Reducing the Engineering Skills Shortage in the Generation Sector

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***Abstract*--Power generators operate in a competitive market for skilled staff. In 2005 the Queensland generators recognised technical skill development as a critical business risk. Three universities, Central Queensland University, Queensland University of Technology and University of Queensland, have started a five-year collaboration with industry to develop to deliver a world-class course work Master of Engineering curriculum in Power Generation. The universities have actively leveraged the synergies between the generators, Stanwell Corporation, CS Energy and Tarong Energy and industry experts. The program focus is to accelerate the technical competency development of power generation engineers. This paper outlines the development of the new program and discusses the operational arrangements between the University and Industry partners.**

***Index Terms*—Electrical Engineering Education.**

I. Introduction

The power engineering sector operates within an Australian economy where engineering skills are in considerable demand. Globally this situation is hardly unique and concerns as to the adequacy of the supply of graduate and experienced engineers continues to be voiced in the USA and Europe.

Queensland is in the midst of a strong resources boom and significant population growth that is driving broad developments in public infrastructure. The generation industry is feeling effects of the corporatisation of the sector during the 1990's. The Queensland Electricity Commission had a well developed graduate program. The break up of QEC saw this program cease and a down turn in graduate recruitment. The industry today is left with an engineering age distribution that is problematic. There will be a retirement bubble over the next ten years that may reduce engineering numbers and this is a serious business risk.

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The broader power engineering industry has expressed concern in regard to the low numbers of engineering graduates with specialized power engineering skills and a desire to enter the power industry. In the past three years a number of industry based initiatives have emerged to support the development of power engineers in the University sector. Apart from this program, [1], examples include the Queensland based Power Engineering Alliance, (PEA), [2] and the more nationally based Australian Power Engineering Institute, (API), [3].

In 2005 three Queensland Generators, Tarong Energy, CS Energy and Stanwell, decided to take a collaborative approach to graduate skills development. These core partners are State Government controlled corporations that trace their ancestry to the QEC. Many senior executives share that history and have friendships that span the corporation boundaries. A shared objective of staff development, attraction and retention emerged.

II. Curriculum Development

In 2005 the Queensland Generators retained a technical consultant, Thermodyne Technologies, [4], to undertake an audit of the industry's perceptions of their skill requirements and of the capabilities of the University sector. The key strategies determined were:

- Offering accelerated professional development for new and middle-ranked engineering and para-professional staff;
- Investing in engineering faculties at Central Queensland University, the Queensland University of technology and the University of Queensland to provide specialist training programs.

The Thermodyne review process identified 47 priority skill areas shown in Table 1. A joint university, industry working party was developed to develop a curriculum using these as a starting point. The curriculum design team was:

- Professor Peter Wolfs (CQU);
- Professor Hal Gurgenci (UQ);
- Professor Tapan Saha (UQ);
- Professor Douglas Hargreaves (QUT); and
- Mr Trevor Johnson (Stanwell Corporation).

The 47 priority skill areas have been subsequently encapsulated into a proposed curriculum of 16 courses as

TABLE I
QUEENSLAND GENERATOR'S PRIORITY SKILL AREAS

PRIORITY	ENGINEERING SKILL AREA	PRIORITY	ENGINEERING SKILL AREA
1	Steam Plant Operation	24	Power Distribution
1	Control Systems	24	Plant Selection
3	Electricity Networks and Markets	24	Hazardous Areas
4	Fuel Preparation	24	Emission and Effluent Control
4	Thermal Performance Monitoring	24	Gas Systems
4	Regulatory and Compliance Issues	24	Material failure modes
4	Electrical Rotating Plant	24	Electrical Metering and Protection
8	Mechanical Rotating Plant	31	Life Cycle Management
9	Electrical Protection	32	Commercial Decision Making
9	Cooling Systems	32	Corrosion
11	Power Station Design	32	Power Systems Analysis
11	Maintenance Management	32	Gas Plant
11	Process and Combustion	32	Project Management
11	Statutory Inspection	37	Network Connection
11	Generators	37	Properties of Materials
11	Unit Cycle Chemistry	37	Electrical Insulation Theory
11	Heat Transfer	37	Earthing Systems
11	Electrical Condition Monitoring	41	Contract Management
11	Management of Generation Assets	41	Risk Management
20	Mechanical Condition Monitoring	41	Supporting Management Systems
20	Bulk Materials Handling	41	Emergency Power
20	Transformers	45	Welding
20	Non Destructive Examination	45	Alternative Technologies
		47	Lighting and Emergency Lighting

shown in Table 2. The design team recommended a post graduate power generation program be offered as five core and a further eleven elective courses. This course offering would support a number of industrially aligned technical streams as indicated in Table 3.

III. PROGRAM DELIVERY

The three University partners are responsible for the development and delivery of approximately one third of the program. In each course unit there is a lead and university and a supporting university that will collaborate as practical on program development. Each of the sixteen courses in the program will comprise approximately 40 class hours, delivered in a combination of the following formats:

- Intensive learning sessions (potentially one to five working days or extended weekends) on University campus or generator sites;
- Self paced study using the material provided through the course online portal;
- Demonstration and simulator sessions at the generator sites.

In addition to the 40 class hours, additional private study will be required for readings and assignments. Standard university online teaching support will be provided using learning portals for each course (all three universities use Blackboard as the online portal www.blackboard.com). Such portals enable students to access the Student Study Guide and other learning resources at any time from any internet connection and at their own pace. As in course development process will actively seek the involvement of the support university and industry experts. Where possible, industry practitioners are selected that are recognised as technical leaders. The involvement of three major generation companies has been invaluable in securing access to these individuals. The involvement will vary but may take one of the following forms:

- One or two specialist lectures;
- Deliver a significant but a small part of the course through one of the above delivery modes;
- Be a part of the teaching team with significant course and delivery design and assessment responsibilities.

A course team have been established to develop each course, led by the lead university assigned course convener and involving industry experts, the support university, and an industry review group.

TABLE II
PROGRAM CURRICULUM

UNIT	TITLE	TYPE
EPG01	**Introduction to Power Plant**	Core
	Thermal performance monitoring; Power station design	
	Steam plant operation – operations and maintenance	
	Alternative energy technologies	
	Electricity networks and markets	
EPG02	**Asset Management Systems**	Core
	Maintenance management;	
	Supporting management systems; Life cycle management;	
	Management of generating assets	
EPG03	**Rotating Machinery**	Core
	Mechanical rotating machinery (except turbines)	
	Electrical rotating plant	
	Mechanical condition monitoring	
EPG04	**Regulation, Compliance and Safety**	Core
	Regulatory and compliance issues for power generation	
	Network connection	
EPG05	**Project Delivery**	Core
	Commercial decision making	
	Contract management; Project management	
EPG06	**Applied Thermodynamics**	Elective
	Cooling systems; Heat transfer	
	Mechanical rotating machinery (turbines)	
EPG07	**Advanced Power Plant**	Elective
	Process and combustion; Fuel preparation	
	Plant selection; Statutory inspection	
EPG08	**Plant Control Systems**	Elective
	Control systems	
EPG09	**Power Plant Chemistry**	Elective
	Unit cycle chemistry	
EPG10	**Bulk Materials and Waste Products**	Elective
	Bulk materials handling; Emission and effluent control	
EPG11	**Industrial Power Distribution**	Elective
	Power distribution; Power systems analysis	
	Earthing methods	
EPG12	**Plant Materials**	Elective
	Properties of materials ; Corrosion; Material failure modes	
	Non-destructive examination (NDE)	
EPG13	**Generator Technology Design and Operation**	Elective
	Generators	
	Electrical protection; Electrical condition monitoring	
EPG14	**Transformer Technology Design and Operation**	Elective
	Transformers; Electrical protection	
EPG15	**Industrial Power Systems**	Elective
	Earthing systems	
	Electrical metering and protection; Electrical protection	
	Emergency power; Lighting and emergency lighting	
EPG16	**Gas Plant and Systems**	Elective
	Gas systems; Gas plant	

TABLE III
STREAMS WITHIN THE PROPOSED CURRICULUM

POWER GENERATION INDUSTRY PROGRAM	Professional Engineer Streams							Para Professional Streams		
Course	Control Systems	Heavy Electrical	Process	Mechanical Plant	Mechanical Plant II	Materials	Gas Plant Specialist	Grad Cert Mech	Grad Cert Elec	Grad Cert Chem
Introduction to Power Plant	1	1	1	1	1	1	1	1	1	1
Asset Management Systems	1	1	1	1	1	1	1			
Rotating Machinery	1	1	1	1	1	1	1	1	1	1
Regulation, Compliance and Safety	1	1	1	1	1	1	1	1	1	1
Project Delivery	1	1	1	1	1	1	1			
Applied Thermodynamics			1		1	1	1			
Advanced Power Plant	1		1	1	1					
Plant Control Systems	1		1				1			
Power Plant Chemistry					1	1				1
Bulk Materials and Waste Products				1				1		
Industrial Power Distribution		1							1	
Plant Materials				1		1				
Generator Technology Design and Operation		1								
Transformer Technology Design and Operation		1								
Industrial Power Systems	1									
Gas Plant and Systems							1			

IV. STUDENT MANAGEMENT

Students will enrol at a 'home university', one where they anticipate undertaking at least three (3) courses. Enrolment is governed by the program rules of that institution. Students are expected undertake courses at the other universities. The schedule and delivery of a course is set by the lead university. Each University will offer their own award program(s). Students must complete the program requirements of their home institution in order to graduate.

Students are given the opportunity to enrol in courses from other partner universities on a cross-institutional basis, within the rule constraints applicable (eg, proportion of credit required to be obtained from home institution). Credit for courses undertaken at a university other than the home university will be granted within the rule constraints of the home university.

Courses are subject to the home institution's quality assurance processes including assessment and teaching and learning polices and are subject to academic directions set by that university. CQU has established three new postgraduate coursework qualifications in Power Generation and is introducing a third. These are:

- Graduate Certificate (Power Generation);
- Graduate Diploma (Power Generation);
- Master of Engineering (Power Generation).

QUT has established two new postgraduate coursework qualifications, consistent with other coursework master's programs in a fashion that compliments its existing (PESTC) Graduate Certificate and Master of Engineering Science (Electricity Supply) award in Power Generation. These two programs are the Graduate Certificate (Power Generation) and the Master of Engineering in Power Generation. The typical format utilises small intensive units of study, breaking a traditional semester course into two block units, each delivered in a 16-24 hour intensive session.

UQ has established a new Plan under its existing Master of Engineering suite named Master of Engineering (Power Generation). Students will also have the option to take out a Graduate Certificate of Engineering (Power Generation). The six courses for which UQ is the lead university will be made available for enrolment in these programs.

V. PROGRAM GOVERNANCE

The program is managed by the Program Leaders Committee. Each Queensland Generator and each University will appoint to the Program Leaders Committee one person who is the person responsible for the coordination of the program at the organisation. The Program Leaders Committee is complimented by regular executive contact between the participating Queensland Generators and Universities. Its functions are to:

- Guide the design and ensure consistency of the program structure, content and delivery. Make recommendations for resource allocation for consideration by the relevant approving authorities at each organisation;
- Monitor the progress of each Course Convener (assigned by the lead university for each course it is responsible for) who manages the development and delivery of the assigned course to budget, schedule and quality standard;
- Implement, maintain, review and improve the Program in accordance with appropriate academic standards and assessment processes, managing coordination and logistical issues relating to delivery of the Program.
- Facilitate and co-ordinate national and international marketing.

The Chair of the Program Leaders Committee serves a two year term. The Chair will be appointed by the members and rotate between the six founding organizations.

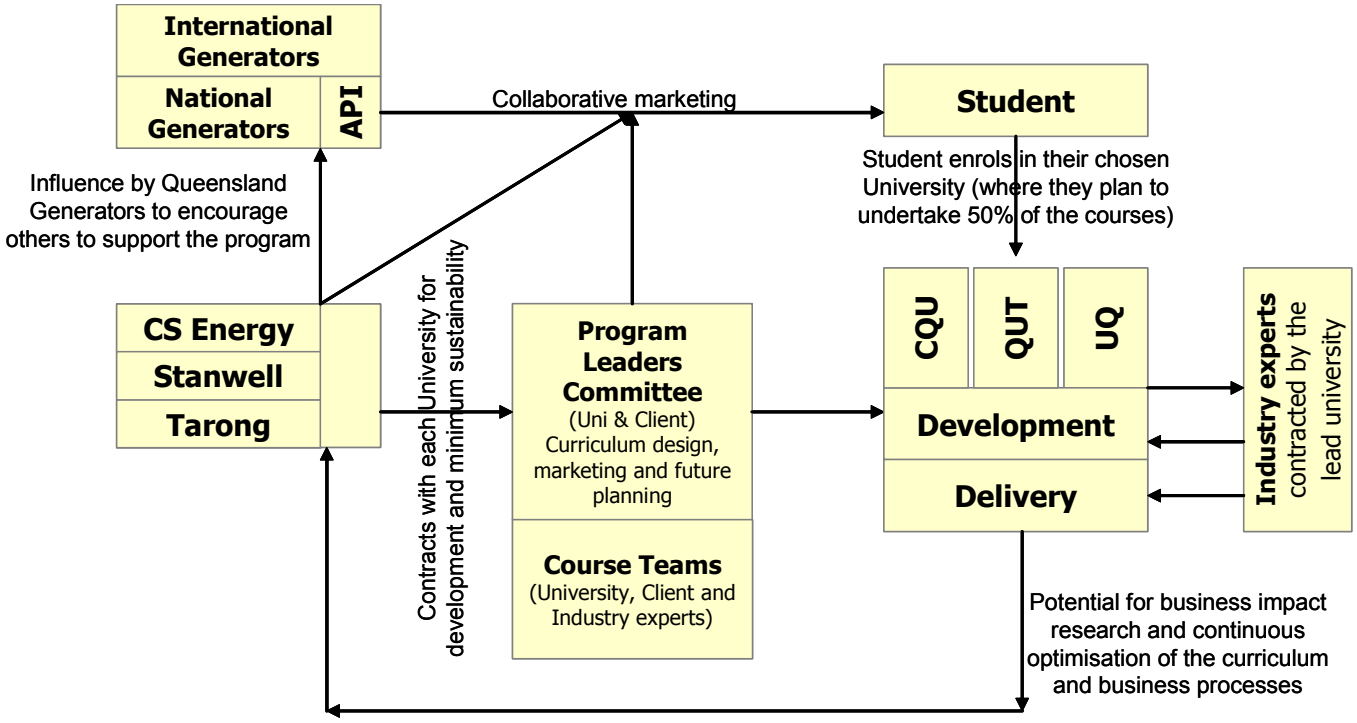

Fig. 1. Program Relationships

VI. Operations in 2007

During 2007 preliminary operations commenced at the partner Universities with a total of six of the course units being offered. Due to the time lines involved in securing DEST approvals for program deliveries, some courses were delivered as non-award continuing education programs. In 2008, all ofthe courses will be in place as formal university awards. Students that have taken the 2007 offerings will be awarded recognition for the prior studies through the processes of the partner universities.

Significant collaboration has occurred between the Universities in regard to the development of learning materials that utilise common approaches and templates. At each offering the Universities have applied their learning experience assessment instruments and the results have been positive and encouraging. For each course unit, significant inputs have been secured from well regarded industry experts. In all cases the preferred approach has been to have a number of experts involved, both in the production of learning resources, in the review process and in delivery.

VII. Conclusions

The new program is being quickly brought into existence by the shared efforts of the university and industry partners. The feedback from the early offerings is very positive. During 2008, 12 of the 16 course units will be on offer. With a significant part of the program development complete, a concerted effort will be made to encourage enrolments from companies outside of the original industry partners.

VIII. References

[1] Power Generators program website http://powergeneration.edu.au
[2] Power Engineering Alliance website http://www.pea.org.au/
[3] Australian Power Institute Website http://api.edu.au/
[4] Thermodyne Technologies Website http://www.thermodyne.com.au

IX. Biographies

Peter Wolfs (M'80, SM'99) was born in Rockhampton Australia in 1959. He graduated from the Capricornia Institute of Advanced Education in 1980 with a Bachelor of Engineering Degree. He subsequently secured a Master of Engineering degree with the Philips International Institute in the Netherlands in 1981 and a PhD degree at the University of Queensland in 1992.

He is the Associate Dean (Research and Innovation) at the Faculty of Sciences, Engineering and Health at Central Queensland University. His special fields of interest include electric traction supplies for railways, power quality and reactive power, harmonics, rural and renewable energy supply, electric, solar and hybrid electric vehicles and intelligent systems applications in railways. Professor Wolfs is Senior Member of IEEE, a Fellow of Engineers Australia, a Registered Professional Engineer in the State of Queensland and a member of the Railway Technical Society of Australia.

Douglas Hargreaves was born in Rockhampton (Australia) on January 24, 1952. He graduated from the Queensland Institute of Technology (now QUT), Brisbane, and studied at the University of Leeds where he attained his Masters and PhD in Mechanical Engineering.

His employment experience includes Queensland Alumina Ltd, Sugar Research Institute, Ampol R&D Laboratory and more recently the Queensland University of Technology, where he is currently the Head of School of Engineering Systems. His special fields of interest lie in tribology (friction, lubrication and wear) and the education of engineering undergraduates.

With his passion for Values Driven Leadership, Hargreaves was appointed in 2006 as an Engineering Executive by Engineers Australia in recognition of his exceptional skills in the areas of leadership and management.

Tapan Kumar Saha was born in Bangladesh and immigrated to Australia in 1989. Dr Saha is a Professor in the School of Information Technology and Electrical Engineering at the University of Queensland, Australia. He is a Senior Member of the IEEE and a Fellow of the Engineers Australia. His research interests include power systems, power quality, and equipment condition monitoring.