

THE  
PENNSYLVANIA STATE UNIVERSITY  
DEPARTMENT OF MECHANICAL AND  
NUCLEAR ENGINEERING



STRATEGIC PLAN  
FOR  
2008/09 TO 2012/13

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## EXECUTIVE SUMMARY

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The disciplines of mechanical and nuclear engineering are critical to address problems at the intersections of science and technology. These problems include meeting energy demands without damaging our environment, developing biomedical devices that minimize surgical impact, and using biologically inspired robots to ensure homeland security. Projections are that our workforce will require large increases in the numbers of mechanical and nuclear engineers. The Mechanical and Nuclear Engineering Department at The Pennsylvania State University is a large and vibrant unit addressing these problems through our research and these workforce needs through our educational programs.

This Strategic Plan contains goals that are directed at further enhancing an already productive department. Through the department's planning process and benchmarking, we determined a number of critical issues including the following: research initiatives, recruitment and retention, educational initiatives, visibility, and corporate and alumni relations. The primary goals will be to recruit diverse and highly qualified faculty and students, provide communication paths through self-identified faculty working groups centered on research, provide contemporary options for our students, increase the department's visibility through invited seminar speakers and improving our website, and fully engage our alumni to help mentor and network our students.

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## STRATEGIC PLANNING PROCESS

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Faculty and staff in the Mechanical and Nuclear Engineering Department developed the plan presented in this document throughout the fall 2007 semester. The faculty members that focused most closely on the plan were the Professors-in-Charge of Undergraduate and Graduate Studies, the Program Chair of Nuclear Engineering, the Chair of the Promotion and Tenure Committee, and the Department Head, who together comprise the Mechanical and Nuclear Engineering Department's Executive Committee.

All faculty members in the MNE Department were asked to complete a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analyses. Based on the SWOT analyses, critical issues were identified for the Department, which were then further discussed in a special faculty meeting on October 9, 2007. An MNE faculty retreat held on Friday, November 2, 2007 featured a presentation on the state of the department. The majority of the time at that retreat concerned the action items needed to address each of the critical issues that were identified for our Department. The MNE staff met on November 1, 2007 and received a presentation on the state of the department. Improvements to the department from their perspectives were discussed. In early January 2008, the MNE Executive Committee and the entire faculty reviewed the plan and provided comments. In March 2008, our Industrial and Professional Advisory Council (IPAC) reviewed our plan and made further recommendations as to how we should proceed particularly with regards to our research thrusts.

In this strategic plan the Department of Mechanical and Nuclear Engineering describes the actions it will take in academic years 2008/09 to 2012/13 to adhere to its vision and achieve its goals.

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## BACKGROUND ON THE DEPARTMENT

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### **Environment for Disciplines**

Many opportunities exist for the MNE Department because the disciplines of mechanical engineering and nuclear engineering are both well-poised in terms of external demands for our high quality students and our research expertise.

Numerous sources exist for predicting workforce needs in the near future, all of which indicate a projected need for hiring both mechanical and nuclear engineers. One such source is the Bureau of Labor Statistics in the U.S. Department of Labor. The Bureau of Labor Statistics predicts that, due to replacements and newly created positions, there will be a need to increase the number of mechanical engineers by 11.1% between 2004 and 2014. This increase will result in the number of mechanical engineers rising from 226,000 in 2004 to 251,000 in 2014. Similar predictions for the same ten years indicate a need to increase the number of nuclear engineers by 7.3% bringing the total from 17,000 to 19,000.

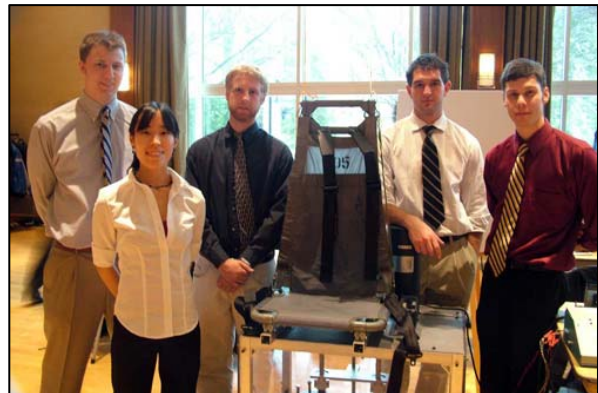
A recent report released from the National Council of the National Academies indicates that mechanical engineering is “critical to the design, manufacture, and operation of small and large mechanical systems throughout the U. S. economy.”<sup>1</sup> Mechanical engineering is a key discipline in the merger of science and technology thereby impacting the fields of micro- and nano-technologies, cellular and molecular biomechanics, information technology, and energy and environmental issues. The report says contemporary issues such as national security, energy, manufacturing competitiveness, and sustainability will have strong influences on research directions in mechanical engineering. To address these issues, there will be a continued emergence of fields such as micro- and nano-technologies, mechatronics, alternative energy sources, biomedical materials and devices, green manufacturing, and materials over many length scales. It will be important that the U. S. maintain leadership in design and manufacturing of civilian and military aircraft, healthcare diagnostics, and power generating systems. U.S. funding of mechanical engineering basic research and infrastructure is projected to remain level with strong leadership in emerging areas.

Nuclear Engineering plays an important and expanding role in meeting national and international electrical power demands and in applied science techniques. Current trends in energy consumption will require the addition of large base-load electrical power generation in the very near term. Global warming is also increasingly recognized as a pressing environmental problem. Nuclear power can be used to meet a portion of the new electric capacity required, while helping reduce greenhouse gas emissions. Research on the design of passive safety systems and fuel cycles will be needed to contribute to advanced reactors that are reliable, safe, and efficient. Research will be needed on reactors designs that will be proliferation resistant. More knowledge is needed, in particular, to develop materials needed in future reactor designs, as these will operate at temperature levels much beyond current reactors to gain higher efficiencies. For the current reactors, research is needed to ensure that the nuclear fuel, being pushed to more severe duty cycles, continues to operate safely and efficiently.

## Department Profile

Penn State’s Mechanical and Nuclear Engineering Department is a vibrant department with highly productive faculty that educates our students with the support of our staff. Undergraduate degrees in mechanical engineering and nuclear engineering are awarded and, similarly, masters and doctoral degrees in both are awarded. At the undergraduate level, a dual degree program is offered that combines mechanical and nuclear engineering, which provides a unique educational option for our undergraduates. At the graduate level, we also offer a master of engineering in nuclear engineering. Our distance learning program in nuclear engineering is in high demand with an enrollment in 2007 of over 100 students.

Our curriculum offers options for a number of engineering minors and suggested technical elective groupings that provide areas of specializations for our undergraduates. The list of engineering minors include agricultural and biological engineering, bioengineering, chemical engineering, engineering entrepreneurship,



<sup>1</sup> *Benchmarking the Competitiveness of the United States in Mechanical Engineering Basic Research*, 2007, Panel on Benchmarking the Research Competitiveness of the United States in Mechanical Engineering, National Research Council of the National Academies, ISBN: 0-309-11425-X (National Academies Press: Washington, DC)

engineering leadership, engineering mechanics, environmental engineering, off-road equipment, peace and conflict studies, product realization, and science-technology and society. Many technical elective groups have been identified to promote specialties within our curriculum including, as a few examples, automotive industries, product design and development, robotics, bio and biomedical, combustion, power plant engineering, nuclear power engineering, radiation science, and acoustics, noise control, and vibrations.

Unique educational experiences for our undergraduates in both mechanical and nuclear engineering exist in our senior capstone design courses. The mechanical engineering students experience a hands-on project sponsored and coordinated by industry that may be multi-disciplinary. The construction associated with these projects takes place in a departmental facility called the Bernard M. Gordon Learning Factory. The nuclear engineering students also experience industry involvement in their capstone course through the use of proprietary codes with industry experts coming to campus to work with our students to design and analyze actual reactor cores and safety systems.



**Figure 2.** Industry expert assisting a nuclear engineering student in his senior design project.

Two separate graduate colloquiums are offered each semester with one being focused on mechanical engineering and the other on nuclear engineering. These colloquiums are weekly with most speakers coming from the outside. The nuclear engineering colloquium requires attendance from all of the nuclear engineering graduate students, and nuclear engineering undergraduate students are encouraged to attend. The first offering of the mechanical engineering colloquium was in fall 2007 with the course requirements currently being formalized.

The offices and facilities associated with the faculty, staff, and students in the MNE Department are located in 13 different buildings that are spread over 1.6 miles. Faculty offices are located primarily in Hammond, Leonhard, Reber, and Research East Buildings.

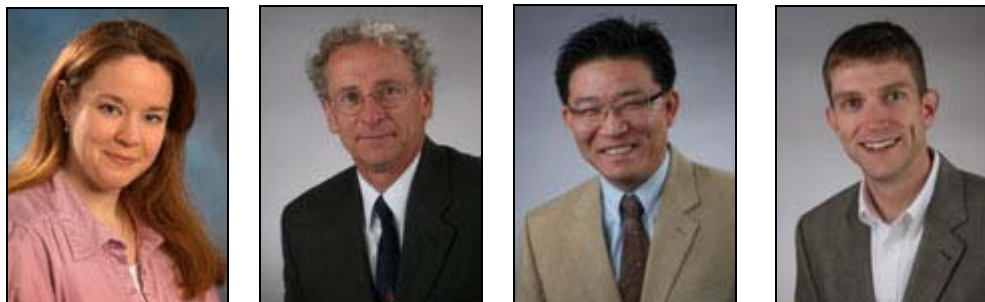
**Faculty.** At present, there are 51 tenured or tenure-track faculty members that have their primary appointment in the Department of Mechanical and Nuclear Engineering. Forty-two are mechanical engineers and nine are nuclear engineers. Three additional mechanical engineering tenure-track faculty members hold primary appointments in School of Engineering Design and Engineering Design, Technology, and Professional Programs (SED-TAPP).

Since the writing of the last strategic plan three tenure-track faculty members were hired: Cari Bryant-Arnold (design, joint hire and primary appointment in SED-TAPP), Seungjin Kim (thermal hydraulics) and Matthew Parkinson (design, joint hire and primary appointment in SED-TAPP). One fixed-term instructor was hired, Leland Engel, to assist in teaching and securing projects for mechanical engineering's capstone design course. Departing faculty members were Yousry Azmy (neutron radiation transport), Bohdan Kulakowski (vehicle dynamics), and Kon-Well Wang (structural dynamics and controls). At the time this report is being written, two faculty searches are in progress in the areas of fuel flexible combustion systems and neutron transport.

Of the 51 tenured or tenure-track faculty, there are five Assistant Professors with four of those in their last two years of their tenure review period, three Associate Professors and the remaining 43 are full Professors. Twelve of the faculty in the MNE Department are over the age of

55 with half of those being over 61. Seven of our faculty hold the title of University Distinguished Professors (Ivanov, Koopmann, Kuo, Modest, Ray, Settles, and CY Wang) and four of our faculty have endowed professorships or chairs (Brenizer, Pauley, Santoro, and Yang). One endowed professorship in our MNE Department is open (William E. Diefenderfer Chaired Professor in Mechanical Engineering), which was formerly held by Kon-Well Wang.

Of the 51 tenure and tenure track faculty whose primary appointments are in the MNE Department, 11% of the faculty are women (six women out of 51) all of whom are mechanical engineering faculty. The percentage of women in our Department can be compared to an average of 8% for mechanical engineering programs considered in the Big-Ten-Plus annual survey. We have one faculty member from an underrepresented group.



**Figure 3.** New faculty and instructors hired since 2005 in the Mechanical and Nuclear Engineering Department (from l to r): Dr. Cari Bryant-Arnold (joint with SEDTAPP), Mr. Leland Engel, Dr. Seungjin Kim, and Dr. Matthew Parkinson (joint with SEDTAPP).

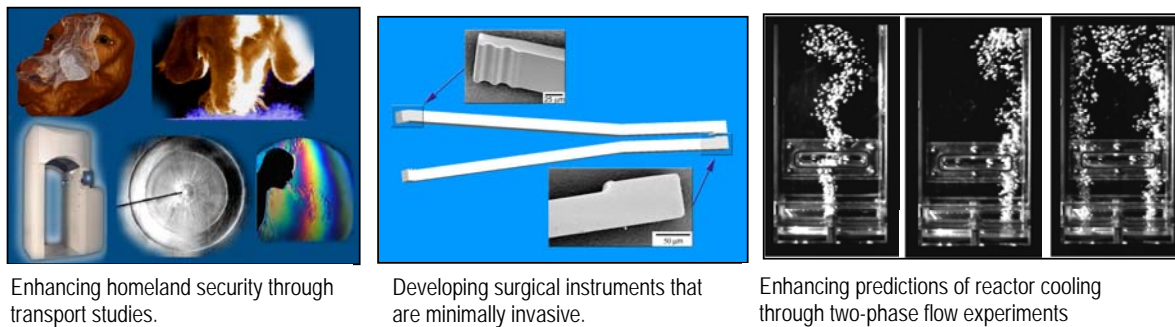
**Staff.** Since the time of the last strategic plan, there have been no additional staff positions defined in our department. There have been, however, some reductions in staff positions and some changes in personnel. The reductions in staff positions are as follows: Director of Departmental Operations and Nuclear Engineering staff position. The changes in staff personnel are as follows: Major Gift Officer is held by Liz Larsen (who also serves Industrial and Manufacturing Engineering); Undergraduate Program Staff Assistant is held by Juls Kralik; Network Support Specialist is held by Allan Knisely; and Staff Assistant IV is held by Tammy Harter.

Pamela Shawver, who supported the Learning Factory activities and faculty housed in the Leonhard Building, is now reporting to the College of Engineering and solely supporting the Learning Factory. Erin Peterson is fully supporting the faculty housed in the Leonhard Building. Dianne Crust has taken on additional duties of working with our newly formed Penn State Society of Mechanical Engineers. Traci Shimmel has taken on the role of supporting the Penn State Nuclear Engineering Society. Teri Noll and Dianne Crust have provided significant service in assembling our annual MNE News.

**Students.** Since 2004, the mechanical engineering program has had controlled undergraduate enrollments with nominally 240 students admitted annually. The enrollments are controlled on grade point averages after their first semester sophomore year. In 2007, the minimum grade point average admitted to mechanical engineering was 2.8 with the average being 3.3. Because of early enrollments and co-op work experiences, in 2007-08 there were a total of 660 mechanical engineering undergraduates enrolled at Penn State. In 2007, there were 68 nuclear engineering undergraduates enrolled and another 38 dual mechanical and nuclear degree undergraduates. The average grade point average of our nuclear engineering undergraduate students is also 3.3.

There are currently 209 students enrolled in mechanical engineering graduate and another 51 graduate students enrolled in nuclear engineering at University Park. In addition, there are 32 students who are seeking a master of engineering degree through our nuclear engineering distance learning program. Of the 209 mechanical engineering graduate students, 64% are doctoral students and of the 48 nuclear engineering graduate students, 65% are doctoral students. Of the total enrolled in our graduate program, approximately half are U.S. students.

**Research Activities.** One of the primary activities of the MNE Department is basic and applied research to further our knowledge in support of the Commonwealth of Pennsylvania, the nation and the world. While there are a large number of research strengths in the Department, only a few will be highlighted in this strategic report and are shown in Figure 4.



**Figure 4.** Examples of research activities taking place in the department associated with homeland security, biomedical engineering, and nuclear power.

The Department has multiple faculty working in such areas as energy conversion, propulsion nano-technology, biomedical engineering, homeland security, robotics, and controls. The breadth in the energy area alone is large considering multiple faculty are working on developing fuel cells, understanding combustion with variable fuels, and researching new nuclear reactor designs. Research in propulsion includes new propellants derived from nanoparticles and through the use of coal processed to be a syngas for gas turbines. Nuclear fuels and the thermal-hydraulics related to reactor cooling and accident analysis are both active research areas. Computational and experimental fluids studies range from understanding particle separations in microfluidic systems to reducing the spread of disease in livestock through full building simulations. The mechanical and thermal properties of nanoscale-sized features are being characterized that can ultimately lead to new biomedical devices that minimize surgical invasiveness. Applying predictions of digestive behaviors to drug delivery requires complex modeling, which is being done through significant computational simulations. Developing devices that are biologically-inspired to identify explosives and developing new methodologies for nuclear and chemical detection are both of high national interest to maintain homeland security. In our department, enhancements to materials, actuators, and robotics are being researched through studying biologically-evolved designs. Optimizing and controlling dynamical systems are being studied with applications to intelligent vehicles, energy conversion, autonomous vehicles, and even performance of computational servers.

In comparing mechanical engineering programs nationally, the research expenditures in Penn State's MNE Department are quite high. MNE's expenditures rank second only to those reported by Massachusetts Institute of Technology, as reported by the 2005-06 American Society of Engineering Education data. Table 1 indicates a rapid growth in expenditures from 2002-03 to

2003-04 and nearly no growth from 2003-04 to 2005-06 with a constant level of approximately \$27M. Given the nearly constant and even decreasing budgets at federal agencies, such as the National Science Foundation, it is not surprising to see a slight increase in the percentage of research funds from industry.

**Table 1. Research Expenditures for the Previous Five Years.**

	2001-02		2002-03		2003-04		2004-05		2005-06	
<b>Total Research Expenditures</b>	\$17,116,395		\$19,621,189		\$26,177,654		\$26,158,294		\$27,635,590	
<b>Federal Foundation</b>	\$12,152,640	71%	\$13,538,620	69%	\$18,586,134	71%	\$16,218,142	62%	\$18,515,845	67%
<b>Industry</b>	\$171,164	1%	\$196,212	1%	\$523,553	2%	\$261,583	1%	\$552,712	2%
<b>University</b>	\$3,080,951	18%	\$3,728,026	19%	\$4,973,754	19%	\$8,370,654	32%	\$6,632,542	24%
	\$1,711,640	10%	\$2,158,331	11%	\$2,094,212	8%	\$1,307,915	5%	\$1,934,491	7%

## Benchmarking of the Department

Several sources of data were used to benchmark the MNE Department with other mechanical and nuclear engineering programs in the U.S. Table 2 presents data, sorted by research expenditures, that originates from two sources: the 2005-06 data acquired by the American Society of Engineering Education (ASEE) (<http://www.asee.org/publications/profiles/search.cfm>) and the 2007 *U.S. News and World Report*. Tables 2, 3a and 3b are inclusive of sub-disciplines within the mechanical engineering departments, such as the nuclear engineering program in the case of Penn State. The diversity statistics for the undergraduate and graduate students, presented in Tables 3a and 3b, are collected from the 2005-06 survey of the Big-Ten-Plus.<sup>2</sup>

The 2007 undergraduate and graduate rankings, based on *U.S. News and World Report*, for mechanical engineering are 12 and 15, respectively. For nuclear engineering, the undergraduate and graduate rankings are 7 and 6, respectively. The data in Table 2 indicate that in 2005-06 Penn State awarded the fourth highest number of undergraduate degrees in mechanical engineering. In 2005-06, Penn State was tied with Texas A&M in awarding the highest number of undergraduate degrees in nuclear engineering (31 degrees). The nuclear engineering undergraduate degrees awarded at Penn State reflect 9.6% of the national total of 324 degrees.

Although the MNE Department at Penn State is only second to the Massachusetts Institute of Technology in terms of research expenditures, the number of graduate degrees awarded relative to the programs listed in Table 2 is relatively low. Note that the research expenditures listed in Table 2 are different from those listed in Table 1 because when reporting expenditures to ASEE, Penn State, similar to other institutions, uses a multiplication factor designed to account for in-kind support. For the 2005-06 ASEE data, the total number of graduate degrees awarded was 62 with 29% of those being doctoral degrees.

Figures 5 and 6 illustrate the data that were just discussed in terms of the Big-Ten-Plus mechanical engineering departments. Figure 5 illustrates that even with enrollment controls, Penn State's number of undergraduate degrees awarded per faculty member is only slightly below that of Purdue's, which is the highest in the Big-Ten-Plus. The number of graduate degrees that are awarded per faculty member by Penn State is below many of the peer universities, as shown in

<sup>2</sup> The Big-Ten-Plus universities include Carnegie Mellon, Cornell, Georgia Tech, Michigan State, Massachusetts Institute of Technology, Northwestern, Ohio State, Penn State, Purdue, Stanford, U of California at Berkeley, U of Illinois at Urbana-Champaign, U of Iowa, U of Michigan, U of Minnesota, U of Texas at Austin, U of Wisconsin at Madison.

Figure 6. Similarly, the number of doctoral degrees awarded per faculty member is also below that of many of our peer institutions.

The data presented in Tables 3a and 3b, sorted on the percentage of women students, indicate that the diversity of our department is much below that of others in the Big-Ten-Plus. In particular, there are only 11.3% undergraduates and 9.5% graduates that are women compared to the average of these mechanical engineering departments at 15.3% and 14.9%, respectively. Other under-represented groups in the MNE Department are also quite low at 3.6% and 0.9% for the undergraduate and graduate student population relative to the averages of 4.6% and 9.1%, respectively.

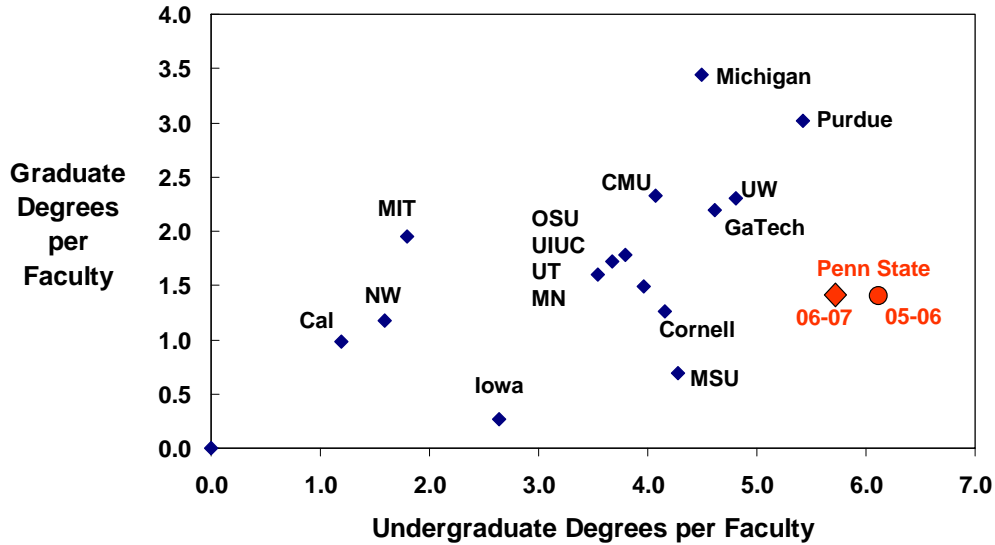


Figure 5. Graduate and undergraduate degrees per faculty for Mechanical Engineering Departments.

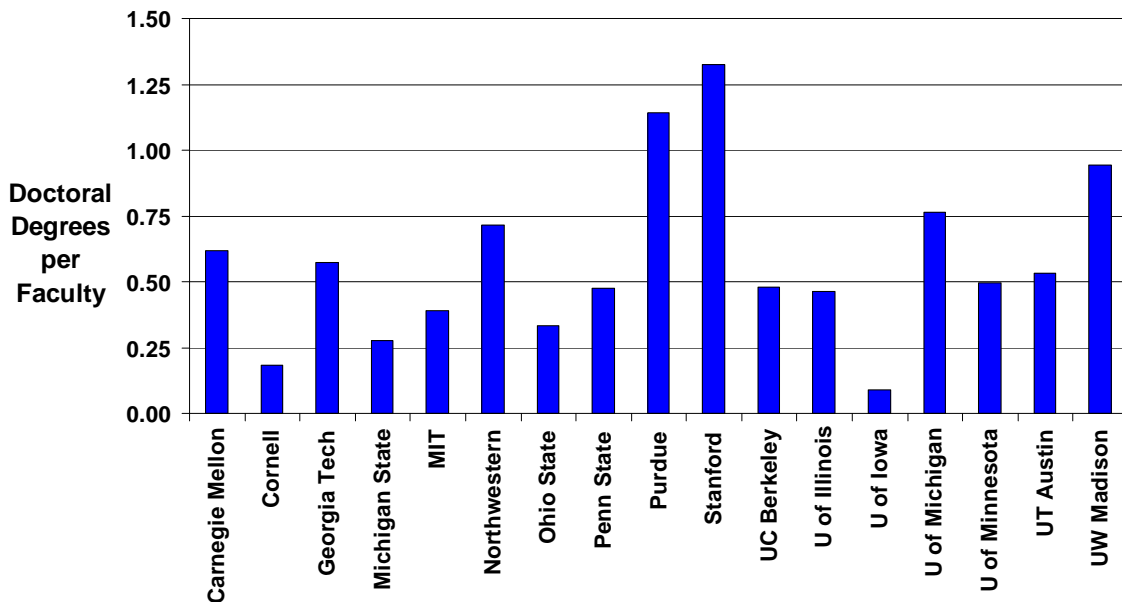


Figure 6. Doctoral degrees awarded in the Big-Ten-Plus Mechanical Engineering Departments.

Table 2. Benchmarking of U. S. Mechanical Engineering Programs Sorted by Research Expenditures.

<b>2005-06*</b>		<b>(Sorted by Research Expenditures); Source: <a href="http://www.asee.org/publications/profiles/search.cfm">http://www.asee.org/publications/profiles/search.cfm</a></b>															
School (List from U.S. News & World Report, with 2007 Graduate Program Rankings; Private Schools in Bold)	Ranking	T/TT Faculty	Total Research Expenditure	Overall Total Full-Time Enrollment (Minus Freshmen)	Total Full-Time UG Enrollment (Minus Freshmen)	Total Full-Time Graduate Enrollment	Undergraduate Enrollment			Master's Enrollment		Ph.D. Enrollment		Bachelor's Degrees Awarded	Master's Degrees Awarded	Doctoral Degrees Awarded	Total Graduate Degrees Awarded
							Full-Time	Including Freshmen	Part-Time	Full-Time	Part-Time	Full-Time	Part-Time				
Massachusetts Institute of Technology	1	73	\$32,648,000	780	379	401	379	0	6	153	0	248	0	113	103	45	148
Pennsylvania State - University Park	15	50	\$30,555,102	768	605	163	605	0	27	37	5	126	6	261	44	18	62
Stanford University	1	31	\$27,727,414	586	96	490	96	0	0	273	42	217	6	67	163	47	210
University of Michigan - Ann Arbor	5	50	\$26,515,000	1,115	630	485	631	1	35	239	15	246	16	223	115	40	155
Georgia Institute of Technology**	7	70	\$26,327,132	1,412	1,031	381	1,340	309	88	183	207	198	15	273	162	47	209
Texas A&M University - College Station	21	52	\$22,994,000	1,101	780	321	1,124	344	66	193	27	128	13	172	81	27	108
University of Maryland - College Park	24	44	\$19,410,023	644	488	156	591	103	18	35	18	121	23	172	25	41	66
Purdue University - West Lafayette	7	46	\$18,563,701	1,043	750	293	750	0	97	73	41	220	24	277	57	38	95
University of Illinois - Urbana-Champaign	6	49	\$17,897,000	903	663	240	842	179	0	105	0	135	0	182	57	18	75
University of California - Berkeley	3	45	\$14,204,000	536	225	311	263	38	315	35	1	276	0	161	48	49	97
Ohio State University	21	50	\$13,855,000	1,034	796	238	1,034	238	0	92	0	146	0	155	70	15	85
University of California - Los Angeles	15	30	\$13,602,117	534	335	199	386	51	0	93	0	106	0	84	47	21	68
University of Wisconsin - Madison	15	32	\$11,345,000	625	454	171	454	0	65	85	8	86	10	141	56	11	67
University of Minnesota - Twin Cities	12	40	\$10,647,406	860	617	243	730	113	0	132	0	111	0	167	43	13	56
University of California - San Diego	21	40	\$10,554,754	666	558	108	690	132	0	56	0	52	0	138	33	7	40
Virginia Polytechnic Institute & State U	15	39	\$8,027,005	965	787	178	793	6	13	97	13	81	5	277	52	15	67
Rensselaer Polytechnic Institute	24	42	\$8,018,808	631	541	90	555	14	0	17	2	73	7	127	58	15	73
Princeton University	10	23	\$7,860,822	187	109	78	109	0	0	6	0	72	0	33	5	15	20
Cornell University	9	31	\$7,792,884	331	249	82	249	0	0	30	0	52	0	122	35	8	43
Northwestern University**	12	29	\$7,241,150	232	153	79	190	37	1	0	1	79	0	37	9	17	26
University of Texas - Austin	12	52	\$6,941,487	884	703	181	889	186	96	98	14	83	45	196	56	12	68
University of Washington	27	25	\$5,851,000	361	208	153	209	1	22	108	0	45	0	76	36	11	47
Duke University	27	20	\$5,606,130	146	88	58	88	0	0	3	0	55	0	41	11	6	17
Carnegie Mellon University	10	21	\$5,291,100	409	314	95	314	0	12	34	2	61	6	110	24	13	37
Johns Hopkins University	19	19	\$5,164,000	173	99	74	129	30	1	4	96	70	0	33	41	7	48
California Institute of Technology	3	7	\$4,187,000	131	71	60	71	0	0	4	0	56	0	21	9	8	17
University of Pennsylvania	27	11	\$3,782,000	204	148	56	176	28	0	12	11	44	3	31	18	3	21
Rice University	27	14	\$2,621,993	116	83	33	83	0	4	0	6	33	2	31	3	3	6
University of Southern California	24	26	\$2,528,400	298	190	108	229	39	0	56	99	52	5	22	35	0	35
Harvard University	19	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
University of California - Santa Barbara	27	27	---	396	313	83	382	69	0	2	0	81	0	79	16	14	30
Columbia University	27	11	---	199	131	68	131	0	0	18	20	50	0	39	27	8	35

\*Sources for the rankings include the *US News and World Report's* 2007 Rankings while the data provided is obtained from the 2005-06 American Society of Engineering Education's database. Adapted from a chart sent by Texas A&M.

\*\*Note that the research expenditures for Georgia Tech and Northwestern are reported from the 2006 Big Ten Plus Survey since they were not reported in the ASEE website.

**Table 3a.** Rankings and Diversity of Undergraduate Programs (sorted by % women)  
(Sources: 2006 Big-Ten-Plus Survey and 2007 USNWR)

University	2007 USNWR Undergrad ME Ranking	Women (%)	Minorities (%)
Stanford	2	38.0	19.0
MIT	1	35.0	27.0
Michigan	4	20.7	1.0
Carnegie-Mellon	10	20.0	10.0
Texas	11	15.7	18.2
Cornell	8	14.0	5.6
Michigan State	not ranked	13.4	18.3
Iowa	not ranked	13.0	3.0
California	3	12.2	12.0
Illinois	5	12.0	7.1
Georgia Tech	6	11.8	10.9
Penn State	12	11.3	3.6
Wisconsin	19	10.0	3.0
Ohio State	21	9.7	6.5
Purdue	7	9.0	7.0
Minnesota	16	6.8	2.5

**Table 3b.** Rankings and Diversity of Graduate Programs (sorted by % women)  
(Sources: 2006 Big-Ten-Plus Survey and 2007 USNWR)

University	2007 USNWR Graduate ME Ranking	Women (%)	Minorities (%)
Cornell	9	35.8	1.8
Stanford	1	22.0	7.0
California	3	20.0	7.0
MIT	1	18.0	5.0
Iowa	50	17.0	3.0
Carnegie Mellon	10	15.5	5.5
Georgia Tech	7	14.5	8.8
Illinois	6	14.5	0.1
Ohio State	21	14.1	4.2
Texas	12	13.6	18.2
Purdue	7	13.0	2.0
Wisconsin	15	12.0	4.0
Michigan	5	10.0	4.0
Penn State	15	9.5	0.9
Michigan State	38	8.0	4.0
Minnesota	12	8.0	3.0

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## VISION AND GOALS OF THE DEPARTMENT

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The vision and goals for the MNE Department provide the framework for this strategic plan. Within this framework, we have compared our Department to that of similar mechanical and nuclear engineering programs in the U.S. Through these analyses, a number of critical issues were identified that will be addressed through our strategic plan.

*Our vision is to be a department that:*

*Provides significant benefits to its students, the Commonwealth, the Nation and society; and achieves international recognition in both mechanical and nuclear engineering for its teaching, research, and service;*

*and*

*Is committed to the life-long intellectual growth and well being of its faculty, staff and students; and provides an environment of respect for different cultures, backgrounds and viewpoints.*

*The goals of our department are to:*

- 1. Attract and develop an outstanding and diverse faculty, student body and staff;*
- 2. Develop and deliver the best possible undergraduate education in mechanical engineering and nuclear engineering;*
- 3. Develop and deliver the best possible graduate education in mechanical engineering and nuclear engineering;*
- 4. Conduct research, continuing and new, in areas of state, national and international interest; and*
- 5. Implement administrative and organizational actions to support our strategic goals and effectiveness.*

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## CRITICAL ISSUES, GOALS, AND ACTION PLANS

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The assessment of our department, in the context to the vision and goals, has identified a number of critical issues. Those issues can be broadly categorized into the following areas: research initiatives, recruitment and retention, educational initiatives, visibility, as well as corporate and alumni relations.

During the next five years, our department's research initiatives will be further broadened through the formation of faculty working groups in a number of contemporary areas in which mechanical and nuclear engineering have a role. During the faculty retreat, faculty working groups were identified in which strengths already exist in our department. The purpose of having faculty working groups is to promote the communication among faculty within in our department as well as outside of our department; to build core strengths in several contemporary research areas; to develop curriculum enhancements for students interested in these areas; to participate in the faculty hiring committees in these areas; and to lead large proposal efforts on campus that will further enhance the visibility of our Department. Our Industrial and Professional Advisory Council (IPAC) strongly suggested creating a roadmap for each of the strategic research thrusts. The IPAC members were very supportive of these research thrusts and offered to help in any way they could.

With regards to recruitment and retention, our highest priorities will be given to faculty recruitment because of the pending retirements; retention of our current faculty; and recruitment of students emphasizing women and underrepresented groups. The retention of faculty will be achieved through continued faculty mentoring of the junior faculty and through becoming further engaged in activities that are associated with the faculty working groups. Currently, the department has a recruitment officer in place (Dr. Mary Frecker) that has enhanced our recruiting efforts. More work needs to be done and, as such, support will continue to be given to the recruitment officer's activities. In particular, increased recruitment efforts will take place for students in their first two years and at the graduate levels.

Educational goals for the undergraduates include establishing additional technical groups in contemporary mechanical engineering areas such as nanotechnology and fuel cells. Publicizing,

especially to first and second year students, all of our technical elective groups will be improved with the aim of further attracting diverse students. An external evaluation of our graduate program will be conducted to give visibility to our graduate program as well as generate ideas for improvements.

Visibility of our department's activities will take place through updating our website and generating written materials that can be handed out in brochures. Our colloquiums will include invitations to department heads from across the country to enhance our visibility.

Establishing closer working relationships with a number of industrial partners will be achieved by forming advisory boards in areas that are identified through the faculty working groups. These relationships can lead to financial support for these activities. Alumni will be further engaged in our department through our Penn State Society in Mechanical Engineering and Penn State Society of Nuclear Engineering. Annual spring luncheons are planned at companies, such as that shown in Figure 6, with a gathering of Penn State alumni. The following section of our strategic plan outlines the detailed activities that are planned to address the critical issues.



**Figure 6.** Luncheon for alumni gathering at AREVA in Lynchburg Virginia that took place in February 2007.

### **Critical Issue 1: Research Initiatives**

Through numerous departmental discussions during the strategic planning process, several concerns leading to opportunities were identified. Given the department's size and many locations, communication is difficult. Given the faculty age distribution, faculty hiring is of eminent importance. To address the communication difficulties along with the faculty hiring, it is planned to form a number of faculty working groups in areas that are of high national importance. Through these working groups, synergies will be enhanced in which some strength already exists in our department. These groups will guide the faculty hiring and identify opportunities. Some of these faculty working groups may dissolve and others may evolve through the next five years. Those groups listed below were self-identified during the faculty retreat to discuss the strategic plan and is a starting point to have continual dialog. The Department will support active faculty working groups by arranging events such as seminars, working lunches, support for proposal development, etc.

**Goal 1: Develop new research initiatives while continuing to support departmental strengths that position the MNE Department and Penn State to be recognized nationally and internationally**

Action	Sub-Tasks	Team	Start and Duration
Form faculty working groups in several research areas through department-sponsored events (lunches, seminars, etc) for the following purposes: promote departmental communication, explore large research opportunities through collaborations, assist with faculty hiring	<b>Nuclear fuels and fuel cycles</b>		
	Form a technical working group	Nuclear Program Chair (Brenizer), faculty, and Penn State Institutes of Energy and the Environment	Summer 2008
	Form a government and industrial advisory board		Spring 2008 / 5 years
	Hold a workshop at Penn State in the nuclear fuel cycle		Fall 2010
	Submit a large-scale proposal in the area of nuclear fuels		Spring 2011
	Hiring of one faculty in this area (junior)		2009-2010
	<b>Future transportation systems</b>		
	Form a faculty technical working group	Faculty (Rahn, Haworth, Brennan, Mockensturm, Sommer, Parkinson, and others); Pennsylvania Transportation	Fall 2008
	Hiring of one new faculty in this area (junior)		2009-2010
	<b>Bioengineering and Nano-science/technology</b>		
	Form a faculty technical working group	Faculty (Freckler, Parkinson, Sommer, and others); Huck Life Science; Hershey Medical Center	Fall 2008
	Hiring of two faculty in this area combined with nano-technology (junior)		2010-2011; 2011-2012
	<b>Cyberscience for mechanical and nuclear engineering</b>		
	Form a faculty technical working group	Faculty (Brasseur, Mockensturm, Ray, Simpson, and others); Institute for Computational Science	Fall 2008
	<b>Fuel cell and energy storage technologies</b>		
	Form a faculty technical working group	Faculty (Mench, CY Wang, and others); Materials Research Institute	Spring 2008
	Form a government and industrial advisory board		Fall 2008
	Hiring of a junior faculty in advanced energy storage technologies		2009-2010
	<b>Homeland security</b>		
	Form a faculty technical working group	Faculty (Settles, Brenizer, Unlu, Patterson, Cimbala, Sharp, and others); Applied Research Lab	Spring 2008
Support of existing departmental research centers and activities	Hiring of one new faculty in smart/adaptive structures (jr or sr)	Faculty (Rahn, Mockensturm, Koopmann, and others)	2008-09
	Hiring of one faculty in energy systems combined with sensors and controls (junior)	Faculty (Ray, Brenizer, Santoro, and others)	2008-09
	Hiring of one faculty in nuclear power (junior)	Faculty (nuclear and others)	2011-2012
	Hiring of two junior faculty through an open search	Faculty	2011-2012;2012-2013

## Critical Issue 2: Recruitment and Retention

As was discussed in the department's profile a number of faculty are projected to retire in the coming years. While the overall size of the faculty is not projected to grow significantly, it is important to recognize that junior faculty need to be hired who will overlap with the senior faculty who are about to retire to allow for a smooth transition and ensure teaching duties are met. It is proposed that 10 new faculty be hired over the next five years. Retention of our current faculty and staff is of high importance and will be achieved through continued engagement in departmental activities such as the faculty working groups described in Goal 1.

Interest is high for many Penn State undergraduate engineering students in becoming mechanical engineers while the interest in nuclear engineering is also high. The focus is then on recruiting a diverse group of undergraduate students since we were much below that of our peers.

Recruiters, too, seek diverse employees. We will endanger our reputation and students' opportunities in obtaining jobs if we do not improve upon our student diversity. As such, we will support our department's Recruitment Officer (now held by Dr. Frecker) in these efforts.

Through our graduate office's surveys, we found our stipends are significantly below our peers. In comparison to our offers at a grade 12, our peers are offering stipends similar to a grade 19. We will increase our assistantship offers to ensure we are aligned with our peer institutions.

<b>Goal 2: Recruit new faculty; retain current faculty and staff; and recruit students that are of high potential and of diverse backgrounds.</b>			
<b>Action</b>	<b>Sub-tasks</b>	<b>Team</b>	<b>Start and Duration</b>
<b>Hire new faculty</b>	Faculty searches: senior faculty in smart/adaptive structures and junior faculty in sensors/controls for energy systems	See faculty working groups in Goal 1.	2008-09
	Faculty searches: junior faculty hire in nuclear fuels/fuel cycles, and junior faculty in future transportation systems;		2009-2010
	Faculty searches: junior faculty hire in biomedical/nanotechnology and energy storage systems		2010-2011
	Faculty searches: junior faculty in nuclear power and biomedical/nanotechnology		2011-2012
	Faculty searches: junior faculty with two open searches		2012-2013
<b>Retain current faculty and staff</b>	Mentor our junior faculty through joint lunches and informal senior faculty interactions	Department Head and tenured faculty	Spring 2008 / 5 years
	Provide resources and teaching load reductions for unique opportunities to lead large proposal efforts	Department Head	Spring 2008 / 5 years
	Enhance communication within our own department to stimulate joint research through retreats and workshops	Departmental Executive Committee	Spring 2008 / 5 years
	Reinstate the Department Head Staff Awards	Department Head	Fall 2009 / 5 years
	Continually assess staff workload	Department Head and staff	Fall 2009 / 5 years
<b>Recruit undergraduate students with high potential and diverse backgrounds</b>	Expand our freshman seminar series to illustrate breadth of our disciplines to attract diverse students	Faculty	Fall 2010
	Reach out to other Penn State campuses to recruit diverse students in their first two years	Department Recruitment Officer	Fall 2009 / 5 years
<b>Recruit graduate students with high potential and diverse backgrounds</b>	Make competitive assistantship offers to meet competitors' offers	Professor-in-Charge of Graduate Studies; faculty	Fall 2008 / 5 years
	Expand and assess our fall recruiting event	Department Recruitment Officer, Professor-in-Charge of Graduate Studies	Fall 2008 / 5 years
	Highlight our graduate program at targeted universities	Faculty	Fall 2008 / 5 years
	Increase fellowship opportunities	Department Recruitment Officer, Professor-in-Charge of Graduate Studies; MNE	Ongoing

### Critical Issue 3: Educational Initiatives

The environments for the disciplines of mechanical and nuclear engineering indicate that both will have a significant impact in our society. During this strategic plan, our curriculum will continue to be improved. Technical elective groupings will be publicized and expanded to reflect contemporary interests and to attract diverse students. An external evaluation of our graduate programs will be conducted to establish potential improvements and provide visibility. Increased

graduate stipends will be offered to ensure that we are competitive with our peer institutions. Ensuring our students are truly aware of the world through international experiences will be planned and followed through. A travel fund will be established for graduate students to attend conferences through the earnings from the Kulakowski Endowed Fund.

<b>Goal 3: Provide continual improvement of our undergraduate and graduate programs through both curricula and other educational experiences</b>			
<b>Action</b>	<b>Sub-Tasks</b>	<b>Team</b>	<b>Start and Duration</b>
<b>Expand our undergraduate options to reflect modern mechanical engineering areas</b>	Establish groupings in nano-technology and fuel cells; publicize other tracks	Professor-in-Charge of Undergraduate Studies; faculty committees	Spring 2010 / 1 year
	Establish a dual degree program in bioengineering	Department Head and Professor-in-Charge of Undergraduate Studies	Fall 2008 / 1 year
<b>Conduct an external evaluation of our mechanical and nuclear engineering graduate programs</b>	Assess graduate course offerings	Professor-in-Charge of Graduate Studies and faculty committee	Fall 2009 / 1 year
	Assemble data for the past five years and prepare notebook for evaluators	Graduate Office	Spring 2009 / 6 months
	Conduct external review	Graduate Office and MNE Department Head	Fall 2009 / Two days
	Implement suggestions from the evaluators	Faculty	Spring 2010 / 2 years
<b>Enhance the educational experiences for undergraduate students</b>	Assess our undergraduate course offerings in terms of requirements and teaching loads	Professor-in-Charge of Graduate Studies and Department Head	Fall 2008 / 2 years
	Increase participation in research experiences	Faculty and Professor-in-Charge of Undergraduate Studies	Fall 2008 / 2 years
	Determine a reasonable plan that provides international experiences for our undergraduate students to ensure they are competitive in the job market	Faculty, Department Head, and the Leonhard Center	Summer 2008 / 5 years
<b>Enhance the educational experiences for our graduate students</b>	Establish a graduate conference travel fellowship through the endowed Kulakowski Fund	Department Head	Fall 2009

## Critical Issue 4: Visibility of the Department

Promoting the visibility of the department will include a makeover of our website and other initiatives. Ensuring diverse students are attracted to our programs will be reflected in the website changes. A suite of brochures will be created for a range of audiences to publicize our program. Further visibility will be provided through invitations to mechanical and nuclear department heads from around the country to present at our colloquiums.

<b>Goal 4: Promote the visibility and strengths of the MNE Department on campus, nationally, and internationally</b>			
<b>Action</b>	<b>Sub-Tasks</b>	<b>Team</b>	<b>Start and Duration</b>
<b>Improve our communication to the outside</b>	Update our website	Webmaster, MNE Website Committee; faculty	Summer 2008 / 4 months
	Publish our annual newsletter and the department head's insiders' letter	Faculty, Webmaster, MNE Website Committee; MNE Executive Committee	Spring / 5 years
	Develop a suite of brochures targeting potential students, alumni, and corporations	Webmaster, Communications student	Summer 2008 / 6 months
	Develop a departmental presentation for others to use during invited seminars	Department Head and faculty	Spring 2008 / 5 years
<b>Enhance our colloquiums</b>	Extend invitations to Department Heads and Deans	MNE faculty	Fall 2008 / 5 years
	Expand our distinguished seminar series	MNE Development Officer, Department Head	Fall 2009 / 5 years
<b>Expand nominations for faculty awards</b>	Submit fellow applications; national awards; and international awards	MNE Awards and Honorifics Committee	Fall 2008 / 5 years

## Critical Issue 5: Corporate and Alumni Relations

Significant efforts will be given to establish closer relations with both alumni and corporations. The corporate relation efforts include forming industrial/government advisory boards, holding an annual senior recognition banquet organized by alumni that is sponsored by corporations, and creating unique educational or research opportunities whereby both benefit. Alumni relations will be enhanced through our Penn State Mechanical Engineering and Penn State Nuclear Engineering Societies. These two groups are now quite active with much interest from our alumni.

<b>Goal 5: Foster relations with corporations and alumni that will lead to resources to meet our goals.</b>			
<b>Actions</b>	<b>Sub-Tasks</b>	<b>Team</b>	<b>Start / Duration</b>
<b>Create industrial partnerships to develop unique opportunities</b>	Form industrial and government advisory boards in key research areas	Groups of faculty	Spring 2008 / 5 years
	Provide opportunities for industry to hold student workshops on interviewing, leadership, and other career skills	Student group leaders of ASME and ANS; College of Engineering Co-op Office	Fall 2009 / 5 years
	Work together with industry partners in diversifying our student population by securing a broad range of capstone design projects	Department Head and MNE Recruitment Committee	Fall 2008 / 5 years
<b>Engage alumni through a range of activities in the department</b>	Hold a senior recognition banquet, organized by alumni, during career fair	Faculty; Penn State Mechanical Engineering Society (PSMES) and Nuclear Engineering Society (PSNES)	Spring 2008 / 5 years
	Hold an annual tailgate to bring alumni back to campus	Student group leaders and PSMES and PSNES	Fall 2008 / 5 years
	Hold annual luncheons at on-site industry locations where many of our alums are employed	MNE Development Officer, Department Head, and Nuclear Program Chair	Spring 2008 / 5 years
	Send a letter to our graduating students asking them to join our alumni groups	Presidents of PSMES and PSNES	Spring 2008 / 5 years
<b>Create funding opportunities for corporations</b>	Submit proposals to form industrial centers of excellence; chaired professorships; support undergraduate and graduate curriculum improvements; undergraduate scholarships and graduate fellowships; diversity enhancement; travel funds; support of colliquium speakers	Industrial Relations Office, Corporate and Foundation Relations Office, and Department Head, and Nuclear Program Chair	Ongoing / 5 years
<b>Create funding opportunities for alumni</b>	Form three levels of 3-Year Excellence Funds: Blue & White (\$15K); Silver (\$30K); Gold (\$60K)	MNE Development Officer, Department Head, and Nuclear Program Chair	Fall 2009 / 5 years
	Naming and funding of student, faculty, and staff awards	MNE Development Officer, Department Head, and Nuclear Program Chair	Fall 2009 / 5 years

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## IMPACT OF THE GOALS

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Our goals outlined in our strategic plan are believed to address the critical issues that have been identified in our department. By creating alternative ways to communicate among the faculty, such as the formation of faculty working groups in strategic research areas, the likelihood exists in securing large research grants with high national visibility. Supportive efforts from the Department will be given to areas in which success is likely. Continual hiring of new faculty in strategic areas will ensure that our reputation continues to grow, our visibility increases, and transitions will be smooth as faculty retire.

Undergraduate recruiting needs to be aimed at increasing the diversity of our students. Educating first- and second-year students on the breadth of mechanical engineering and the opportunities of nuclear engineering will help in broadening diversity. Moreover, by better publicizing the contemporary elective track opportunities for our students we also believe will impact our student diversity. For our graduate students, increasing stipend levels to that of our peer institutions will allow us to attract a highly qualified and highly diverse group of students. More visibility of our programs through large research center activities and an updated website will help to attract students. As the junior faculty build their programs through graduate student research, it is projected that our number of graduate students may grow.

The impact of having increased alumni support and interest will provide opportunities for our faculty and students. Those opportunities will take place through networking with our highly successful alumni whether it be advice for students or championed efforts to secure industry-sponsored research.

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## FINANCES AND RESOURCES

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The plan outlines an aggressive plan, one that is designed to position the Mechanical and Nuclear Engineering Department as an organization that will be leading our engineering disciplines while ensuring an environment that students, faculty, and staff can succeed. The most significant resources needed to accomplish the plan are those needed for the new faculty hires and for the increased grade level for the graduate assistantship offers.

As requested in the charge for developing this strategic plan, three scenarios were required to be considered. The baseline that was considered for these three scenarios is one in which there is a 1% reduction in the general budget to be used for recycling funds. The 1% recycling funds in the MNE's general budget is nominally \$80,000 each year. The three scenarios were the following: half of the recycling funds returned, all of the recycling funds returned, and double the recycling funds returned.

In analyzing the impact that these three scenarios had on the budget and in achieving the aforementioned goals of the strategic plan, several assumptions were made. The first major assumption was that other than the recycling costs, the overall budgetary allocation of funds would remain the same in the department including the general budget, the returned overhead, and the gift funds available. In this manner, only the costs required to accomplish our goals were calculated.

A number of other assumptions were made in performing the financial resources needed to accomplish the proposed goals. First, it was assumed two senior faculty would be departing our department each year over the next five years. Just prior to the start of the first year of the plan (2008/09), three faculty will have departed with one of the three being replaced through our 2007/08 faculty search. A second faculty will be hired through the 2007/08 search. This second hire is a joint hire with the Penn State Institute for Energy and the Environment and only requires half of the new hire's salary and no departmental start-up funds. For the second year of the plan, only one of the two faculty who was assumed to retire has been confirmed.

Second, as discussed in this plan it was assumed that the graduate teaching assistantships would increase from grade 14 in 2008/09, to grade 15 in 2009/2010, and remain at a grade of 16 from 2010/11 to 2012/13. Our current operating procedure is such that it requires funds each year beyond our department allotted teaching assistantship budget to meet our teaching needs. For example, in 2006-07 the additional funds beyond the allotted budget was nominally \$210,000. This

additional funding is taken from our general budget primarily through faculty salary savings. As such, the amount of additional funds was calculated that would be beyond our current operation to account for the higher grade levels for the teaching assistantships.

Third, it was assumed that an additional faculty position will be secured through the Penn State Institutes of Energy and the Environment over the next five years such that it will only require half of the newly hired faculty member's salary with no start-up funds needed. The departmental start-up funds were assumed for all other new faculty hires to be \$100,000.

Figure 7 indicates the changes in the budget that would need to occur based on that of the projected costs for that year (graduate stipends, faculty salaries, etc). Note that the difference for the graduate students stipends is based on the base level of a grade 12 for that year. The financial analyses indicates that the projected goals for the first two years are realizable with additional funding if the full 2% recycling funds were returned to the department. The primary differences between 2009/10 and 2010/11 can be explained by increased new faculty start-up costs that solely need to be covered by the department rather than provided by PSIEE, for example. Years beyond and including 2010/11 indicate there will be a significant shortage in funds. As such, this will require our Department to reduce the number of faculty hires for one year and potentially reduce the number of graduate teaching assistantships to be made available. Both of these scenarios will reduce the likelihood of our Department achieving complete success for this strategic plan.

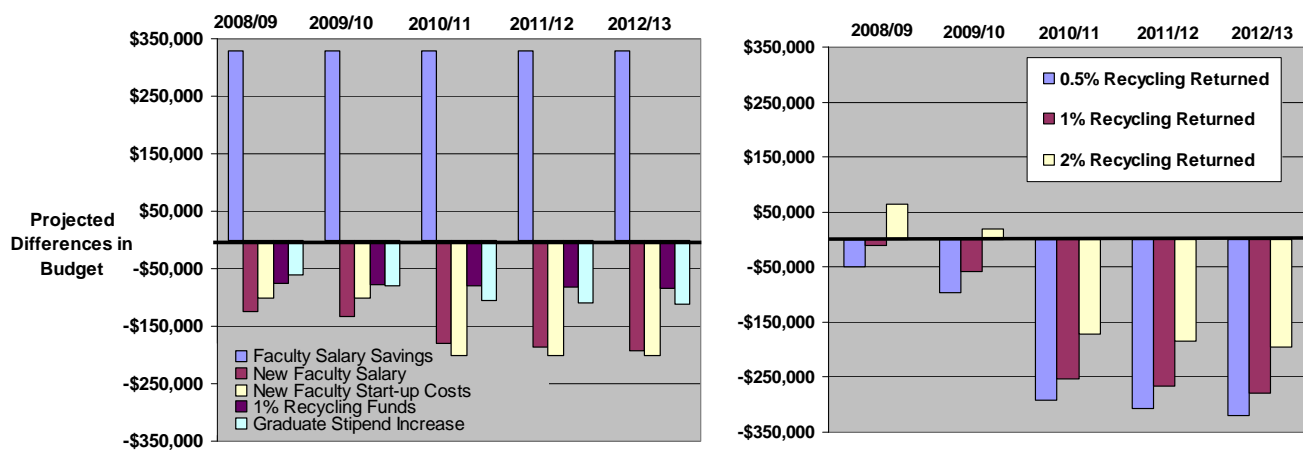


Figure 7. Financial analyses indicating the projected differences that would need to occur in the general budget to meet our strategic goals and on the right are three required scenarios that were considered.