State of Power Engineering Education in the U.S. and Canada: Overview of Results of the 2013-2014 PEEC Survey

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Acknowledgements

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Objectives

- Promote power engineering education through an easy-to-access web location with information on power engineering education opportunities
- Facilitate advancement in the quality of power engineering education
- Assess the state of power engineering education and research from a national perspective

Retirements and New Knowledge Needs Motivate Assessment of the Education System

	Potential Replacements 2013 - 2017		Potential Replacements 2018 - 2022	
Job Category	Potential Attrition & Retirement	Estimated Number of Replacements	Potential Retirement	Estimated Number of Replacements
Lineworkers	32%	24,100	14%	10,300
Technicians	41%	28,300	14%	10,100
Plant Operators	42%	14,900	13%	4,600
Engineers	34%	9,200	12%	2,900
Total	**36%**	**76,500**	**14%**	**27,900**
Totals exclude Nuclear				

Source: Center for Energy Workforce Development. *Gaps in the Energy Workforce Pipeline: 2013 Survey Results*.

Overview of the 2013-2014 PEEC Survey

- Self-reporting, online survey conducted between May and September 2014.
- Eligibility: Four year institutions in the U.S. and Canada awarding accredited (i.e., ABET accreditation in the U.S.) degrees in electrical engineering.
- Invitations to participate were widely distributed.
- The survey reporting year was July 1, 2013 - June 30, 2014.
- Focus on electrical engineering education

Survey Sections

- General university information
- Power faculty and staff
- Undergraduate and graduate programs
- Course offerings
- Student enrollment and graduation estimates
- Research

Uses of Survey Data: University Specific

- "University Education and Research Programs in the U.S. and Canada for Power and Energy Engineering Careers": a PDF file available at: http://www.ieee-pes.org/professional-development/education/university-power-programs
- Report contains: university descriptions, websites, academic programs, degrees offered, courses, research centers, research areas, faculty directory, and faculty instruction and research areas

Uses of Survey Data: Aggregated Statistical Information

- Currently given in this presentation
- Also available at: http://www.ieee-pes.org/professional-development/education/university-power-programs
- Note: The data are self-reported. No effort has been made to verify it. Data errors can occur for a variety of reasons, such as due to a respondent not fully understanding what data were requested.

Universities Responding to 2005/6 and 2013/14 PEEC Surveys

Year of Survey	U.S. Responses	Canadian Responses
2005/6	112	8
2013/14	122	10

Although 132 universities responded to the survey, each university did not necessarily provide data in each area of the survey. When some of the universities did not respond in a survey area, we report the number of responding universities.

Faculty and Staff Delivering Course Instruction

	Canada		US	
Rank/Title	**N**	**%**	**N**	**%**
Professor	19	43.2%	222	44.9%
Associate Professor	11	25.0%	93	18.8%
Assistant Professor	8	18.2%	96	19.4%
Adjunct Professor	0	0.0%	44	8.9%
Emeritus Professor	4	9.1%	16	3.2%
Instructor/Lecturer	2	4.5%	23	4.7%
Total	44	100.0%	494	100.0%

Average: 4 per university. Range: 1 to 13. For this presentation, staff are defined as adjunct professors, emeritus professors, instructors and lecturers.

Faculty Rank Distribution (U.S. and Canada Combined)

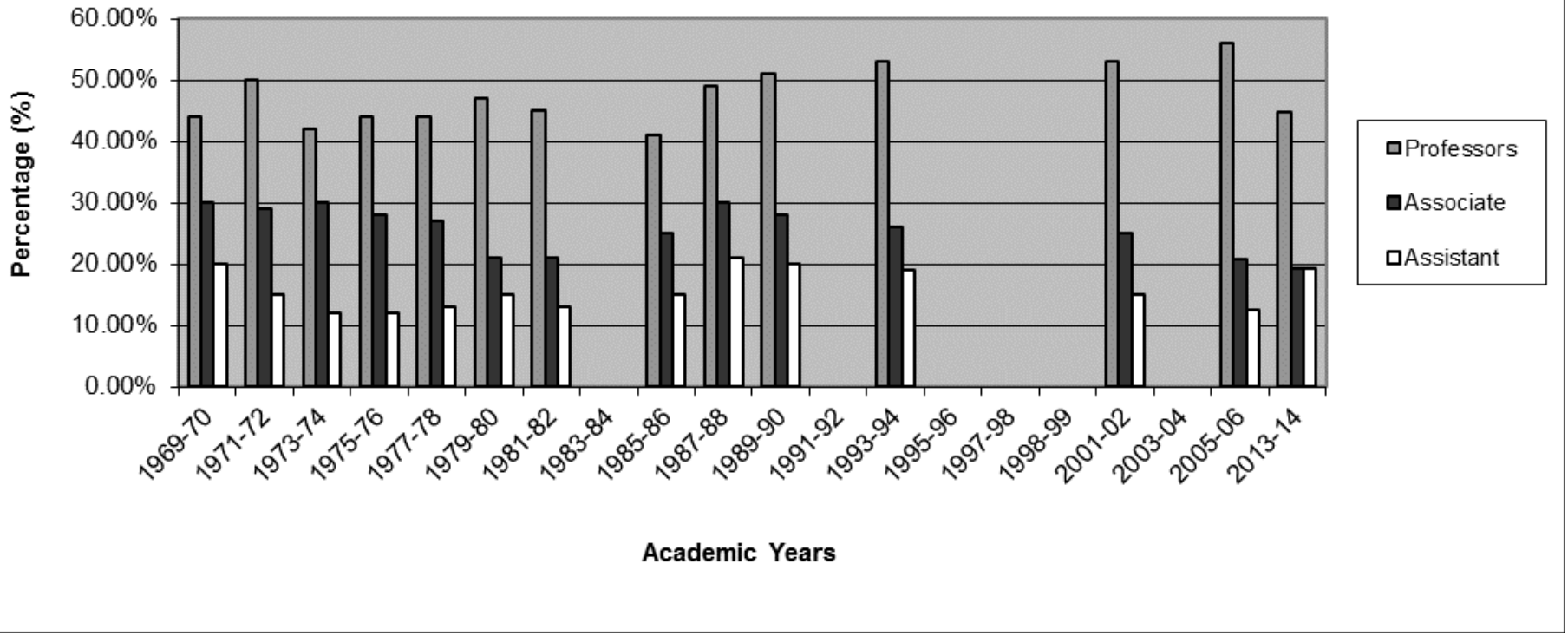
Rank/Title	N	% of all
Professor	241	44.8%
Associate Professor	104	19.3%
Assistant Professor	104	19.3%
Total	449	83.5%

The number of full professors, associate professors, and assistant professors reported in the 2005/6 survey were 212, 79 and 48 respectively.

Comments

- In the 2005/6 Survey, 380 faculty and staff were reported for the U.S. and Canada combined (538 in 2013/14 Survey). 339 were faculty (i.e., full, associate, and assistant). The increase in the 2013/14 Survey may be due to more hires, more faculty being classified as in “power engineering” as the discipline expands, and to more universities responding to the survey.
- The faculty percentage of total instruction personnel fell from 89.2% in 2005/6 to 83.5% in 2013/14. This suggests greater use of staff for instruction (i.e., adjunct professors, emeritus professors, instructors and lecturers).

Professorial Rank/Title Trends (% of all Reported Faculty and Staff)



The significant rise in the number of associate and assistant professors suggests that universities are building their faculty for the future.

Highest Degree for Faculty and Staff

	Canada		US	
Highest Degree	**N**	**%**	**N**	**%**
PhD	42	95.5%	466	94.3%
Masters	2	4.5%	23	4.7%
Bachelors	0	0.0%	5	1.0%
Other	0	0.0%	0	0.0%
	44	100.0%	494	100.0%

In the 2005/6 Survey, 95.8% of faculty and staff reported as having PhD's. Instruction by PhD recipients appears to still be the norm. Those faculty and staff with Masters and Bachelors as the highest degrees are almost all adjunct professors, instructors or lecturers.

Faculty/Staff who are IEEE PES Members and/or IEEE Fellows

	Canada		US	
	N	%	N	%
IEEE PES Member	36	81.8%	395	80.0%
IEEE Fellow	11	25.0%	136	27.5%

In the 2005/6 Survey, 91.8% (or 349 in total) of faculty and staff were PES members so interest by faculty/staff in PES membership appears to not be rising as quickly as the total. However, this may be due in part to the diversification of the reported power engineering faculty and staff (such as engineering faculty focusing on power electronics or economics faculty focusing on power markets and policies).

Years in Academia

	Canada		US	
Years in Academia	**N**	**%**	**N**	**%**
0-10	12	27.3%	192	38.9%
11-20	10	22.7%	96	19.4%
21-30	15	34.1%	118	23.9%
31-40	2	4.5%	61	12.3%
41-50	3	6.8%	22	4.5%
>50	2	4.5%	5	1.0%
Total	44	100.0%	494	100.0%
Average	21.55		18.22	
Median	21.00		17.00	

Average academic experience across U.S. & Canada was 18.5 years.

Comments

- Average reported power industry experience was 7.4 years in Canada and 4.8 years in the US. Due to survey response inconsistencies, these are only estimates by the Survey Team. Average academic experience was 18.5 years.
- In the 2005/6 Survey, the average reported academic experience was 20.5 years and the average power industry experience was 4.14 years.
- Lower academic experience is consistent with a faculty with relatively more younger professors. Industry experience trends will need to be studied more.

Full-time Personnel Changes and Retirement Eligibility Status

	Canada		US	
	N	% of all	N	% of all
Faculty/Staff Left	2	4.5%	50	10.1%
Faculty/Staff Hired	4	9.1%	78	15.8%
Retirement Eligible				
Now	2	4.5%	58	11.7%
In 1-5 years	6	13.6%	54	10.9%
In 6-10 years	8	18.2%	100	20.2%

Through 2024, up to 43% of faculty and staff in the U.S. and 42% in Canada will be retirement eligible. Again, the survey reporting year was July 1, 2013 - June 30, 2014, and responses were received in 2014.

Education Statistics

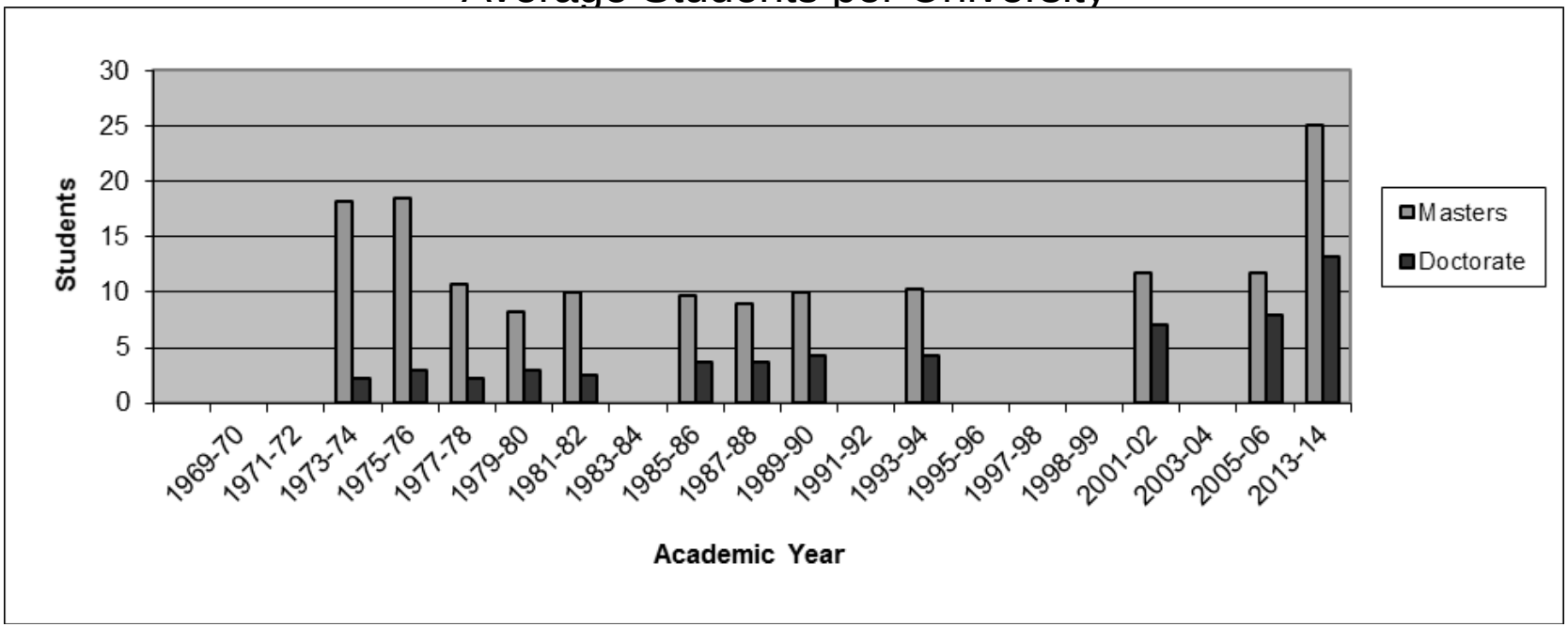
	Canada		US	
	N	%	N	%
Universities Offering Masters	10	100%	104	85.0%
Universities Offering PhD	10	100%	86	70.0%
Estimated Graduations				
Undergraduates	338		2,551	
Masters	174		1,185	
PhD	70		379	
Est'd Average Undergraduate % who are Domestic	80%		81%	

Graduations were not reported in previous PEEC surveys. Survey respondents were asked to estimate the number of degrees conferred to electrical engineering students graduating during the reporting year who were likely to pursue positions in electric power engineering. Estimating undergraduates going into power engineering is particularly difficult. {Note: 131 universities provided undergraduate estimates.}

Full-Time and Part-time Graduate Student Enrollments

		Canada		US	
Masters FT Domestic		89	43.8%	704	34.0%
Masters FT International		114	56.2%	1369	66.0%
Total Masters FT		203	100.0%	2073	100.0%
Masters PT Domestic		125	96.2%	443	79.4%
Masters PT International		5	3.8%	115	20.6%
Total Masters PT		130	100.0%	558	100.0%
PhD FT Domestic		40	29.0%	298	23.4%
PhD FT International		98	71.0%	975	76.6%
Total PhD FT		138	100.0%	1273	100.0%
PhD PT Domestic		6	100.0%	95	70.4%
PhD PT International		0	0.0%	40	29.6%
Total PhD PT		6	100.0%	135	100.0%

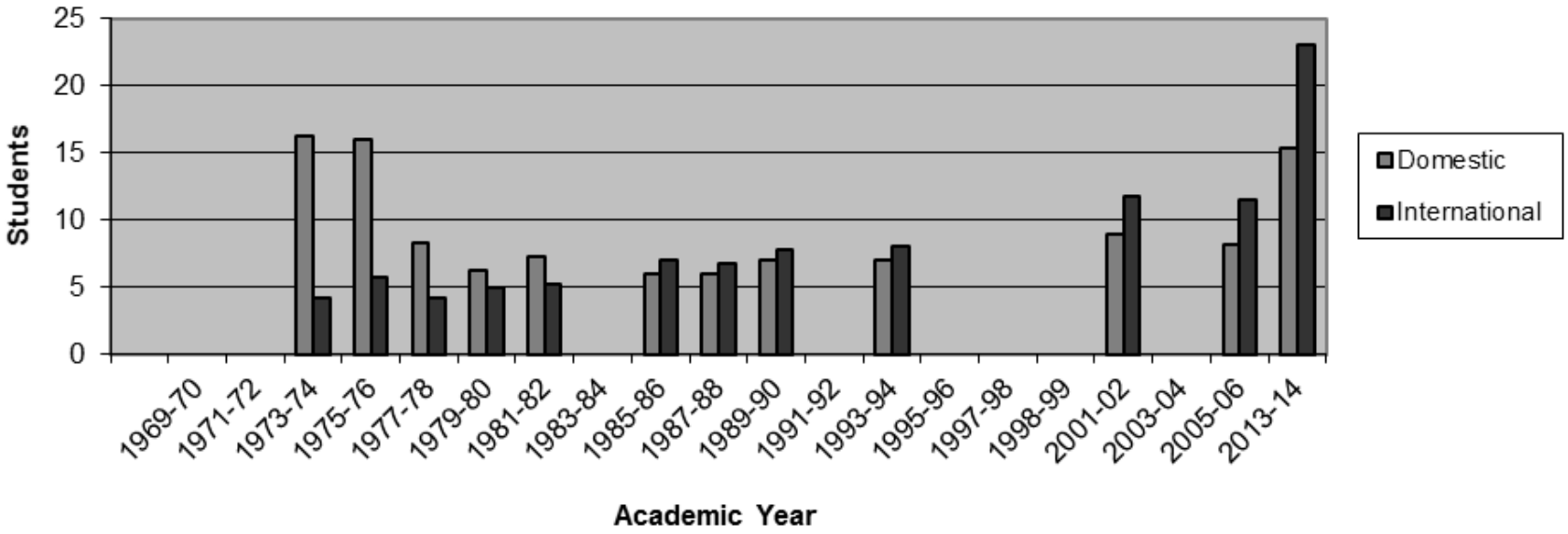
Graduate Student Enrollment Trends



The average number of enrolled Masters and PhD students (full-time and part-time) across all universities rose from 12 and 8 in the 2005/2006 Survey to 25.1 and 13.2 in the 2013/14 Survey. This is about a 110% increase in Masters students and a 65% increase in PhD students. This result could be due to both increased interest in power engineering and to increased enrollment in electrical engineering. {Note: 14 universities reporting zero graduate students were not included in the calculation.}

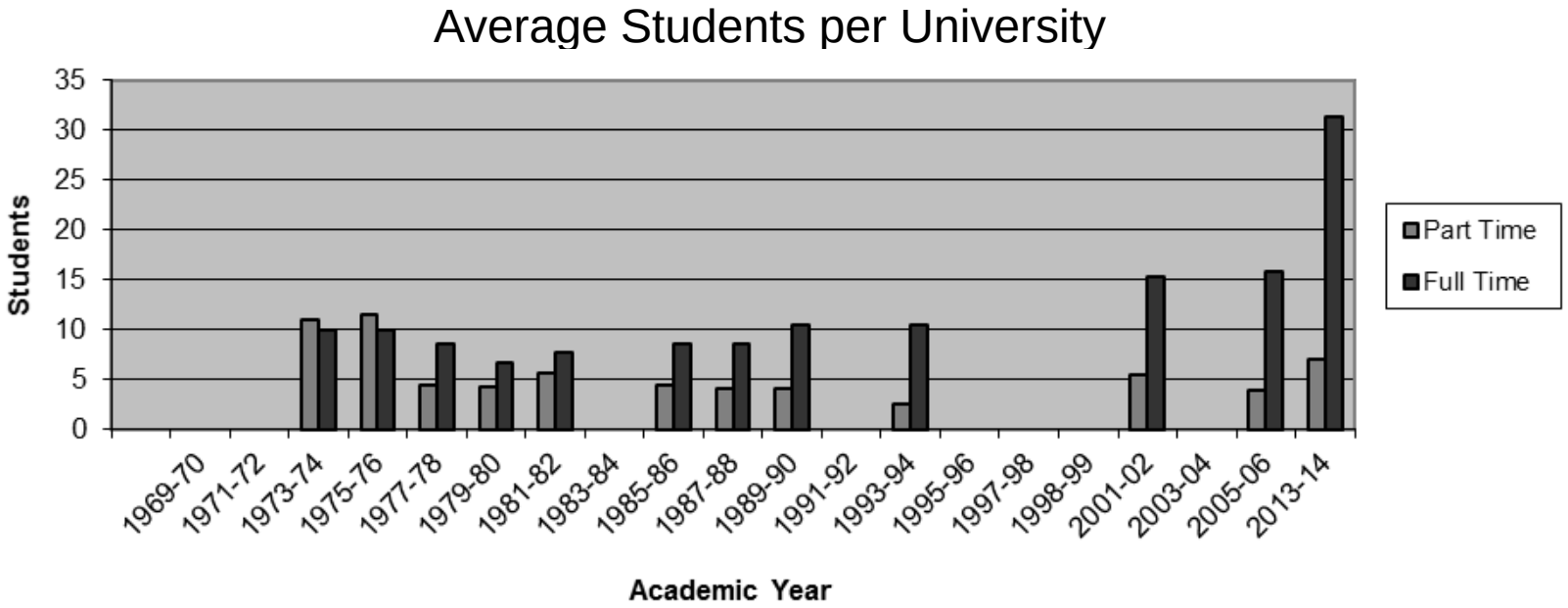
Domestic and International Graduate Student Enrollment Trends

Average Students per University



The percentage of international graduate students increased from 59.4% in the 2005/6 Survey to 60.1% in the 2013/14 Survey. Average domestic students increased from to 8 to 15.3 (i.e., by 91%). Average international students increased from to 11.7 to 23.0 (i.e., by 97%). {Note: 14 universities reporting zero graduate students were not included in the calculation.}

Full-Time and Part-Time Graduate Student Enrollments



PT graduate students likely have a regular job while working on their degrees. The average number of FT and PT graduate students has risen from 16 and 4 respectively as reported in the 2005/6 Survey to 31.3 and 7.0 in the 2013/14 Survey. Thus, the average enrollments have grown 96% (FT) and 75% (PT). The total number of FT and PT graduate student enrollments was 3,687 and 829. {Note: 14 universities reporting zero graduate students were not included in the calculation.}

Undergraduate Graduation Trends: Highest Enrollment Class Sizes

Survey Date	Total Students in Highest Enrollment Classes	Number of Universities	Average
2013-2014	6,558	126	52
2005-2006	3,335	115	29
2001-2002	3,565	115	31
1993-1994	2,912	91	32

As an indicator of increased undergraduate interest in power engineering, the average enrollment in classes with highest enrollment has gone up almost 80% since the 2005-06 Survey. 55 of the 126 classes with highest enrollment were mandatory classes which is consistent with 60% of the Canadian universities and 43% of the US universities having mandatory classes for all students. {Note: 126 universities provided undergraduate course data.}

Why Don't We Know How Many Power Engineering Undergraduates There Are?

- Universities do not know which students are interested in power engineering careers and which ones actually took jobs in that career field.
  - Most universities do not have degrees, certificates, etc., explicitly for power engineering.
  - Students do not have to report which companies they go to work for so faculty do not know how many students are actually going to work in power engineering.
- We don't know how many universities are graduating students who are going into power engineering careers. There were universities that did not respond to the survey request.

What's Our Best Guess of the Trend in Power Engineering Undergraduates?

- The number of undergraduates going into power engineering about doubled between the 2005/6 and the 2013/14 surveys.
- Basis for this conclusion:
  - The average number of undergraduate students in the "max enrollment classes" went up 80% from the 2005/6 Survey to the 2013/14 Survey.
  - Reported average domestic Masters student enrollments went up by 91%.
  - The estimated number of graduating U.S. undergraduate power engineering students went from 800-1,000 [see Workforce Collaborative (2009)] to 2,551 (2013/14 Survey).
- Reminder: This is the first PEEC survey in which universities were asked to estimate graduation counts so there are no comparable reference numbers to use from the 2005/6 Survey.

Typical Education Program Size

	Canada	US
Median Student Enrollment		
Full-Time Masters	16.5	11
Full-Time PhD	12.5	10
Median Student Graduations		
Undergraduate	30	15
Masters	12.5	7
PhD	4.5	3

The range of reported enrollments and graduations is high. All above median values are calculated using only schools that offer that respective degree type; e.g., only schools that offer a Masters program are used to calculate median Masters enrollment. {Note: 10 Canadian universities reported MS and PhD programs, 104 US universities reported MS programs, and 86 US universities reported PhD programs.}

Undergraduate Program Options

	Canada		US	
	N	%	N	%
Mandatory courses for all students	6	60.0%	52	42.6%
Mandatory course for all students in a special track, minor, certificate, etc.	3	30.0%	43	35.2%
Elective courses	9	90.0%	112	91.8%
Special track	5	50.0%	27	22.1%
Minor	1	10.0%	4	3.3%
Certificate	0	0.0%	12	9.8%
Coop				
Available (optional)	8	80.0%	80	65.6%
Available (mandatory)	2	20.0%	2	1.6%
Not available	0	0.0%	40	32.8%

Topics in Undergraduate "Power Engineering" Course Offerings (using words in course titles)

- Electronic (105 occurrences) {e.g., power electronics}
- Renewable (16), Sustainable (8), Wind (7), Solar (5), Green (1)
- Smart (12) {e.g., smart "grid", smart "power system"}
- Communication (1)

Notes:

(1) Courses reported were to help prepare students for a power engineering career. Total courses reported: 665 undergraduate
(2) 4 faculty/staff reported to have taught power electronics in Canada in the last two years (undergrad and/or grad)
(3) 43 faculty/staff reported to have taught power electronics in the U.S. in the last two years (undergrad and/or grad)
(4) 129 universities reported grad and/or undergrad course data

Topics in Graduate "Power Engineering" Course Offerings (using words in course titles)

- Electronic (96 occurrences) {e.g., power electronics}
- Renewable (25), Sustainable (12), Wind (13), Solar (3)
- Smart (27) {e.g., smart "grid", smart "power system"}
- Communication (3)

Total courses reported: 756 graduate
129 universities reported grad and/or undergraduate course data

Graduate Degree Delivery Methods

Number of Degree Offerings			
	Masters	**PhD**	**Total**
In Class	110	94	204
Distance Education	10	1	11
Both	32	8	40

Many universities have multiple graduate degree offerings. In-class degrees are by far the most prevalent, but distance learning offerings do exist. 115 universities responded to survey questions about their degree offerings.

Courses Delivered via Distance Learning

2005/6 Survey	2013/14 Survey
22 out of 118 universities (19%) offering one or more courses	44 out of 127 universities (35%) offering one or more courses with one or more students 32 out of 127 universities (25%) offering one or more courses with at least one course with more than 5 enrolled students

More universities are offering courses via distance learning rising from 19% to 35% of reporting universities. The commitment of universities to distance learning varied from universities seeming to be just starting to universities with substantial distance learning programs. The courses offered via distance learning tend to be graduate courses. For the 2013/14 Survey, the courses with distance learning students were: (1) Graduate - 28% of all reported grad courses and (2) Undergraduate - 10% of all reported undergrad courses.

Research Expenditures ($)

	Canada		US	
Government - Non-Equipment	$6,620,301	49.4%	$96,480,448	76.4%
Domestic Utility - Non-Equipment	$5,423,501	40.4%	$14,690,600	11.6%
Other Dom. Industry - Non-Equipment	$1,336,001	10.2%	$15,183,471	12.0%
Total Non-Equipment Expenditures	$13,409,803	100.0%	$126,354,519	100.0%
Median Non-Equipment Expenditures*	$570,000		$587,500	
Government - Equipment	$2,462,876	79.1%	$16,130,682	70.1%
Domestic Utility - Equipment	$440,001	14.1%	$1,785,200	7.8%
Other Dom. Industry - Equipment	$212,501	6.8%	$5,100,363	22.2%
Total Equipment Expenditures	$3,115,378	100.0%	$23,016,245	100.0%
Median Equipment Expenditures*	$247,500		$70,000	
Median Total Expenditures*	$978,333		$600,000	

**One Canadian university and 20 US universities reported zero non-equipment research expenditures. No Canadian universities and 49 US universities reported zero equipment research expenditures. These zero responses may be valid or they may indicate missing data. The median values reported above are the median values for universities reporting non-zero expenditures. US universities rely heavily on government funding. Although the survey results indicate that Canadian universities receive more support from industry than US universities, public ownership plays a more wide-spread role for Canadian utilities than in the US. The median research funding is probably sufficient for supporting only two or three faculty members.*

Reported Research Funding Outlook for Next Three Years

All Universities

	Canada		US	
Funding Outlook	**N**	**%**	**N**	**%**
Rising	5	50.0%	40	32.8%
Stable	5	50.0%	62	50.8%
Declining	0	0.0%	20	16.4%
	10	100.0%	122	100.0%

55 Universities with more than $600K in Non-Equipment Research Expenditures

Funding Outlook	N	%
Rising	16	29.1%
Stable	29	52.7%
Declining	10	18.2%
	55	100.0%

Universities generally reported a positive research funding outlook in the near term. Views on the long-term outlook were not requested in the survey. Adequacy of research funding is critical for faculty support and for decisions to hire new faculty.

Universities with Power Faculty Working to Attract K-12 Students or to Help K-12 teachers

Canada		US	
N	% of all	N	% of all
5	50%	82	75%

Most universities reported that their power faculty participated in outreach events to attract K-12 students to the power engineering career field or to help K-12 teachers.

Conclusions - Students

- Student interest in power engineering has grown significantly (almost a doubling of the number of students graduating in power engineering from the 2005/6 Survey to the 2013/14 Survey).
- The percent of international graduate students has grown (from 59% to 61% of all graduate students from the 2005/6 Survey and 2013/14 Survey). Excluding part-time students, 65% and 76% of Master's and PhD students respectively are international. Domestic students still dominate undergraduates (81% in the 2013/14 Survey).
- A majority of universities (about 75% in the 2013/14 Survey) are working to build the pipeline of students from high school to college.

Conclusions - Faculty

- Faculty ranks reflect a healthier balance with strong growth in the number of assistant and associate professors (e.g., the percent of assistant professors rising from 12% to 19% of faculty and staff from the 2005/6 Survey to the 2013/14 Survey).
- The potential for faculty and staff retirements is high over next 10 years (over 40% of faculty and staff will be retirement eligible through 2024 according to the 2013/14 Survey).

Conclusions - Courses

- Diverse course topics are being offered (renewables, smart grid, etc.) with electronics being the most frequently noted in course titles besides traditional course topics. Diversity within actual course material was not surveyed.
- In general, in-class degrees still dominate the degree options.
- Use of distance learning is growing (percent of universities offering any distance learning has grown from 19% in the 2005/6 Survey to 35% of universities in the 2013/14 Survey). Masters degrees are more frequently offered via distance learning than doctoral degrees.

Conclusions - Research

- Adequacy of research funding is critical for faculty support and for hiring decisions.
- The near-term outlook for research funding is viewed as positive by the reporting faculty members.
- Heavy dependence on government sources of research funding may be a significant source of funding uncertainty over the long-term. This is a concern as new faculty need to be hired in the next 10 years to replace retiring faculty.

Questions or Comments

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