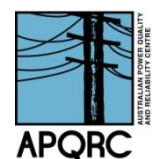


Australian Power Quality and Reliability Centre

Prospectus & Business Plan

2015-2016



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1. *The APQRC at a Glance*

Key Facts about the Centre

Established	1996
University Partner	University of Wollongong
Major Industry Partner	Networks NSW
Number of Staff	20 (7 academics + 4 professional staff + 1 Emeritus Prof. + 2 Research Fellows + 4 Honorary Prof.s)
Website:	www.elec.uow.edu.au/apqrc

Major Projects and Research Undertaken by the Centre

- Power Quality Compliance Audit – A significant annual project run by the Centre, analysing, benchmarking and reporting on power quality data supplied from electrical distribution utilities across Australia. This is now being developed for expansion to transmission utilities.
- Handbook HB 264-2003 “Power Quality – Recommendations for the Application of AS/NZS 61000.3.6 and AS/NZS 61000.3.7”, ISBN 0 7337 5439 2, written for Standards Australia for use by the Industry. This has been recently revised.
- Cost of Poor Power Quality – A major research project was recently completed which carried out a preliminary examination of the cost of poor power quality on network equipment and consumer loads. Further research is being performed by means of an Australian Strategic Technology Program (ASTP) research project.
- Staff within the centre have published over 180 research publications and papers in the areas of power quality, reliability and distributed generation.

Major Achievements of the Centre

- Hosting ICHQP 2008 (IEEE International Conference on Harmonics in Power Systems). This was the first time the world’s premier conference on harmonics was held outside of Europe or North America.
- Collaborative research with the University of Canterbury, New Zealand to study the impact of emerging technologies on the power quality of the NZ electricity network – 3 year project.

- Preparation of application guidebooks for Standards Australia / Energy Networks Association on the current MV / HV harmonic and flicker standards AS/NZS 61000.3.6, AS/NZS 61000.3.7, and the unbalance standard AS/NZS 61000.3.13.
- Implementation of a Master of Electrical Power Engineering Degree at the University of Wollongong specifically to meet the needs of improving the skills of engineering staff in the Australian Electricity Supply Industry. Operation of this modular program began in 2011.
- Delivery of over 60 CPD courses to staff of the electricity supply and other industries.
- Major contributions to CIGRE / CIREN Working Groups C4.108, C4.111 and C4.112.
- Major contributions to power quality monitoring and reporting for distribution utilities.
- Completion of over 100 power quality consultancy projects for companies from a wide range of industries.

2. *Executive Summary*

The Australian Power Quality and Reliability Centre (APQRC or “The Centre”) has been operating for over 19 years and has become recognised both locally and overseas as a provider of high quality collaborative research, teaching and consulting in the area of quality of electrical supply.

The aim of the Centre is to be a world recognised centre of excellence for research, education and consulting in distribution and transmission system power quality, reliability and distributed energy systems.

This document outlines the purpose of the Centre and its benefits to industry, its objectives, strategies, activities and capabilities. This is followed by a detailed description of the Centre’s Business Plan for 2015-2016.

3. *Purpose and Business Benefits*

The Australian Power Quality and Reliability Centre strives to be a world recognised centre of excellence for research, education and consulting in distribution and transmission system power quality, reliability and distributed energy systems.

The focus of the Centre is to work in conjunction with the electricity supply industry, manufacturers and customers to improve the quality and reliability of electricity supply for the benefit of all consumers.

The benefits to Networks NSW of sponsoring the Centre include:

- **Education** – Funding ensures that the next generation of skilled engineers is available for Networks NSW and for the electrical power industry as a whole. This includes educating the next generation of power engineering University academics, teachers and researchers.
- **Training** – Access to in-house training of graduate engineers and specialist industry CPD short courses.
- **Support for input to national and international standards** – development allowing the production of realistic codes and regulatory requirements.
- **Research** – Funding provides opportunities for research to find solutions to medium to longer term problems particularly when in-house resources are constrained.
- **Consulting** – Expertise is maintained and is available for solution of short term problems.
- **Recognition** – sponsorship ensures that Networks NSW is seen as an industry leader in the promotion of University-industry partnerships.
- **Leverage of investment** – Multiplication of staff and equipment resources for education and R & D through the attraction to the Centre of other research and consulting income (an important KPI of the Centre).
- **Access to world-wide resources** – Achieved via international standards committees and industry committees and their technical experts, as well as through networks established at international conferences.
- **Community recognition** – Network NSW is seen to be supporting engineering education and leading-edge research for the benefit of the whole community.

4. Objectives and Strategies

The Centre has the following key **objectives**:

1. **Education** – Enhance the level of power engineering education, allowing it to play a key role in the fostering of power engineering education on a state, national and international basis. Furthermore, provide to the electricity supply industry, customers and the community generally, training services ranging from general quality of supply awareness to the specialised technical requirements of engineers and technicians.
2. **Research** – Foster and conduct research and development into power distribution engineering with specific emphasis on power quality and reliability and to inform and promote the outcomes to the electricity supply industry and consumers in general. The commercialisation of the results of such research and development will be promoted. The Centre aims to be internationally recognised for its expertise in these areas of research.
3. **Consultancy** – Provide to the electricity supply industry and customers access to the expertise, experience and resources of the Centre on a consultancy basis.
4. **Industry Collaboration** – Partner with industry to understand trends, issues and challenges facing the electricity supply industry to enable mutually beneficial solutions to be achieved.
5. **Influence Debate** – Be in a position to influence and provide credible and informed input into the direction of power quality and reliability debate amongst the electricity supply industry, governing, regulatory and standards bodies, customers and the community in general.
6. **Long Term Success** – Establish a broad funding base from a diverse range of sources including industry and government research grants, industry sponsorship of an expanded Centre for education and research focussing on power quality and reliability aspects of future electricity networks and consultancy revenue. Attraction of high quality staff to support the activities of the Centre is a complementary priority.

The objectives are realised by the Centre through various strategies. In the chart following, these strategies are mapped to their relevant objectives.

Objectives and Strategies

		Objectives						
		Education	Research	Consultancy	Industry Collaboration	Influence Debate	Long Term Success	
Strategies	A	Maintain expertise of the Centre through hiring of appropriate staff and development of existing staff to support power engineering teaching, to conduct research and development activities and provide expert advice and consultancy services.						
	B	Ongoing encouragement of local students to undertake postgraduate study and building a pool of talented future academics focussed on the power supply industry.						
	C	Maintain a national and international presence in high impact journals and at Australian and International conferences in the areas of electrical power, power quality, reliability and renewable energy systems.						
	D	Seek funding for industry specific research from organisations or government bodies such as the ASTP or ENA.						
	E	Actively seek opportunities to provide consultancy services.						
	F	Continue to develop strong ties with key organisations within the electricity supply industry.						
	G	Continue as active members of standards and industry groups such as EL34, CIGRE APC4 & APC6, CIGRE C4, WG C4.24, WG C4.27 and ENA committees.						
	H	Provide informed and credible input into the development of local and international power quality and reliability standards, including but not limited to; standards issued by Standards Australia and the IEC.						
	I	Establish a long term broad based funding structure for the Centre.						

5. *Activities*

The Centre has identified and will undertake the following activities which are aligned to the broader strategies of the Centre:

1. *Education*

- Continued provision of a course work Masters program in Electrical Power Engineering to meet the ongoing needs of the electricity supply industry. [G]
- Delivery of continuing education courses for the electricity supply industry. [F]
- Delivery of continuing education courses for Endeavour Energy, Ausgrid and Essential Energy staff to keep their knowledge current. [F]

2. *Research*

- Conduct further research into power quality and reliability issues particularly voltage problems and the impact of distributed generation and the smart grid. [F]
- Continue to develop power quality analysis and reporting by means of the Power Quality Compliance Audit. [F]

3. *Consultancy*

- Actively seek consulting work through the development of a marketing brochure and website, and by advertising in industry magazines. [F]

4. *Industry Collaboration*

- Develop projects to obtain ASTP funding or seek suitable industry partners for ARC Linkage funding. [B]

5. *Influence Debate*

- Continue as active members of standards and industry groups and so provide informed and credible input into the development of local and international power quality and reliability standards. [C,D]
- Attend three conferences – PESGM 2015, Denver, US, July 2015; AUPEC – Wollongong, Australia, September 2015; EECON 2015, Sydney, Australia, November 2015 [E]

6. *Long Term Success*

- Expand the Centre to focus on power quality and reliability aspects of future electricity networks, sponsored by industry partners to support ongoing education and research. [A]

6. *Capabilities & Strengths*

The strength of the Centre comes from its wide ranging expertise and investigations in power systems and customer loads, its strong contacts with industry and its knowledge of international research efforts. The Centre operates a modern laboratory with equipment and instrumentation necessary to undertake a range of investigations into both power systems and equipment behaviour. The Centre has extensive consulting experience and has provided consultancy services to some of Australia's largest manufacturing companies and electricity utilities. Expert advice and consultancy services can be engaged in the following areas:

- Investigation and resolution of power quality problems
- Routine power quality monitoring as well as monitoring for compliance with standards and regulations.
- Harmonics – modelling, analysis and allocation studies
- Voltage fluctuations / flicker – modelling, analysis and allocation studies
- Voltage sags – modelling and analysis
- Transients – modelling and analysis
- Connection Agreements.
- Interpretation of power quality standards
- Power quality data analysis and reporting
- Distribution system reliability
- Equipment power quality immunity testing to national and international standards as well as equipment performance testing
- Renewable Energy Systems integration and power quality
- Frequency response measurement of voltage transformers
- Conducted EMI
- Performance testing of drives and motors
- Fault current limiter and magnetic device design and analysis

The Centre also offers the following continuing education courses:

- Quality of Electrical Supply
- Applied Power Quality (Harmonics, Unbalance and Sags)
- Applied Power Quality (Fluctuations / Flicker, Harmonics and Unbalance)
- Advanced Quality of Electrical Supply (Sags, Transients and PQ Monitoring)
- Renewable and Distributed Power Generation
- Electrical Drive Systems

- Power Electronics in Distribution Systems
- Power Quality Monitoring from an Energy Managers Perspective

7. Business Plan: 2015-2016

7.1 Key Performance Indicators

The planned activities of the Centre are aligned to the following KPI measures.

KPI	Component	Measure	Target
1. Technical Support Hours		Hours	520
2. Education	Average UG elective enrolments	Number per total number of 4 th year students	-
	UG power theses	Number per total number of 4 th year students	-
	PG enrolled	Number	-
	PG completions	Number	-
3. Publications	Conference and Journal papers	Number	10
4. Continuing Education	Courses for Networks NSW	Number	2
5. Income	Total income with respect to industry funding	Ratio	>2

7.2 Education

The educational activities to be undertaken by the APQRC for the 2015 to 2016 period are as follows.

KPI	Priority	Objective	Date Due	Comments
All	A	Lecturer	June 2016	Undergraduate and postgraduate teaching
2	A	Coursework masters in electrical power engineering	Ongoing	4 modules to be run
2	A	Enhancement of power engineering teaching through field trips for undergraduates including large industrial plants	March 2016	Substation & power station visits
2	A	Selection of high quality HDR students to receive the scholarship supplementation	Ongoing	
2	A	Attraction of suitable undergraduates to carry out R&D – final year thesis projects	June 2016	

2	B	Invited lectures by industry personnel for inclusion in final year electives	November 2015 & June 2016	
2,3,5	A	Seeking for industry funding to supplement PGs	Ongoing	
4	A	Development of continuing education courses for industry graduate engineers and other staff	June 2016	Reliability 101, December 2015
2	A	Development of continuing education short courses for industry	August 2015 October 2015 April 2016	Quality of Electrical Supply Course. Power Electronics in Distribution Systems Course. Applied Power Quality Course.

7.3 Power Quality

The activities related to power quality to be undertaken by the APQRC for the 2015 to 2016 period are as follows.

KPI	Priority	Objective	Date Due	Comments
5	A	Power Quality Compliance Audit	Ongoing	Both Distribution and Transmission companies
1	A	EL34, CIGRE C4, CIGRE C6, ENA committee work	Ongoing	
5	A	Pursue strategic research activities in areas of interest to industry, seeking ARC/industry funding	Ongoing	Priority area will be cost of poor power quality to networks and consumers.
1,2	A	Student projects in relation to case studies	Ongoing	Case studies provided by Endeavour Energy, Ausgrid & Essential Energy
3	A	Attendance at national and international conferences	Ongoing	<ul style="list-style-type: none"> • PESGM 2015, Denver, US, July 2015 • AUPEC – Wollongong, Australia, September 2015 • EECON 2015, Sydney, November 2015

7.4 Reliability

The activities related to reliability to be undertaken by the APQRC for the 2015 to 2016 period are as follows.

KPI	Priority	Objective	Date Due	Comments
1,2	B	Seminars by expert engineers (local and international) on reliability improvement	June 2016	At least one event

7.5 Future Grids

The activities related to future electricity networks to be undertaken by the APQRC for the 2015 to 2016 period are as follows.

KPI	Priority	Objective	Date Due	Comments
All	A	Sustainable Building Research Centre (SBRC) microgrid research	June 2016	Develop research laboratory

7.6 Strategic Directions

The activities related to strategic directions to be undertaken by the APQRC for the 2015 to 2016 period are as follows.

KPI	Priority	Objective	Date Due	Comments
5	A	Establishment of the Foundation for Power Engineering Excellence	Ongoing	Develop management structure, identify key potential sponsors, and launch Foundation.

7.7 Timeline of Activities: 2015-2016

The timeline of the activities and tasks identified to be carried out by the Centre in 2015-2016 is as follows:

Activities 2015 - 2016	2015						2016					
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Educational Activities												
Lecturers												
Coursework Masters in electrical Power Engineering												
Enhancement of power engineering teaching through field trips for undergraduates including large industrial plants												
Selection of high quality HDR students to receive the scholarship supplementation												
Attraction of suitable undergraduates to carry out R&D – final year thesis projects												
Invited lectures by industry personnel for inclusion in final year electives												
Seeking for industry funding to supplement PGs												
Development of continuing education courses for industry graduate engineers and other staff, and industry in general												
Power Quality Activities												
Power Quality Compliance Audit												
EL34, CIGRE C4, CIGRE C6, ENA committee work												
Pursue strategic research activities in areas of interest to industry, seeking ARC/industry funding												
Student projects in relation to case studies												
Attendance at national and international conferences												
Reliability Activities												
Seminars by expert engineers (local and international) on reliability improvement												
Future Electricity Networks Activities												
Sustainable Building Research Centre (SBRC) microgrid research												
Strategic Directions Activities												
Establishment of the Foundation for Power Engineering Excellence												

Appendix 1 – Management Advisory Committee

The strategic direction and governance of the Centre is provided through the Management Advisory Committee (MAC), comprising members from Endeavour Energy, Ausgrid, Essential Energy and the University of Wollongong.

Networks NSW	University of Wollongong
Mr Jim Battersby <i>Chief Engineer – Endeavour Energy</i>	Professor Chris Cook <i>Dean of the Faculty of Engineering and Information Sciences</i> <i>Professor of Electrical Engineering</i>
Mr Ty Christopher <i>General Manager Network Development – Endeavour Energy</i>	Professor Sarath Perera <i>Technical Director of the APQRC</i>
Rick Wallace <i>Manager Asset and Network Planning – Endeavour Energy</i>	Emeritus Professor Vic Gosbell <i>Technical Advisor of the APQRC</i>
Matt Webb <i>Chief Engineer – Ausgrid</i>	Professor Danny Sutanto <i>Professor of Power Engineering</i>
Brian Green <i>Chief Engineer – Essential Energy</i>	

MAC meetings are conducted on a quarterly basis, as are joint technical meetings between Endeavour Energy, Ausgrid, Essential Energy and Centre staff.

Appendix 2 – Key Staff

The key academic, research and administrative staff associated with the APQRC are as follows:



Professor Alex Baitch

Visiting Professorial Fellow

School of Electrical, Computer and Telecommunications Engineering

Principal

BES (Aust) Pty Ltd

Alex holds BE, MEngSc and MBA degrees from Sydney University, University of NSW and Deakin University respectively. He is a Fellow of Engineers Australia and Australian Institute of Energy, a Senior Member of IEEE and an Associate Member of the Australian Institute of Arbitrators and Mediators. In November 2012 Professor Baitch was announced as national deputy president of Engineers Australia for 2013, and will succeed president elect Dr Marlene Kanga in 2014.

Alex has over 40 years industry experience in the electricity industry including electricity utilities, manufacturing, importing and consulting. Alex is principal of BES (Aust) Pty Ltd specialising in electrical distribution and utilisation. Alex is one of Australia's leading authorities on electric safety



Dr Robert Barr AM

Visiting Professorial Fellow

School of Electrical, Computer and Telecommunications Engineering

Director

Electric Power Consulting Pty Ltd

Robert commenced his career in the electricity supply industry in 1973 as a cadet engineer with Prospect Electricity. He was appointed as a professional engineer with Prospect Electricity in 1976 & gained experience in electricity distribution including load forecasting and system planning. Robert joined Illawarra Electricity as System Control Engineer in 1982 and was later appointed Area Manager Nowra with overall responsibility for electricity supply to 28,000 customers in the Nowra/Shoalhaven area of NSW.

Robert has managed and worked for his company "Electric Power Consulting Pty Ltd" since 1990 and has dealt with a wide range of power quality and general electricity industry problems.

Dr Barr was recognised by the Electrical College of Engineers Australia as the 2012 Professional Electrical Engineer of the Year and was announced as being appointed as a Member of the Order of Australia (AM) in the Queen's Birthday 2013 Honours List for significant service to engineering, particularly electrical energy supply and distribution.



Dr Peeter Muttik

Visiting Professorial Fellow
School of Electrical, Computer and Telecommunications
Engineering
Chief Engineer, Systems
Areva T&D Australia Ltd

Peeter holds Ph.D, B.E. (Hons) and B.Sc degrees from the University of Adelaide. Peter has many years experience in a wide variety of electric power projects, power systems analysis and design including substations and high power electronics



Dr David Sweeting

Visiting Professorial Fellow
School of Electrical, Computer and Telecommunications Engineering
Director
Sweeting Consulting Services

David holds Ph.D, B.Sc and B.E. (Hons) degrees from Sydney University. David has many years industry experience and is internationally recognised for his work on electric arc burn hazards.

David is principal of Sweeting Consulting Services specialising in HV electrical distribution and power quality reviews for distributors and customers



Emeritus Professor Vic Gosbell

Emeritus Professor Gosbell was a cadet engineer with Sydney County Council while an undergraduate student. He obtained his Ph.D. in 1971 from the University of Sydney with work on the asynchronous operation of turbogenerators.

In 1972 he commenced lecturing at the University of Sydney where his research interests included model power systems, power system stability, HVDC transmission, power

electronics and variable speed motor drives. In 1990 he moved to the University of Wollongong where he became foundation Professor of Power Engineering. His current research interest is power quality with an emphasis on harmonics, PQ survey measurements, and standards.

He is a member of the Standards Australia "Power Quality" Committee, a Fellow of the Institution of Engineers, Australia and past Chairperson of the Australasian Committee for Power Engineering. He was the recipient of the M.A. Sargent Medal in 2008.



Professor Chris Cook, Dean of Engineering and Information Sciences

Chris Cook is an Electrical Engineer who graduated from The University of Adelaide with a BSc in 1971 and a BE in 1972. After working on the modelling and control of electrical machines he received his PhD from The University of New South Wales in 1976.

He then went to the U.K. to work for Marconi Avionics on the design of computers for various aerospace applications. After three years he returned to Australia to work for GEC as Technical Manager of their automation and control division in the area of industrial automation.

In 1983 he joined The University of Wollongong and established and became Managing Director of a University non-profit company called The Automation Centre with the assistance of \$750,000 funding from Commonwealth and State Governments. This Company has since installed several million dollars worth of robotic and other automation systems in Industry.

In 1989 he became Professor of Electrical Engineering at Wollongong University with research interests in industrial automation and power engineering. The University of Wollongong's School of Electrical and Computer Engineering has now built up one of the strongest power research groups in New South Wales. In 1990 he was involved in establishing, with Pacific Power, the Energy Efficient Research Centre Ltd., a non-profit company which designs and installs variable speed drive and other power engineering systems in Industry. In 1996 he continued to develop joint Industry-University initiatives by assisting with the setting up and running of the 'Power Quality Centre' at the University of Wollongong with Endeavour Energy. In 2002 he was appointed Dean of Engineering (now Engineering and Information Sciences).



Professor Sarath Perera

Sarath Perera graduated from the University of Moratuwa, Sri Lanka with a BSc (Eng) specialising in Power. He obtained his MEngSc from the University of New South Wales and PhD from the University of Wollongong.

He has been on the academic staff at the University of Wollongong since 1988. He has been active in electromagnetic modelling, machine design and analysis, in particular permanent magnet machines.

His current research interests are in the general area of power quality and in particular voltage fluctuations and flicker. He also has strong interests in modelling and simulation. He is a member of the Standards Australia Committee on Power Electronics. He is currently the Technical Director of the Australian Power Quality and Reliability Centre.



Professor Danny Sutanto

Danny Sutanto received his B.Eng. and Ph.D. from the University of Western Australia in 1978 and 1981 respectively. Following his graduation he joined GEC Projects, Australia as a Power System Analyst. In 1982 he joined the School of Electrical Engineering at the University of New South Wales.

In 1996 he joined the Hong Kong Polytechnic University as a Professor in Electrical Engineering. In 2006, he joined the School of Electrical, Computer and Telecommunications Engineering at the University of Wollongong as the Professor of Power Engineering.

His main areas of research are power system analysis, power system economics, voltage stability, harmonics, power electronics and computer aided education. He has published numerous papers in the areas of electromagnetic transient analysis, power system analysis, voltage instability, design of harmonic filters, FACTS, Battery Energy Storage Systems, computer aided teaching systems, power system expansion planning, electrical machines and power electronics, in total over 170 papers.

He was awarded the N. Svennson's Award for Teaching Excellence in the Faculty of Engineering in 1994. In 2000, he was awarded the HK Polytechnic University President's Award for Outstanding Performance in Teaching. He has extensive consultancy experience both in Australia and Hong Kong covering areas such as power system planning, fault analysis and harmonic filter design. While at the Hong Kong Polytechnic University, he received grants from the RGC, Learning and Teaching Development Committee (LTDC), British Council, various research studentship and grants from the Hong Kong Polytechnic University totalling more than HK\$15 million.

He was appointed as the Regional Representative of the Power Engineering Society of the Institute of Electrical and Electronics Engineers (IEEE) for Region 10, Asia-Pacific from 2001-2004. He has been invited to be the members of International Advisory Board for several international conferences. He is also a member of the International Editorial Advisory panel of the International Journal "Electric Power Systems Research"



Associate Professor Kashem Muttaqi

Dr. Kashem Muttaqi received his Bachelor of Science in Electrical and Electronic Engineering degree from Bangladesh University of Engineering and Technology, Bangladesh in 1993. He then received Masters of Engineering in Science degree from the University of Malaya, Malaysia in 1997, and received his Doctor of Philosophy degree from Multimedia University, Malaysia in 2001.

Currently, he is an Associate Professor and Postgraduate Coursework Degrees Coordinator at the School of Electrical, Computer and Telecommunications Engineering and member of Endeavour Energy Power Quality and Reliability Centre (EEPQRC) at the University of Wollongong. He was associated with the University of Tasmania, Australia as a Research Fellow/Lecturer/Senior Lecturer from 2002 to 2007, and with the Queensland University of Technology, Australia as a Research Fellow from 2000 to 2002. Previously, he worked for Multimedia University, Malaysia as a Lecturer from 1997 to 2000. He also worked as an Electrical Executive for KTA Tenaga (Consulting Engineers) in Malaysia from 1996 to 1997.

Dr. Muttaqi worked as the Deputy-Director of the Centre for Renewable Energy and Power systems (CREPS) at the University of Tasmania before he joined the University of Wollongong. In recognition of his skills in the sphere of teaching and learning, he was awarded a 'Teaching Merit Certificate' in 2004 from the University of Tasmania. He is a Senior Member of IEEE and Member of the IEEE/PES. His special fields of interests include distributed generation, renewable energy, power system planning, intelligent grid, and power system reliability.



Dr Phil Ciufu

Philip Ciufu graduated from the University of Wollongong with a B.E. (Hons) in Electrical Engineering in 1990 whilst also completing an Industry Cadetship. In 1991 he joined the University as Research Associate where he worked on several research projects and provided engineering support to many of the research programs within the School of Electrical Computer and Telecommunications Engineering. He obtained an M.E. (Hons) in Electrical Engineering in 1993. He joined the academic staff of the University after

completing his Ph.D. in 2002. The title of his thesis was "Magnetic Modelling and Sensorless Control of the Synchronous Reluctance Machine". Dr Ciufu has had various stints in industry as an Electrical Engineer and returned to academia in 2007.



Dr David Stirling

Dr Stirling obtained his BEng degree from the Tasmanian College of Advanced Education (1976). He further obtained his MSc degree (Digital Techniques) in Digital Techniques from Heriot-Watt University, Scotland UK (1980), and his PhD from the University of Sydney (1995).

He has worked for over 20 years in wide range of industries, including as a Principal Research Scientist with BHP Steel. David is as Senior Lecturer at the University of Wollongong.

David has developed considerable expertise in data analysis and knowledge management with skills in problem solving, statistical methods, visualization, pattern recognition, data fusion and reduction, and programming and is widely experienced in applying these to organizations requiring solutions to complex problems. He has applied machine learning and data mining techniques in specialized classifier designs for noisy multivariate data to medical research, exploration geo-science, and financial markets, as well as to industrial primary operations.



Dr Duane Robinson

Duane Robinson graduated from the University of Wollongong with a B.E. (Hons I) in Electrical Engineering in 1998 after completing a seven year cadetship with the BHP Port Kembla Steelworks. In the same year he joined the (then) Integral Energy Power Quality Centre as a research student under scholarship to complete his PhD degree. His PhD research project was concerned with the study of harmonic distortion within distribution systems and related mitigation techniques.

In 2002 Duane took up a position as research fellow with the Centre working on power quality related research projects for Integral Energy and other consulting activities. Later that year he joined the University's academic staff as a Lecturer and then Senior Lecturer, his position fully funded by the Centre to increase undergraduate student exposure to the power engineering discipline.

Duane temporarily departed the university to pursue more industrial experience, working for a multidisciplinary consulting firm primarily on LV and MV electrical distribution design, control, and protection projects for heavy industry clients. In 2011 he returned to the University to take up a new research interest in the area of energy efficiency and demand side management

with the Sustainable Buildings Research Centre, and to rejoin his colleagues at the Australian Power Quality and Reliability Centre.



Dr Ashish Agalgaonkar

Ashish P. Agalgaonkar graduated from Walchand College of Engineering, Sangli, Maharashtra, India with a B. E. (First Class with Distinction) in Electrical Engineering in 1997. He worked as a Maintenance Engineer in KSB Pumps Limited, Pune, India for around 2 years (1997 to 1999) after his graduation.

In 1999, he joined the Maharashtra State Electricity Board (MSEB) (State owned power utility) as a Junior Engineer (Testing). He completed his M.E. (First Class with Distinction) in Electrical Power Systems from Walchand College of Engineering in year 2001 while working with MSEB.

He commenced his Ph.D. at Indian Institute of Technology - Bombay, Mumbai, India in 2002 with 3 years study leave from MSEB. After the completion of his Ph.D. pre-synopsis in 2005, he resigned from MSEB and joined as a Scientist in Energy Technology Centre, NTPC Ltd (formerly the National Thermal Power Corporation), one of the largest power generating companies in India. Subsequently, he was awarded Doctorate in 2006 for defending his thesis titled "On Viability and Planning Aspects of Distributed Generation".

He worked with NTPC for around 2 years (2005-2007) on condition monitoring of electrical equipments such as Partial Discharge (PD) detection and localization in power transformers, generators, etc. He was also involved in technology identification for establishing a Centre of Excellence in power systems.

He joined the School of Engineering, University of Tasmania, Australia as a Postdoctoral Research Fellow in 2007 to work on an ARC linkage project titled "On-line Monitoring and Modelling of Electrical Loads for Improving Operational Conditions of Power Systems". He worked on the same ARC project as a Postdoctoral Research Fellow at the Endeavour Energy Power Quality and Reliability Centre (EEPQRC), School of Electrical, Computer and Telecommunications Engineering (SECTE), University of Wollongong, Australia from February 2008 to November 2010. He was also involved in the ARC discovery project titled "Optimising Control of Hydroelectric Turbines Subject to Basslink Instability" and URC research partnership project titled "Agent-Based Simulation for Catastrophic Disturbances in a Distributed Power Grid System".

He had been also successful in securing internal research grants (URC Small Grant and URC Near Miss Grant) jointly with other fellow colleagues. He has taken up a Lecturer position in

the SECTE from December 2010. He is also the part of APQRC at the University of Wollongong. He has been involved in the supervision of Higher Degree Research (HDR) students. He is a member of the IEEE.



Dr Jeff Moscrop

Jeff Moscrop received the B.E. (Hons.) and Ph.D. degrees from the University of Wollongong, in 1998 and 2008 respectively. He is currently a Senior Lecturer with the School of Electrical, Computer and Telecommunications Engineering at the University of Wollongong.

Since the year 2000 he has been involved in the design and development of complex experimental test-beds for research purposes, including linear servo-motor test-beds, magnetically impelled arc butt welding test-beds and high temperature superconducting test-beds. In 2008 he set-up a Fault Current Limiter (FCL) research group at the University of Wollongong, along with Australia's first dedicated FCL testing facility (which tests small and medium scale FCL designs, at voltages up to 1 kV). In 2009 he coordinated the first high-power fault tests of a Saturated Core FCL in Australia at Ausgrid's Lane Cove Testing Station. He has also been directly involved in commercial FCL designs and overseas testing of commercial FCLs (in both North America and Europe).

Throughout his academic career, Dr Moscrop has been actively involved in working closely with industry. In the area of saturated core FCLs he has directly generated in excess of \$3 million cash income for the University of Wollongong, through both industry contracts and competitive government grants. In 2014 his FCL research group became a part of the Australian Power Quality and Reliability Centre.



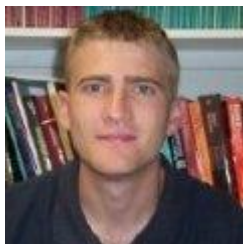
Dr Vic Smith

Dr Smith commenced his career in 1973 as an engineering cadet with the Sydney County Council electricity distribution utility and concurrently studied for his undergraduate degree at the NSW Institute of Technology, Sydney. Upon graduation, he was employed as an electrical engineer with the Sydney County Council and worked in a

variety of areas including zone substation construction, design and maintenance of protection systems for substations and distribution networks, design of distribution networks, estimating for distribution network alterations and additions, routine and type testing of high voltage switchgear, cables and transformers, dielectric evaluation testing, impulse and interference testing of electronic equipment, cable fault location, electromagnetic interference complaint investigations and dissolved gas analysis of transformer oils.

In 1981, Dr Smith studied for his MSc degree at the University of Manchester Institute of Science and Technology (UMIST), Manchester, UK, while on leave-of-absent from the Sydney County Council. In 1985, Dr Smith took a research position with the High Power Testing and Arc Studies Laboratory of Sydney University Electrical Engineering and concurrently studied for his PhD degree. He worked on a range of projects including the investigation and modelling of arc-gas flow interactions and energy exchange processes in the high-power arcs of circuit interruption devices during circuit interruption, examination of electrical hazards that are of concern to Australian utilities particularly vegetation contact with high-voltage, overhead lines and high resistance contacts in low-voltage reticulation systems, and the development of a current-limiting medium voltage expulsion fuse.

In 1997, Dr Smith joined the (then) Integral Energy Power Quality Centre at the University of Wollongong as a research engineer and is responsible for the day-to-day running of the Centre which includes administration and budgetary control, research, organisation of courses and seminars, consultancy and publicity.



Mr Sean Elphick

Mr. Sean Elphick (Research Associate) graduated from the University of Wollongong with a BE(elec) (hons) degree in 2002 after completing thesis projects in the area of power quality. In 2003 he joined the Endeavour Energy Power Quality Centre to work on the Strategic Partnerships with Industry - Research and Training Scheme (SPIRT) project. The aim of the SPIRT project was to develop cost-effective methods for monitoring large power systems, including a specification for monitoring instruments, their number and location, methods of data compression, automatic recognition of the types of disturbances and characterisation by useful power quality indices.

He is currently employed by the Australian Power Quality and Reliability Centre to provide support to for the projects that the centre is engaged on. This work often involves undertaking power quality surveys and preparing reports. He is heavily involved in the production of the Power Quality Compliance Audit, a power quality survey involving most electricity distributors in the eastern states. His interests lie in power quality monitoring methodology, instrumentation and power quality standards.



Mr Gerrard Drury

Mr Gerrard Drury graduated from the University of Wollongong with a BMath (Comp Sci) in 1991 while completing a computing science cadetship with BHP. While at BHP he worked on a variety of systems from manufacturing systems on mid-range computers through to corporate systems on mainframe computers.

At end of 1991 he joined Wollongong based software company Process Software Solutions Pty Ltd where he worked on the DIMPLE image processing software which was used in industry and education. While at Process Software Mr Drury also worked on a variety of projects as a contractor including low-level serial communications, graphical user interface based multimedia applications, and complex distributed telecommunications systems.

In 2002 Mr Drury joined the Telecommunications and Information Technology Research Institute at the University of Wollongong to work on the smart multimedia delivery project. As part of this project Mr Drury was involved with the development of ISO/IEC 21000 (MPEG-21 multimedia framework) and was co-editor of a number of parts of this standard. The work from this project led to formation of a startup company enikos pty ltd, to which Mr Drury was seconded for a time, and from end of 2007 to mid 2009 Mr Drury contracted directly to enikos. Mr Drury joined the Endeavour Energy Power Quality and Reliability Centre in 2009 as a programmer/analyst focusing on the ongoing database and software development for the Power Quality Compliance Audit.

Mrs Raina Lewis

Mrs Lewis is the Project Administration Officer with the Centre providing administrative support for the daily activities of the Centre.

Appendix 3 – Centre Plant and Equipment

The Centre operates a number of laboratories for teaching and research purposes. Teaching laboratories contain modern specialised equipment for teaching subjects such as power systems, electrical drives and renewable energy systems.

The Power Quality and Renewable Energy Research Laboratory have a range of equipment useful for a broad range of research. This includes power quality immunity testing of equipment and evaluation of equipment performance characteristics. Hardware is complemented by advanced software packages allowing simulation and analysis. Key equipment for the laboratory includes:

- California Instruments 5 kVA and 30 kVA programmable arbitrary waveform generators plus an OMNI AC source line impedance network
- 100 kW, 3000rpm, 1000Nm 4-quadrant dynamic dynamometer
- Tektronix PA4000 dc to 1 MHz 3-phase harmonic analyser
- Fluke 41 dc to 2.5kHz single-phase portable harmonic analyser
- Conducted EMI measuring equipment up to 64A, 3-phase, and near-field E-H field probes
- Low frequency magnetic field measuring equipment
- 100 pF, 100 kV standard capacitor and 1000:1 voltage divider
- 5 PM30, 1 PM40, 3 PM45 and 4 PolyloggerQ Power Quality Monitoring Instruments
- 2 Hioki 3196 and 1 Hioki 3198 Power Quality Analysers
- 1 Dranetz PowerXplorer PX5 Power Quality Monitoring Instrument
- 1 ELSPEC G4500 Portable Power Quality Analyser
- 1 Agilent Technologies InfiniiVision DSO7034A 350 MHz digital storage oscilloscope
- 1 Fluke 192 60 MHz Scopemeter
- 3 x 10 kW solar array simulators
- 3 x 4.5 kW electronic loads
- Various software packages such as PSCAD/EMTDC™, PSS/E™ and DlgSILENT PowerFactory™
- Energy storage systems for distributed generation

Appendix 4 – List of Key Publications

The Centre has published several Technical Notes which look at specific aspects of power quality and examines them in detail:

Technical Note No.1 - Understanding Power Quality - Describes the range of power quality problems, what causes them, what they affect and what can be done to manage them.

Technical Note No.2 - Power Factor Correction and its Pitfalls - Considers power factor correction as applied by large customers and the possible consequences when power factor correction capacitors are incorrectly applied where there are major harmonic producing loads such as adjustable speed drives. Also examines detuning methods.

Technical Note No.3 - Harmonic Distortion in the Electric Supply System - Discusses harmonic distortion, its causes and adverse effects, what levels are unacceptable and how to reduce it.

Technical Note No.4 - Voltage Sag Measurement and Characterisation - Discusses voltage sags, their causes and effects, and how they are measured and reported.

Technical Note No.5 - Power Quality Monitoring - Plant Investigations - Discusses Power Quality Monitoring, what features are required in a power quality monitor and how it can be used to identify specific problems in an installation

Technical Note No.6 - Voltage Unbalance - Discusses Voltage Unbalance, its causes and effects, and what can be done to reduce it.

Technical Note No.7 - Voltage Fluctuations in the Electric Supply System - Discusses voltage fluctuations, their causes and adverse effects, what levels are acceptable and how to reduce their consequences

Technical Note No.8 - Transient Overvoltages on the Electricity Supply Network - Classification, Causes and Propagation - Discusses transient overvoltages, how they are classified, their causes and how they propagate through the electricity network

Technical Note No.9 - Transient Overvoltages on the Electricity Supply Network - Effects on Connected Equipment and their Mitigation - Presents an overview of the adverse effects on connected equipment of transient overvoltages that can occur on the electricity distribution network, and how to provide protection against them.

Technical Note No.10 - Small Scale Domestic Rooftop Solar Photovoltaic Systems - Examines small scale domestic rooftop solar PV systems and more specifically, the subset known as grid connect systems. A description of the components, including construction and operating characteristics, which constitute a solar PV generating source, namely solar panels and the grid connect inverter, is given. The level of solar resources in Australia and the pros and cons of solar PV systems are discussed. A review of the Australian standards concerning connection of PV generation is presented. Finally, the Technical Note examines some of the potential engineering difficulties associated with the connection of large numbers of solar PV sources. These potential difficulties include deterioration of network power quality levels, interference with protection schemes and stability problems.

Technical Note No.11 - Voltage Sag Mitigation - Discusses voltage sags including characterisation, causes, measurement and financial impact. Techniques which may be utilised to mitigate voltage sags are described and the advantages and disadvantages of each technology are discussed. It should be noted that the voltage sag mitigation techniques examined are limited to solutions involving the use of equipment designed for this task at the plant/equipment level. Other mitigation strategies such as network improvement along with improving equipment immunity have not been considered. Finally a comparison of the costs of each voltage sag mitigation technology is given.

Technical Note No.12 - Power Quality in Future Low Voltage Electricity Networks -

Forecasts how power quality (PQ) issues in low voltage (LV) networks may develop over the next decade or so. It has four sections to cover PQ concepts, PQ disturbances, possible developments of the network and the future of PQ.

Technical Note No.13 - Domestic Energy Saving Devices – Examines the operation and efficacy of purported energy saving devices which are marketed for domestic applications.

Technical Note No. 14 – Ripple Injection Load Control Systems – These systems provide communications methods for use by electricity distributors to turn on and off loads such as off-peak hot water systems. At times these communications signals, which are superimposed on the mains voltage, can be too high or too low, affecting customers' equipment. This technical note describes the origins of these problems and what mitigation methods are available.

Furthermore the Centre has contributed over 200 research papers and publications as listed below:

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- connected to islanded mode," *IEEE Transactions on Sustainable Energy*, vol. 5, (4) pp. 1337-1347, 2014.
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Key to Acronyms

⁽¹⁾AUPEC - Australasian Universities Power Engineering Conference

⁽²⁾ICHQP - International Conference on Harmonics and Quality of Power