise, it became clear that the membership information was not readily available and could be of interest to those involved in engineering education, retention, support, and advancement of women; for example, the Women in Engineering Programs and Advocates Network (WEPAN) and the International Network of Women Engineers and Scientists (INWES). In an increasingly global economy, an understanding of the representation of women in the various academies may be useful in the development of domestic and international polices for education, recruitment and retention. In addition, those involved in the advancement of women in the profession, may find the information on the status of women within the community of international academies, a useful discussion point in pro-actively encouraging the recognition of women through a fellow-based nomination process.

Methodology

At the early stages of the benchmarking study, a brief review of all the academies was carried out using the various academy websites as well as the correspondence files and the formally published documentation available at the CAE. With the assistance of the Executive Director of the CAE, and based on CAETS fees, membership dues, geographical location and trade agreements, a subgroup of the academies was chosen for more detailed study. These academies are those of: Australia, Belgium, Canada, Croatia, Denmark, Finland, France, Japan, Korea, Mexico, Norway, Sweden, the United Kingdom and the United States.

- Belgium ($1000), Denmark ($3000), Finland ($3000), France ($3000), Sweden ($3000) and the United Kingdom ($6000) are members of the European Union (EU). Croatia ($1000) is a candidate member of the EU. Belgium and Croatia have small but developing academies. The former is funded entirely by corporate member dues. The United Kingdom charges member dues. France is also the upcoming host of the 14th International Conference of Women Engineers and Scientists (ICWES) in July 2008.
- The Scandinavian countries, Denmark, Finland, Norway and Sweden, like Canada, are assessed $3000, and share our northern climate. Of these, only Canada has member dues although Finland does have corporate membership dues.
- Mexico ($3000) and the United States ($6000) are, like Canada, members of the North American Free Trade Agreement (NAFTA) and all three collect member dues. The United States is also Canada's largest trading partner.
- Korea ($3000) was the host of the 13th ICWES in August 2005. Japan and Australia are assessed $6000 and have large well established academies. With Korea they are geographical placed in the Pacific Rim and all three have membership dues.

Each academy noted above, was evaluated on a best-efforts basis. Current data from the academy websites, recent annual reports, e-mail or fax or telephone conversations were used where possible. Alternatively, the best available formally published data were used. As many of the websites were not fully available with English translations, the on-line translator at www.tranexp.com, was used. All websites were assessed for the impression of their opening page and the presence of women or statements relating to diversity. All financial conversions were made using the on-line currency converter, www.xe.com/uccc. Summary tables of key information are presented below. Where the information is not easily presented in a tabular form, a written commentary is used.

Results

The operating budgets of the various academies are presented in Table 1. For convenience the academy acronyms are also presented. Canada's operating budget is among the lowest and roughly in the same category as Croatia, Finland and Mexico. Sweden, the United Kingdom and the United States have the highest operating budgets of the academies studied. Australia, Sweden, the United Kingdom and the United States, also have substantial reserves held in property and/or investments. Table 1 also shows the number of members in the various academies considered, along with the CAETS fee and formally identified membership dues. Also included is the contribution of the dues as a percent of the operating budget and an indication of whether corporate or supporting members exist.

In terms of the number of members, Canada is at the lower end of the academies studied whereas the United States is at the other extreme. Unless otherwise noted, the total number of members includes all those living individuals quoted by the specific academy as members; i.e., active and inactive, emeritus, honorary, foreign, international etc. In some cases, member dues were estimated using the number of members in combination with a line item in the financial statement where dues were reported as revenue. Membership dues are of interest to the CAE as there is anecdotal evidence that some members, including high profile members, have objected to paying such dues as part of receiving the honour of being appointed to fellow. Further confidential studies are required to examine this issue. Of particular interest is that the Scandinavian academies have no individual member dues. Only Canada, Japan and Mexico have individual dues that form a substantial portion of the operating budget. In other academies, such dues contribute less than 10% of the operating budget.

While it is not presented here in detail, some academies such as that of United Kingdom and France rely heavily on support from government grants and/or contracts. The NAE receives about 20% of its budget in this way while the CAE has no government support. Korea, Norway and Sweden receive much of their support from industrial funds and/or foundations.

Member Information

Some academies such as the NAE report a clear breakdown of the originating background of the fellows as one of academic, industrial, non-profit or government. The latter three can be grouped as non-academic. Most academies studied, including the CAE and the NAE, have a member source profile that approaches a balance of members with about 50% having an academic background and 50% having a non-academic background.

Several academies have a split other than 50/50. For instance, about 80% of Croatian fellows come from the academic world where as France has only about 35% academic fellows. In Japan, candidate members are 58% academic but full members are 52% academic. The Swedish profile shows about 60% non-academic fellows.

The CAE (Cockshutt, 2006-07) has noted stylistic and content differences between those nominations originating in the academic community and those originating in the non-academic community. There has been some thought that this might be related to the familiarity of reference, grant and paper writing associated with the academic experience. It was not possible to determine whether this is the case at other academies and that may be a subject of a further

Table 1. Academy Budgets and Members

Country	CAETS Fee US$	Operating Budget US$	Members	Member Dues US$	% of Operating Budget	References
Belgium BACAS	1000	49,000	115	-	-	(BACAS, nd) (CAETS, 2004)
Croatia HATZ	1000	111,000	306	-	-	(CAETS, 2004) (HATZ, nd) (HATZ, 2005)
Canada CAE	3000	128,000	382	257	60	(CAE, 2006) (CAE, nd) (CAETS,2004) (Cockshutt, 2006-07)
Denmark ATV	3000	852,000	615	-	-	(ATV, nd) (ATV, 2006) (CAETS, 2004) (Sjolander, 2006) (Thurmann, 2006)
Finland FACTE	3000	107,000	550	-	-	(Crotogino, 2004) (FACTE , nd) (Saarela, 2006)
France NATF	3000	851,000	228	-	-	(CAETS, 2004) (NATF, nd) (NATF, 2004) (NATF, 2005)
Korea NAEK	3000	2,200,000	635	215	5	(NAEK, nd) (NAEK, 2005a) (NAEK, 2005b).
Mexico AI	3000	98,000	400	86	55	(AI, nd) (CAETS, 2004)
Norway NTVA	3000	256,000	452	-	-	(CAETS, 2006) (NTVA, nd) (NTVA, 2006)
Sweden IVA	3000	9,380,000	766	-	-	(IVA, nd) (IVA, 2004) (IVA, 2005) (Josefsson, 2006)
Australia ATSE	6000	2,300,000	753	155-300	6	(ATSE, nd) (ATSE, 2006) (CAETS, 2004) (Dimech, 2006)
Japan EAJ	6000	584,000	629	643	66	(CAETS, 2004) (EAJ, nd) (EAJ, 2004) (Kumabe, 2006)
United Kingdom RAEng	6000	19,600,000	1470	240	2	(CAETS,2004) (RAEng , 2006) (RAEng , nda) (RAEng , ndb)
United States NAE	6000	12,000,000	2538	200	2	(CAETS, 2004) (McFerson, 2007) (NAE, nd) (NAE, 1999) (NAE, 2005)

study. Nevertheless, those involved in the advancement of woman and the possible nomination and election of women to an academy of engineering, may find the observation useful when preparing nomination documents.

Age and Gender Profile

Table 2 gives the average age of male and female fellows and the percent female fellows for active or individual members where known. Collection of age data was somewhat problematic. Few academies report such data on the academy website and when reported it is often not clear whether it includes all members or just active members. Some annual reports were found to include average age data; one reported the median age. Several academies were willing to calculate the average age of their membership. In other cases, published academy membership data on websites, handbooks or membership registries were used find the date of birth of each of the members and then calculate their average age.

It is obvious that the average of male fellows in the various academies approaches the age of retirement. Women fellows, in general, are younger than their male counterparts. This is consistent, in Canada at least, with the 2002 National Survey of the Engineering Profession (CCPE, 2002) which found that the average age of men in the profession was 9 years older than the average age of the women. It should be noted that Sweden has no active members over 65. Korea and Belgium have no members at all over 65. The oldest average age for men is about 70 in Japan, the United Kingdom and the United States. The youngest female fellows appear to be in Denmark and Finland with average age of about of 50. It should be noted that the NAE also provided age information for its 'newer' members although it was not clear how 'newer' was defined.

Emeritus or non-active standards vary, with some countries using age or self-determination for the shift to an emeritus or non-active status. The United States uses the concept of age 70 or 10 years of regular dues. In Canada, individual fellows requests the switch to an emeritus status typically as the member approaches the early 70s and has a number of years of appointment as a regular fellow.

Table 2 also gives the representation of women fellows in the various academies. At the low end are Japan, Korea, the United Kingdom and Mexico at less than 2%. In the mid-range, of 4 to 5%, are Canada, Norway and the United States. At the high end are Croatia, Finland and France at about 10%. Sweden stands alone at 15%.

The CAE and the NAE with 4% to 5% female representation in the academies are at about half the overall representation of women in the North American engineering profession. For example, the 2002 Canadian survey (CCPE, 2003) stated that the overall participation of women in professional engineering in Canada was 9%. Similarly, the Society of Women Engineers website (SWE, nd) shows that in 1999, 10.6% of employed engineers were female. However, the average age of women in the 2002 Canadian survey was 35 (compared to 44 for the men). As women in the academies have an average age of 57 for Canada and 64 for the United States, it is to be expected that their participation rate in the academies (4% to 5%) would be less than their participation in the overall female engineering population (9% to 10.6%).

Table 2. Age and Gender Profile

Country	Comment	Average Age Men	Average Age Women	% Women	References
Australia ATSE	Individual	67	61	5.3	(ATSE, nd) (ATSE, 2006) (Dimech, 2006)
Canada CAE	Individual	64	59	5.2	(CAE, nd) (CAE, 2006) (Cockshutt, 2006-07)
Croatia HATZ	All	-	-	9.4	(HATZ, nd) (HATZ, 2005)
Demark ATV	Active	58	48	9.8	(ATV, nd) (CAETS, 2004) (Thurmann, 2006)
Finland FATCE	Active	60	50	10	(Crotogino, 2004) (FACTE , nd) (Saarela, 2006)
France NATF	Active	61	57	5.7	(NATF, nd) (NATF, 2004) (NATF, 2005)
Japan EAJ	Individual	71	59	<1	(EAJ, nd) (EAJ, 2004) (Kumabe, 2006)
Korea NAEK	Full Candidate	60 53	-	<1	(NAEK, nd) (NAEK, 2005a)
Norway NTAV	All	60		5.3	(CAETS, 2006) (NTVA, nd) (NTVA, 2006)
Sweden IVA	Active	58	57	14.7	(IVA, nd) (IVA, 2004) (IVA, 2005) (Josefson, 2006)
United Kingdom RAEng	All -except honorary & international	70	60	<2	(RAEng , 2006) (RAEng , nda) (RAEng , ndb)
United States NAE	Individual	72 60 (called new)	64	4.5	(McFerson, 2007) (NAE, 1999) (NAE, nd) (NAE,2005)

History and Trends in Appointments

Table 3 shows how the various academies compare in terms of their first appointment of a female fellow and the year the academy began. The very first women were appointed to the academies of the United States and Denmark in 1965. A number were appointed in the 1970s. By the 1980s and 1990s, women had been appointed in most of the academies studied.

Of particulate interest is the higher percentage of appointments of female fellows in recent years with Norway and Sweden demonstrably higher than all other academies studied. The higher levels of recent appointments; e.g., 10% women in the NAE in 2005, is more in line with the general participation of women in engineering.

Table 3. Female Fellows, Year of Formation (CAETS, 2006), New Members per Year

Country	Began	1st woman	New per Year	History of Female Appointments	References
Australia ASTE	1975	3 in 1977	30	3 - 1977, 1 - 1981, 1 - 1987, 1 - 1988, 2 - 1990, 1 - 1991, 1 - 1992, 1 - 1993, 1 - 1994, 6 - 1996, 1 - 1997, 1 - 1998, 2 - 1999, 5 - 2000, 2 - 2001, 1 - 2002, 1 - 2003, 1 - 2004, 2 - 2005 (~7%)	(ATSE, 2006) (Dimech, 2006) (ATSE, nd)
Canada CAE	1987	1 in 1988	20-30	1 - 1988, 1 - 1999, 1 - 1993, 1 - 1994, 1 - 1997, 1 - 1998, 1 - 1999, 4 - 2000, 3 - 2003, 4 - 2004 (~13%), 1 - 2005, 0 - 2006.	(CAE,2006) (CAE, nd) (Cockshutt, 2006-07)
Croatia HATZ	1993	2 in 1993			(HATZ,nd) (HATZ, 2005)
Demark ATV	1937	1 in 1965	15	1 - 1965, 1 - 1981, 2 - 1985, 1 - 1987, 2 -1989, 5 - 1991, 3 - 1993, 1 - 1995, 1 - 1997, 3 - 1999, 2 - 2001, 13 more 2002 - 2006 (30 appointed alternate years)	(CAETS,2004) (Thurmann, 2006) (ATV, nd)
France NATF	1982	5 in 2000	~ 24	5 - 2000, 3 - 2002, 3 - 2003, 1 – 2004	(NATF, 2005) (NATF, 2004) (NATF, nd)
Korea NAEK	1996	2 in 2005 full 1 in 2003 candidate	~ 23 to 28	1 - 2003 (candidate), 2 - 2005 (full) (~7%)	(NAEK, nd) (NAEK, 2005a)
Norway NTAV	1955	1 in 1986	~ 3 to 15	1 - 1986, 3 - 1988, 1 - 1991, 1 - 1992, 2 - 1996, 1 - 1997, 1 - 1998, 2 - 1999, 1 - 2000, 1 - 2002, 3 - 2003, 3 - 2004 (30%), 0 – 2005	(NTVA, nd) (CAETS, 2006) (NTVA, 2006)
Sweden IVA	1919	1 in 1970	~ 20 to 25	1 - 1970, 1 - 1977, 1 - 1982, 2 -1986, 2 - 1988, 1 - 1989, 3 - 1990, 1 - 1991, 4 -1993, 1 - 1994, 4 -1995, 5 - 1996, 4 -1998, 3 - 1999, 4 - 2000, 1 - 2001, 6 - 2002, 3 - 2003, unknown for 2004, 4 – 2005 (~ 19%)	(IVA, nd) (Josefsson, 2006) (IVA, 2005) (IVA, 2004)
United Kingdom RAEng	1976	1982	max 60		(RAeng , 2006) (RAEng , nda) (RAEng , ndb)
United States NAE	1964	1965, then 1973	~ 70 to 80	1 - 1965, 1 - 1973, 2 - 1974, 1 - 1975, 1 - 1976, 1 - 1977, 1 - 1978, 1 - 1979, 1 - 1980, 1 - 1981, 1 - 1982, 1 - 1983, 1 - 1984, 1 - 1985, 1 - 1986, 4 - 1987, 4 - 1988, 2 - 1989, 3 - 1992, 4 - 1993, 2 - 1994, 5 - 1995, 3 - 1996, 5 - 1997, 2 - 1998, 2 - 1999, 5 - 2000, 7 - 2001, 5 - 2003, 4 - 2003, 6 - 2004, 7 – 2005 (~10%)	(McFerson, 2007) (NAE, nd) (NAE,2005) (NAE, 1999)

As the presence of women in the academies was of interest to the CAE, attention was paid to those related details that surfaced as part of the benchmarking study. It quickly emerged that both Canada and Sweden have had female fellows in the position of academy president. Canada has had two female presidents, which appears to make it unique in this area. A check of available data showed that there has been no female academy president in Australia (ATSE, 2006), Norway (NTVA, 2006) the United Kingdom (RAEng, ndb) and the United States (McFerson, 2007). The latter two, however, do indicate strong presence for women in engineering on their respective websites. The United Kingdom, with less than 2% female fellows, has a Young Woman Engineer Award (and several other projects related to women) and a stated policy in the

area of diversity (www.raeng.org.uk/about/diversity/default.htm) relating to the appointment of fellows and the assignment of grants. The United States has a high presence for women on it website including reference to the "Engineer Girl!" website (www.engineergirl.org), the "Celebration of Women in Engineering" website (www.nae.edu/cwe) and reference to the "Extraordinary Women Engineers Project" and the "Gender Equity Extension Project". These two academies appear to have the strongest "front page" website presence related to women.

Categorization of Fellows by Discipline

The academies of Australia, Canada, Croatia, Korea, Norway, Sweden, the United Kingdom and the United States had sufficient recent information to allow an assessment of the areas in which the female fellows are positioned by discipline in their own academies. Naturally, the experience developed over a career may not be in the same area as the original degree or area of practice. The discipline areas used were based largely on the twelve areas selected by the NAE as they reflected most of the areas of the participating academies. Some areas of expertise were difficult to classify; e.g. textile production was placed in the industrial classification.

Figure 1, representing a group of over 200 international female fellows in the eight academies shows that the largest single group fall into nontraditional interdisciplinary areas (18%), followed by the chemistry-chemical discipline at 14%. The latter has traditionally been an attractive discipline for women in engineering; e.g., (CCPE, 2002). The computer science and systems discipline follows with 13% of the group. It is important to note that based on the average age of woman fellows, newer disciplines such as biomedical engineering will be less reflected in these numbers than might be seen, for example, in university enrollment figures.

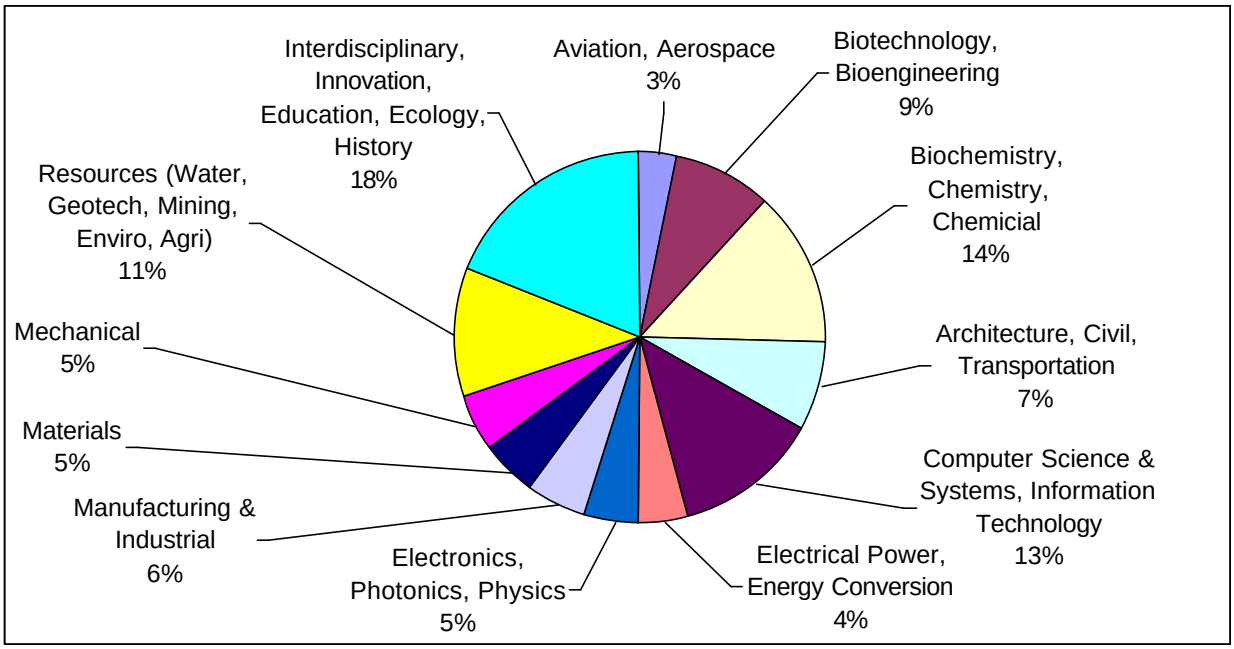

Figure 1. Female Fellows by Discipline in Eight CAETS Academies

Figure 2 shows the same breakdown by discipline for the over 2000 fellows in the NAE (NAE, nd), including the female fellows. Here, electronics and photonics claim the largest fraction (18%), followed by architecture, civil and transportation (11%) and computer science and systems (10%). Using these data for the NAE, it appears that men in engineering and

technological sciences are being recognized and nominated to fellow for slightly different reasons, with proportionately more women making their mark in nontraditional interdisciplinary areas and more men making their mark in traditional core areas.

The complications of career choices and discipline preferences; e.g., (Eisenhart, 1998) in combination with the standard academy nomination process suggest that further study is required to determine why women are being recognized in nontraditional fields.

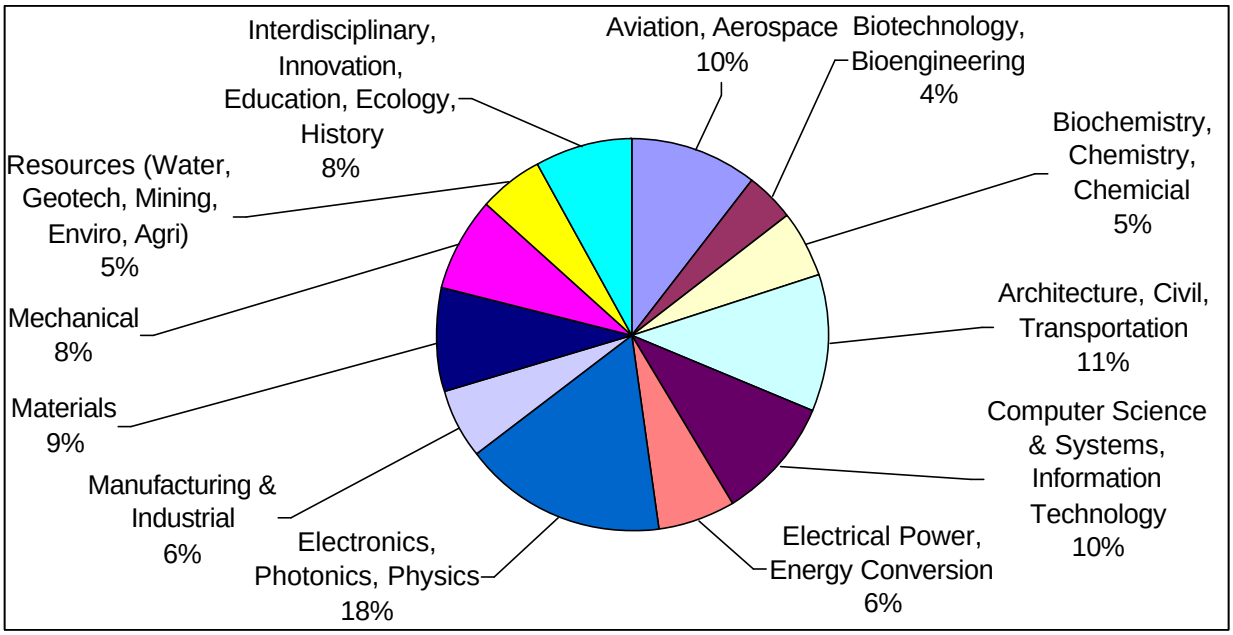

Figure 2. All Fellows of NAE by Discipline [40]

Conclusions and Contributions

- Women fellows in the academies studied are, on average, younger than their male counterparts and represent a small fraction of the fellows elected ranging from a low of less than two percent to a high of fifteen percent in the academies studied. Recent appointment data suggest that the fraction of women recognized as fellows is increasing in many academies.
- Those involved in the advancement of women in the profession, may find the information on the status of women within the community of international academies, a useful discussion point in pro-actively encouraging the recognition of women through a fellow-based nomination process.
- Women fellows appear to making their mark in somewhat different discipline areas than their male counterparts. Further study is needed to better understand the reasons behind this.

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