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Electric Power Engineering Education National Trends

J. DERALD MORGAN

Abstract—At a time when energy issues are of great importance and the Power Industry has an increasing demand for the best young minds available to solve its problems, trends have developed that suggest possible future problems for Power Engineering Education. This paper reviews these national trends.

I. Introduction

In spite of the growth of the number of reported electrical engineering power programs over the past eight years, there are some disturbing long term and short term trends. The area of electric power engineering education may again be facing a future decline on a national basis. This comes at a time when the challenge that faces us as a nation is to overcome the paralysis that has gripped us for the past four to five years. We need to develop national energy policies and programs to eliminate waste, conserve energy and to protect the environment to an optimum extent and in every practical way. We also need to produce the energy that we will need in the future.

At a time when these issues are of great importance and the power industry needs the best minds with highest quality education that can be made available, several factors have developed that indicate possible future problems for the power area of education. It is time that these trends are recognized and steps taken to correct this course so that engineering talent in the quality and numbers vitally needed by the power industry will be available.

Further, the need to assure top quality research and teaching staffs in the University must be recognized and addressed. The development of this resource is vital to the power industry as properly prepared educators must be available in the field, if future supplies of engineering talent are to be adequate.

Study Data Base

The information presented in this paper describes national trends in electric power engineering education over the past eight years. The basis for the statistical results presented in this paper are the biennial surveys of the IEEE Power Engineering Society's (PES) Educational Resources Subcommittee (ERS).

For those readers not familiar with the biennial reports and activities of the (ERS), it would be beneficial to make a brief review of the original survey reports which are referenced in this paper.[1,2,3,4] The (ERS) is affiliated with the Power Engineering Education Committee (PEEC), a major Committee of the IEEE Power Engineering Society (PES). The subcommittee has as its charge the surveying, compiling, and publishing of information on power engineering education programs provided by educational institutions and on industry views of their educational expectations and needs. The referenced reports are a part of this subcommittee's activities and are a compilation of data returned to the subcommittee by educational institutions. The data on power engineering education are requested from all Engineers Council for Professional Development (ECPD) accredited electrical engineering departments on a biennial cycle. Data received are compiled and published by the committee. These summary reports are the most comprehensive review of the status of electric power education in the U.S. that is available.

In reviewing the past reports, the author noted trends that have developed that are worth reviewing and evaluating. This review should be helpful to the reader of this special issue on Power Engineering Education.

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Study Results

Tables I, II, III, and IV are summarizations of data drawn from references 1, 2, 3, and 4. Some minor corrections to original data in the references are made in these tables where the reported numbers did not sum correctly. The tables give pertinent statistics on numbers of power faculty, their highest earned degrees, their rank, their membership in the Power Engineering Society of the IEEE and their registration as professional engineers. The tables also give statistics on the student bodies at the graduate and undergraduate level, give the number of degrees and enrollments by citizen and noncitizen categories and information on the enrollments by subject area for the survey years.

Figure 1 shows that the number of schools reporting power programs has increased over the past eight years from 82 to 92 giving about a 12% increase over this period. Figure 2 shows that there has also been an increase in total reported faculty over this same period of about the same percentage. A short term dip in power faculty between the last two reporting periods is seen in the Figure. Reviewing the data in Table I, it is seen that there is a trend for power professors to have an earned doctorate showing an increase of 17% over the past six years. It is discouraging to note that there has been a 5% decline in professional registration among power professors and that membership in the IEEE PES has remained essentially constant at 57% to 59%. A detailed review of the data also shows that it is approximately this 60% figure that represents those power professors with a significant participation in the power area academic programs of research and teaching out of the total number reported. These low percentages do not seem to be healthy trends for the professional area and its development.

TABLE I
LISTING OF POWER ENGINEERING FACULTY FOR STUDY YEARS BY RANK, HIGHEST EARNED DEGREE, PROFESSIONAL REGISTRATION AND MEMBERSHIP IN THE POWER ENGINEERING SOCIETY

		Academic Rank							Highest Earned Academic Degree					
Academic Year	Total Faculty	Prof Spons Chair	Prof	Assoc Prof	Asst Prof	Chrmn or Head	Adjt/ Visit Prof	Instr/ Lect	PhD DS	Engr	MS	BS	Registered Professional Engineer	Member-Power Engineering Society
1969-70	267	*	117	80	53	2	8	7	*	*	*	*	*	*
	100%	*	43.9%	30%	20%	0.7%	2.9%	2.5%	*	*	*	*	*	*
1971-72	275	*	121	78	43	11	22	*	143	13	95	11	170	157
	100%	*	44%	28%	16%	4%	8%	*	52%	5%	35%	4%	62%	57%
1973-74	320	6	122	97	40	11	24	20	181	11	96	9	159	182
	100%	2%	38%	30%	13%	3%	8%	6%	57%	3%	30%	3%	50%	57%
1975-76	302	7	114	83	38	14	31	15	207	5	89	8	173	179
	100%	2%	38%	27%	13%	5%	10%	5%	69%	2%	29%	3%	57%	59%

*Category or data not taken this survey year.

TABLE II
LISTING OF GRADUATE POWER ENGINEERING DEGREES GRANTED AND ENROLLMENT FOR STUDY YEARS

	Degrees Granted				Enrollment							
	U.S. Citizens		Foreign Nationals		U.S. Citizens				Foreign Nationals			
					Full-time		Part-time		Full-Time		Part-Time	
	Masters	Ph.D D.S.	Masters	Ph.D D.S.	Masters	Ph.D D.S.	Masters	Ph.D D.S.	Masters	Ph.D D.S.	Masters	Ph.D D.S.
1969-70	*	*	*	*	112	36	327	40	109	9	25	29
1971-72	204	20	77	12	163	35	386	51	145	34	72	26
1973-74	231	14	64	7	279	49	423	23	96	41	74	7
1975-76	205	9	102	14	232	40	425	44	157	42	46	19

*Category or data not taken in this survey year.

TABLE III
LISTING OF GRADUATE AND UNDERGRADUATE POWER ENGINEERING ENROLLMENT BY SUBJECT AREA FOR SURVEY YEAR

	Graduate and Undergraduate Enrollment by Subject Area and Survey Year														
	Elementary Power Engineering	Elementary Electric Machinery	Engineering Economics	System Stability and Dynamics	Economic Operation of Power Systems	Digital Methods in Power Systems	EHV Power System Problems	Transients, Lightning and Switching Surges	Symmetrical Components	HVDC Transmission and Power Electronics	Power System Distribution Engineering	Protective Relaying	Environmental Problems of Power Systems	Advanced Electric Machinery	Nonconventional Energy Conversion
1969-70 Graduate	63	59	11	226	134	236	89	266	233	184	13	130	52	188	27
1971-72* Graduate	2426	4877	1893	511	407	550	247	366	835	193	273	180	127	268	
1973-74 Graduate	107	16	82	485	322	439	224	298	323	147	190	263	145	243	
1973-74 Undergrad	2706	4962	1361	688	544	675	261	437	1228	162	592	389	197	437	
1975-76 Graduate															
1975-76 Undergrad															

Turning to graduate student enrollment as shown in Table II and Figure 3, the following trends are seen. First of all, Figure 3 shows that the overall graduate student enrollment has grown by over 38% during the past eight years, triple the growth rate of the number of programs and professors as shown earlier. Reviewing Figure 4 shows that a 47% increase has occurred in the total number of master candidate enrollments among U.S. citizens studying power. However, a slight decrease of about 7% occurred over the last survey interval. It should also be noted in Figure 5 that full-time master's enrollments of U.S. citizens more than doubled in the last eight years. It should further be noted that during the last survey interval, this enrollment declined by 20%. Part-time master's enrollment of U.S. citizens has increased by 27% over the last eight years and remained essentially flat over the last period as shown in Figure 6. These long range eight-year trends are up, but the short trend is down in all of the above figures for master's level students. Figure 7 also shows that the number of master's degrees granted has remained relatively constant in spite of the long range trend of increasing enrollments. Again the short term trend shows a down turn.

It is hard to analyze the data given for master's degree enrollments and degree grantings. The long term eight-year enrollment trends are up strongly in spite of recent down turns. It is disturbing, however, to note that apparently a large number of these candidates do not complete degrees

TABLE IV
LISTING OF UNDERGRADUATE POWER ENGINEERING DEGREES GRANTED AND ENROLLMENT FOR STUDY YEARS

	Degrees Granted		Enrollment			
	U.S. Citizens	Foreign Nationals	U.S. Citizens		Foreign Nationals	
			Full-Time	Part-Time	Full-Time	Part-Time
73-74	888	91	2,819	102	167	15
75-76	854	62	1,732	115	177	7

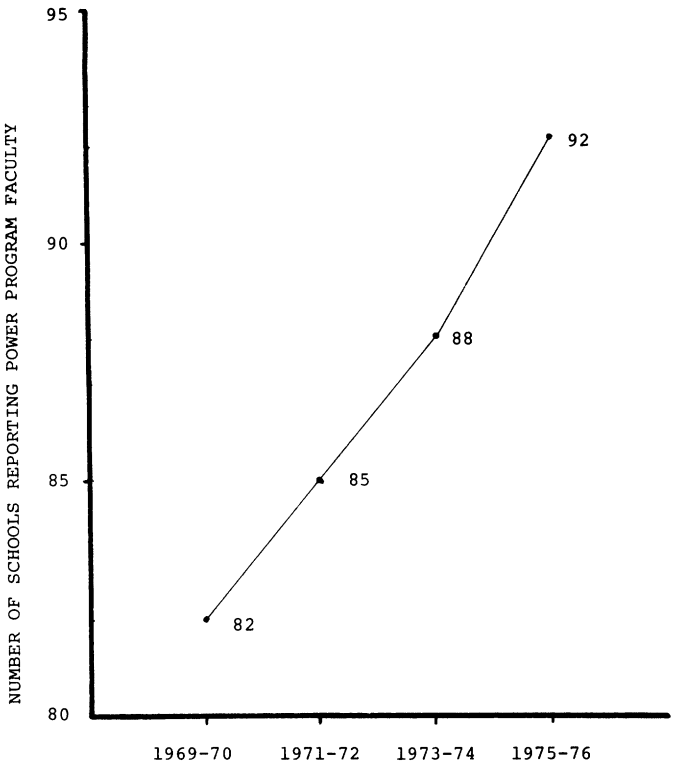

Fig. 1. Number of electric power engineering programs reported by survey year.

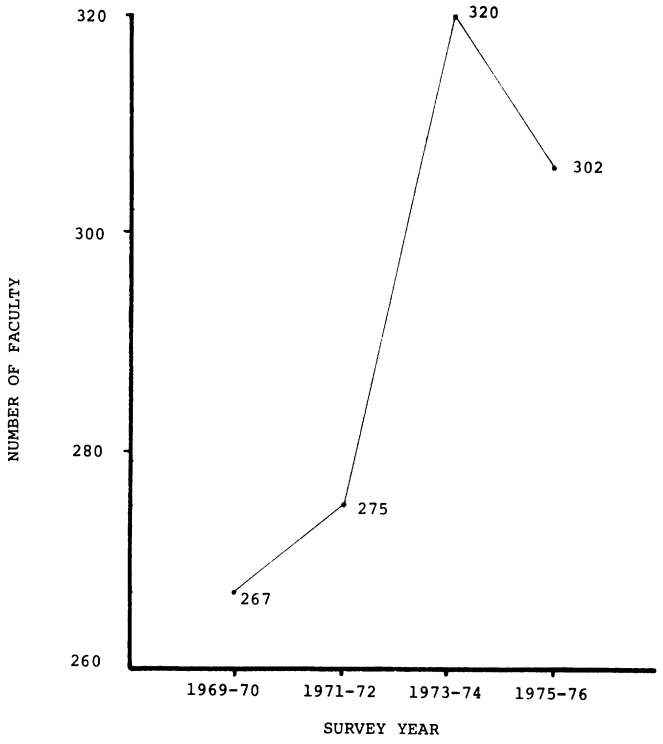

Fig. 2. Number of electric power engineering faculty by survey year.

since the number of degrees granted has remained essentially flat over the past six years. It is disturbing to note that industry need for higher levels of education in the field has not brought about greater numbers of students receiving advanced degrees in the power field.

Turning to doctoral enrollments as shown in Figure 8, a cyclic pattern of enrollment is noticed. Total enrollment is up 31% over the last eight years. Figure 9 shows that there has been a 43% increase in enrollment in full-time doctor candidates over the past eight years, with a recent downturn of 23%. Figure 10 shows that part-time enrollment is the factor which causes the doctoral enrollment to be cyclic. Part-time enrollment has not increased significantly on the average over the eight years showing a 19% increase with a recent upturn of over 90%.

The disturbing fact in the doctoral analysis is the sharp downturn in number of degrees granted as shown in Figure 11. The number of doctoral degrees granted to U.S. citizens has been cut in half in the past six years. This is a very disturbing factor in the overall evaluation of power engineering education, since it is from the doctoral ranks that industry will fill its advanced research needs and Universities will fill their staffing requirements. Even the fact that recently doctoral enrollments have taken an upturn does not soften the impact of this trend. This is due to the fact that the increase is primarily an effect of part-time doctoral enrollments. Part-time doctoral students typically have a high attrition rate and are definitely long term students not likely to reverse the trend in the immediate future.

Some minor concerns have been noted in regard to trends in graduate education in power engineering. However, since the numbers are small and the percentage changes generally not large, there is little concern over a major immediate impact on the industry. At the entry job level, the item of greatest concern to the industry is undergraduate enrollments and degrees granted in power engineering. Figure 12 shows that over the last two years there was a 4% decline in B.S. degrees granted to U.S. nationals entering the power field. This is certainly not significant, even though the number of programs has increased since graduation numbers normally fluctuate to some extent. However, Figure 13 shows that the number of undergraduate students enrolled in power engineering programs has declined by over 36% between the last two survey periods.

This drop is likely to be directly related to the same approxi-

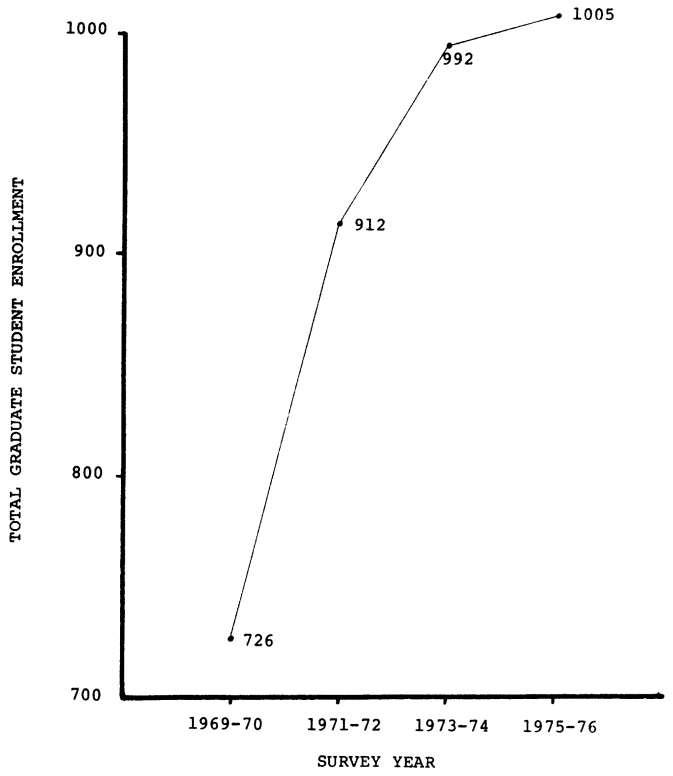

Fig. 3. Total electric power engineering graduate student enrollment by survey year.

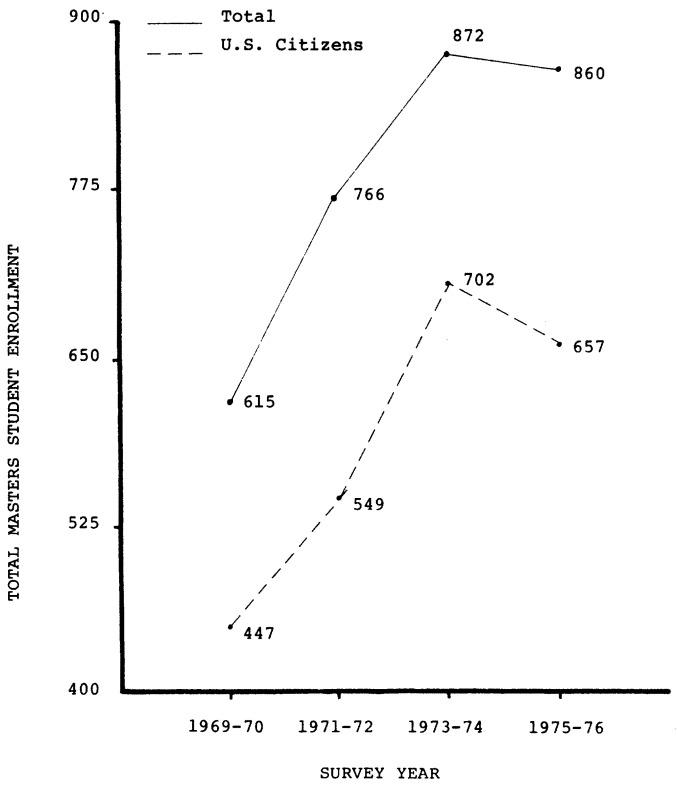

Fig. 4. Total electric power engineering master's degree enrollment by survey year.

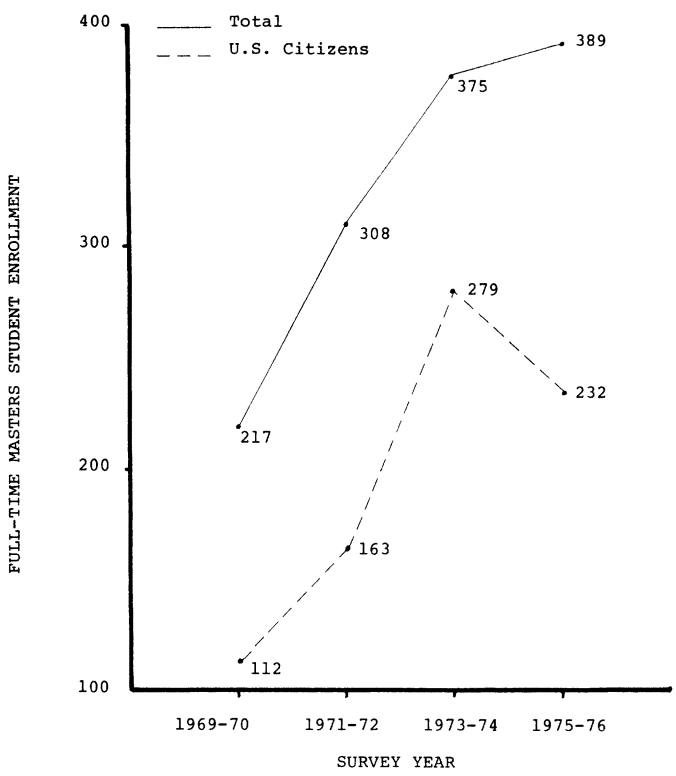

Fig. 5. Full-time electric power engineering master's enrollment by survey year.

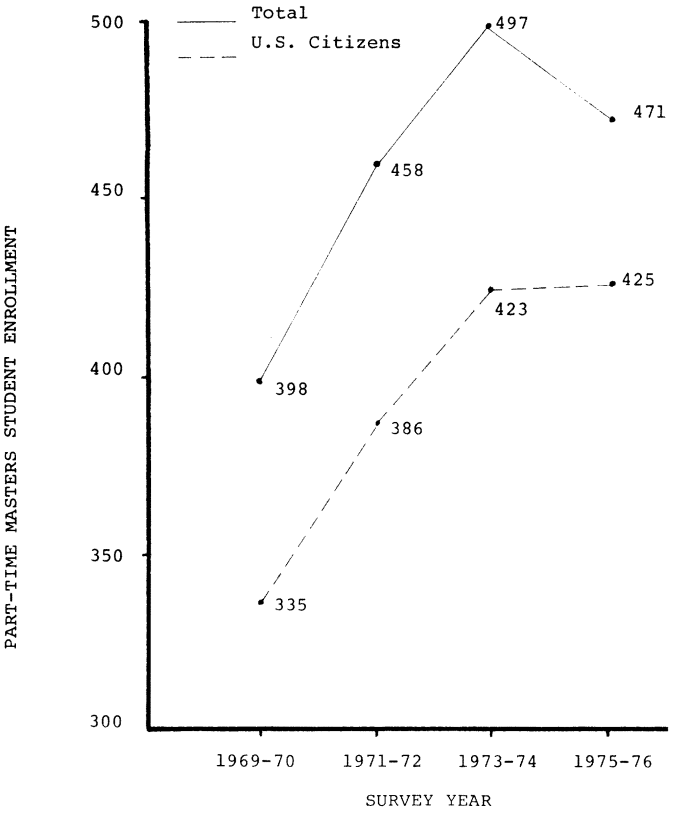

Fig. 6. Part-time electric power engineering master's enrollment by survey year.

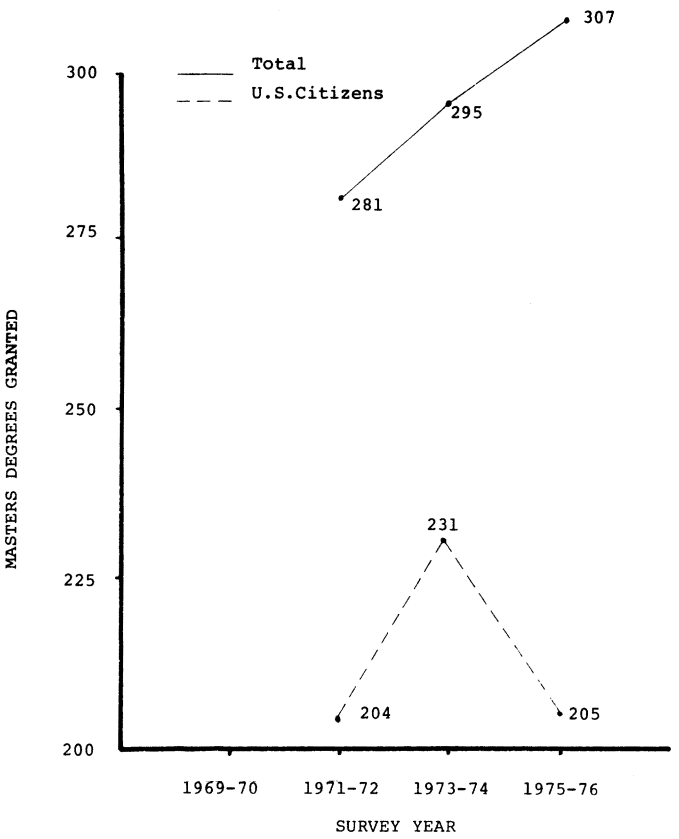

Fig. 7. Number of electric power engineering master's degrees granted by survey year.

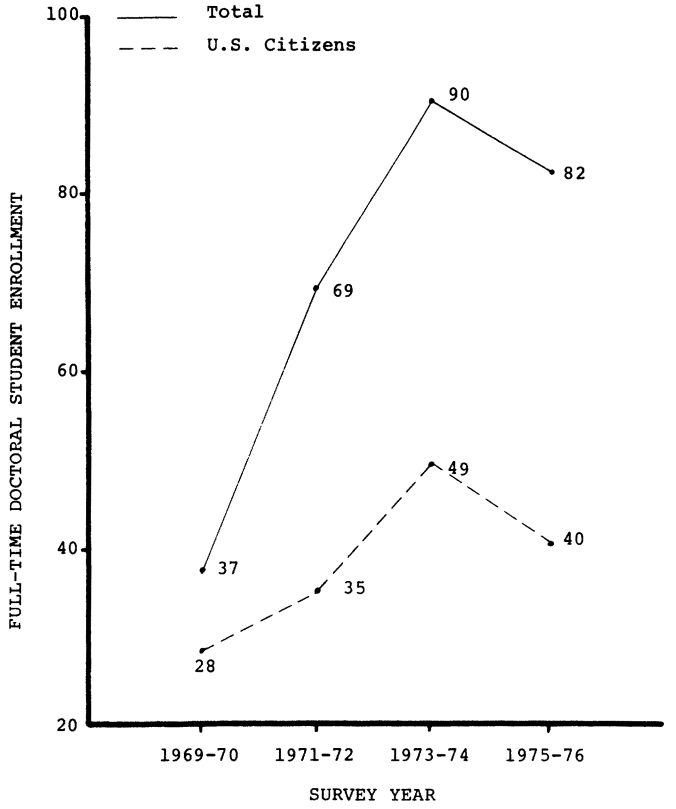

Fig. 9. Full-time electric power engineering enrollment by survey year.

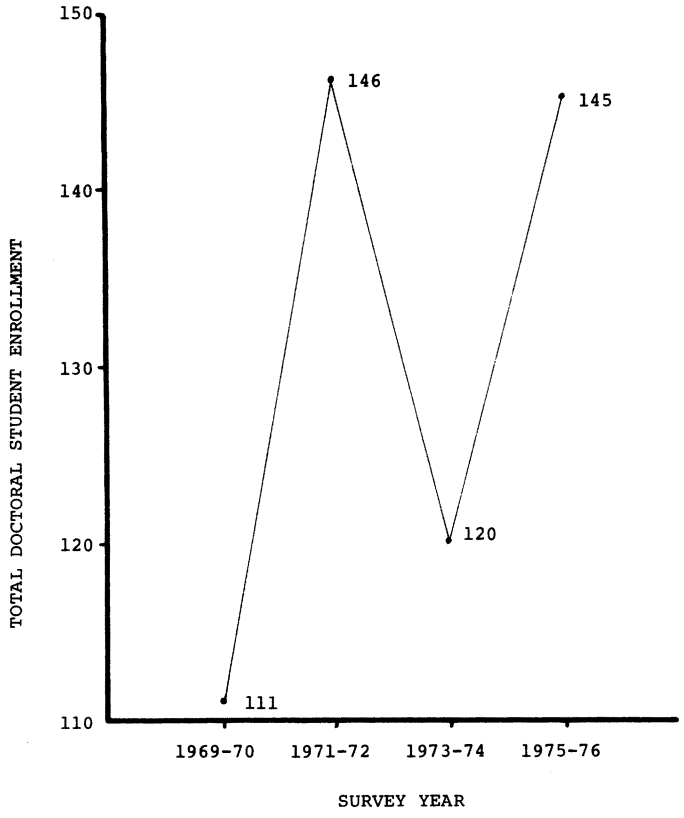

Fig. 8. Total electric power engineering doctoral enrollment by survey year.

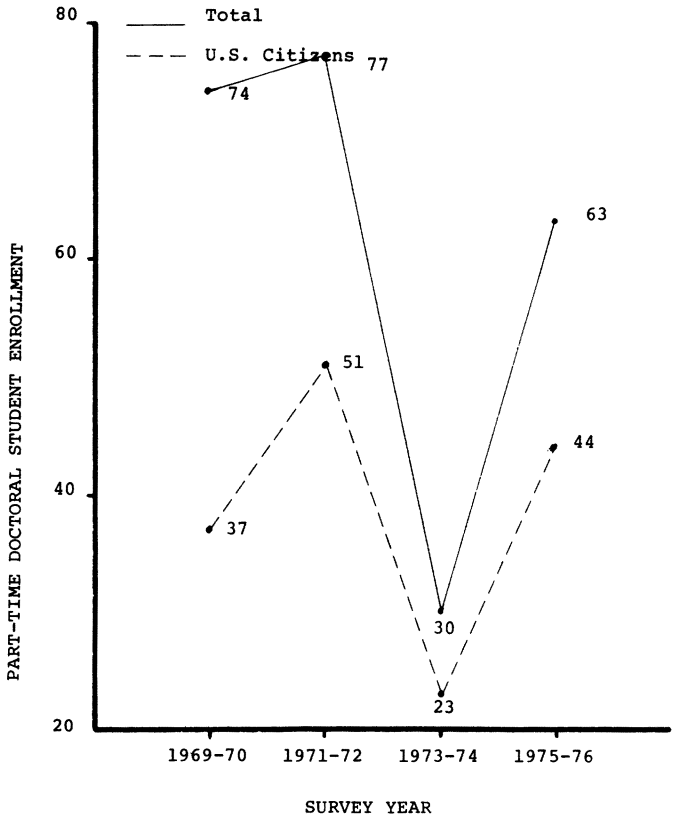

Fig. 10. Part-time electric power engineering doctoral enrollment by survey year.

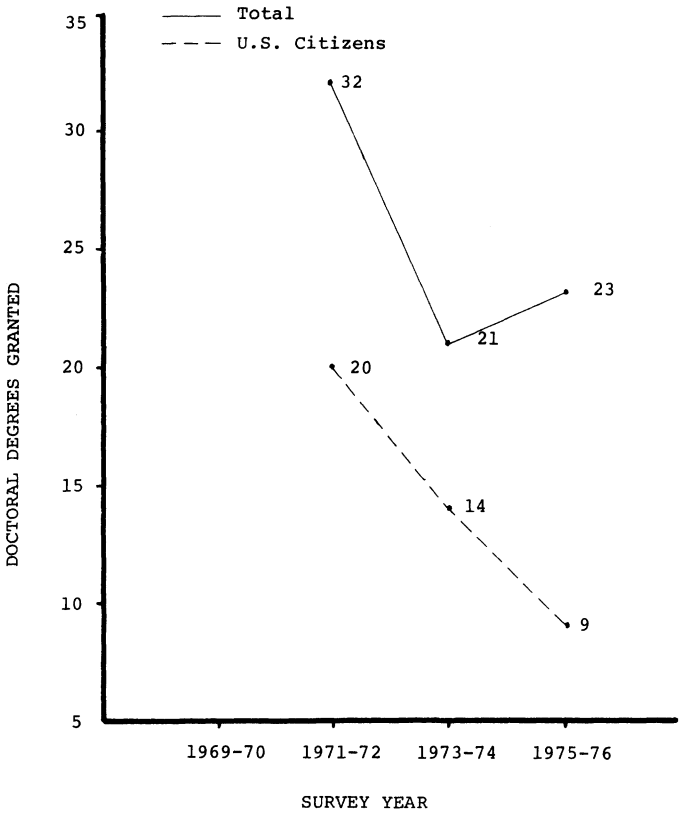

Fig. 11. Number of electric power engineering doctoral degrees granted by survey year.

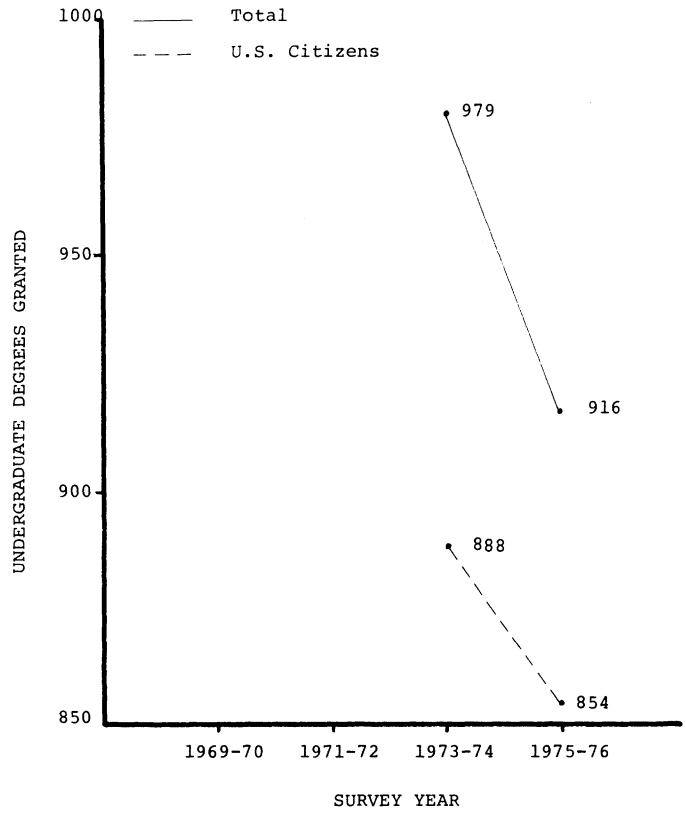

Fig. 12. Number of electric power undergraduate degrees granted by survey year.

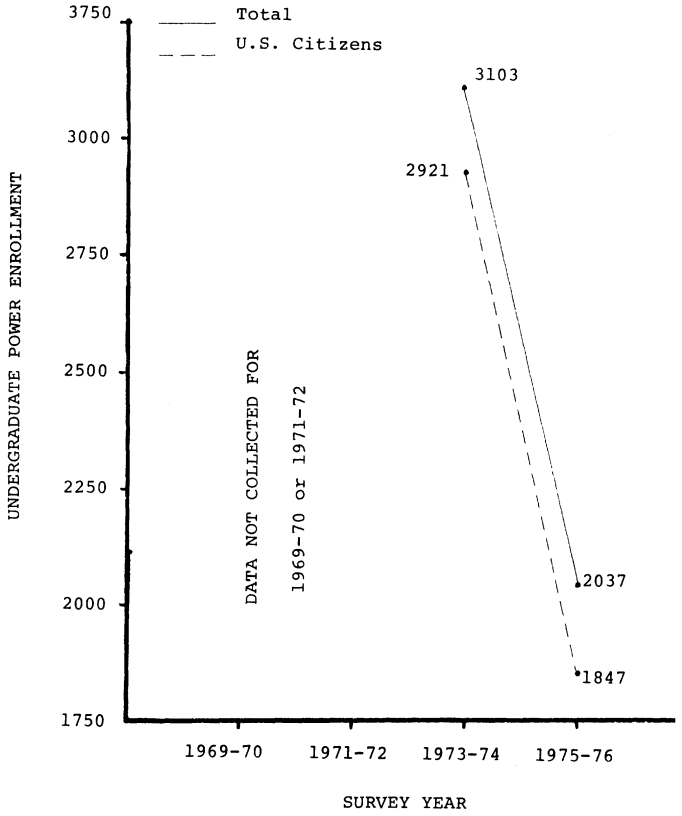

Fig. 13. Undergraduate power enrollment by survey year.

mate percentage drop in the freshman engineering class of 1971. The impact of this drop is becoming painfully apparent. It is difficult to fill the entry level jobs currently available with top quality power graduates and it is increasingly difficult to recruit power graduate students from the ranks of U.S. nationals. The recruitment of top students to graduate programs is of concern since the industry needs more employees with a higher degree of skills to solve its complex problems associated with assuring a future energy supply. Further, the Universities need to assure a continued supply of researchers and qualified educators in this vital area of engineering specialization.

Even though undergraduate enrollments in general have increased from the 1971 levels the power industry must face the fact that the numbers of graduates available before these dates are unlikely to again be achieved. Unless the power area is aggressive in attracting future students, it may find itself in the doldrums it experienced in the 1960's.

Conclusions

There is definitely a close link between economic health, employment, growth in output and energy as shown in Figure 14. National policies or trends that do not indicate a potential for assuring adequate energy supplies and talent to work on providing adequate future energy supply are dangerous, in this author's view, to the future of our country.

In the struggle to overcome energy problems that face our nation, the primary obstacles are ignorance, fear, prejudice,

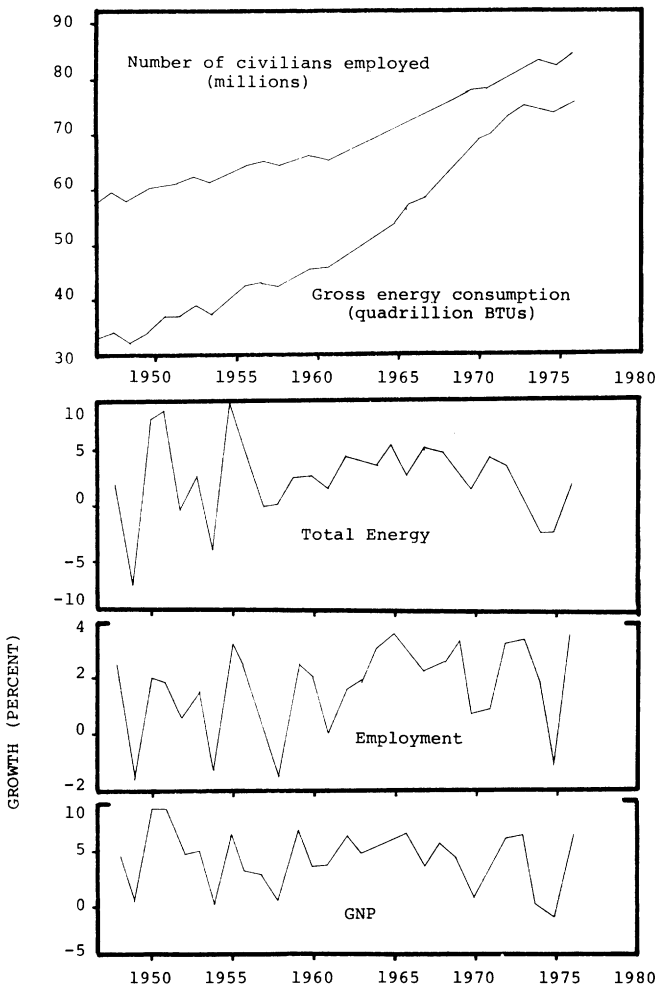

Fig. 14. U.S. energy consumption, employment, and gross national product.

and emotionalism. The solutions to our problems do lie before us. They will be based in a relatively high technology in spite of numerous counter opinions. We do need well trained people to provide courageous and responsible leadership in the application of technology. Unless leaders in education and industry are aggressive in promoting power engineering education, we will not have the supply of future leaders needed available to work on the problems of conserving energy wherever practical and producing the energy required to keep the people of the United States of America strong, healthy and free. Industry, government and higher education must join hands to develop programs in this vital area of engineering that will assure the supply of future quality engineering leadership by attracting the best students to quality educational programs.

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