Power Devices and Systems Group
Department of Electrical and Computer Engineering
University of Toronto

Wind Power Generation Symposium

Friday Feb. 20, 1 – 5:30 pm
Sandford Fleming Building (SF 1105)

Organization Committee

- **Prof. M.R. Iravani**, Full professor, IEEE Fellow, Power devices and systems group, Department of Electrical and Computer Eng. , University of Toronto.

- **Farid Katiraei**, Senior Ph.D. Candidate, IEEE student member, Power devices and systems group, Department of Electrical and Computer Eng. , University of Toronto.

- **Barry Rawn**, MASc student, IEEE student member, Power devices and systems group, Department of Electrical and Computer Eng. , University of Toronto.

- **Amir Parayandeh**, BASc student, Chair of IEEE student branch at University of Toronto.

Related Websites:

Power Devices and Systems:
http://www.ele.utoronto.ca

Power Group Graduate Student Union:
http://joule.ele.utoronto.ca/gradunion

IEEE University of Toronto Student Branch:
http://ieee.eecg.toronto.edu

Energy Sustainability Community (ESC) at University of Toronto:
http://esc.ele.utoronto.ca

Speakers

Jim Prall was Born in Philadelphia, PA in 1958. Jim attended Case Western Reserve University in Cleveland, OH where he majored in Political Science and Philosophy. However all of his roommates were E.E. or Comp.E. majors, one of whom later completed a Ph.D. in parallel processing.

In 1981 Jim came to Toronto to pursue graduate studies in philosophy, then realized there was no money in this. Since then he has worked in computer support and system administration, including 10 years at a graphics and printing company. In 2001 Jim joined the U of T ECE department as a system administrator, and has enjoyed taking further courses at U of T including Genetics, Global Warming, Climatology, and a semester undergrad research project on "A Wind Resource Assessment for Canada" completed last spring.

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Subtitle*:* Canada's Energy Future: What Place for Wind Power?

Murray Paterson holds a MSc. in geography from the University of Toronto and has over 25 years of experience in the environmental planning and assessment field with the former Ontario Hydro. He used to be the Vice President of Huron Wind Inc and is currently the manager of Green Power in OPG's Business Development Group.

Murray has received two awards; the Ontario Hydro's President's Sustainable Energy Development Champions Award (1999) and OPG's Power Within – Environmental Leadership Award (2002) for his involvement in facilitating the installation of the Pickering Wind Turbine project.

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Subtitle: Tales from Down on the (Wind) Farm

This presentation will discuss OPG's wind development program, in the context of its overall Green Power Program. Specific wind projects undertaken by OPG will reviewed with a discussion of issues encountered and lessons learned. OPG's future wind development plans will also be briefly outlined.

Stewart C. Russell holds BEng (Hons.) MSc CEng MBCS. He is a long-term advocate of renewable energy. While in UK, he worked as an engineer for Renewable Energy Systems Ltd, one of Europe's largest wind energy consultancies. He is currently a director of WindShare at CNE, the Toronto wind energy co-op.

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Subtitle: Building Canada's First Urban Wind Turbine: WindShare's Experience at the CNE

In late 2002, WindShare built Canada's first urban wind turbine at Exhibition Place, Toronto. The turbine, a joint venture with Toronto Hydro, is now a landmark and a tourist attraction, as well as being a source of power for the equivalent of 250 homes. The history of the project will be described, from initial planning to final approvals. Considerable obstacles had to be overcome, and some surprising benefits were discovered.

David Cooke is an ex-military pilot and a graduate of the Royal Military College in Kingston holding a BSc in Computer Science. He is the president and CEO of Cooke & Associates Inc., and TRUE-NORTH Power Systems. He also operates the FREE Wind Test Centre near his home in Lion's Head, Ontario. He is an entrepreneur and an enterprise architect with the history of successes.

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Subtitle: Current advances in small wind systems blade, controller and inverter technology

This presentation will outline the operations of the FREE Wind Test Centre located at Ferndale ON and describe the testing conducted there over the past year. Advances in blade, inverter and controller technology offer several new options to employing small wind turbines more cost effectively. Mr. Cooke will discuss and illustrate how these advances will lead to greater focus on small wind turbines in Canada. He will also dispel some of the many of the "Cheap and Dirty " solutions being offered that just don't measure up to the laws of physics.

Ahmadreza Tabesh holds a B.Sc. in electronics and M.Sc. in control systems from Isfahan University of Technology (IUT), Iran. He had started his career as a faculty member of IUT in the Submarine R&D Center from 1998 to 2001. He is currently a PhD candidate in power systems at the Electrical Engineering department, University of Toronto. His research interests include applications of control theory to power systems, power electronics, and mechanical systems.

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Subtitle: Frequency Response Modelling and Analysis of Wind Energy Conversion Systems

This talk addresses modeling and analysis of a grid connected wind energy conversion system based on frequency response data. The model includes both mechanical and electrical components of a wind energy conversion system. The model and analysis consider the small-signal behaviour of a wind energy conversion system within the frequency range of 1 to 120 Hz. Thus, the linearized equations of the system about an operating point are considered. The approach basically models the system in frequency domain as a classical feedback control loop. Then, electrical and mechanical perturbations (e.g. load variations and wind gust) are defined as disturbances applied to the system. Transfer functions, which associate rotor angle deviation or electromechanical torque to the disturbances are defined as sensitivity transfer functions. Frequency response of sensitivity transfer function evaluates performance of system and shows how a system can reject or mitigate electrical and mechanical disturbances. The method is applicable to both fixed speed and variable speed multi-units wind energy conversion system. Since the sensitivity analysis is preformed merely based on frequency data, this method is a suitable approach for large size systems considering required computational efforts.

Barry Rawn holds a degree in Engineering Science Program from University of Toronto and is Currently a MASc candidate in the Edward S Rogers Department of Electrical and Computer Engineering. He conducts research into the modelling and control of wind energy conversion systems. He has worked in the hydrogen fuel cell industry is one of the directors of the Energy Sustainability Community at U of T.

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Subtitle: Power Management for Wind Turbines: Modelling and Control Issues

Having matured to the point where they can be rapidly developed and commercialized, wind turbines are likely to provide a larger share of electrical power in the future. This increased penetration of wind power into the electrical grid raises questions as what kind of power quality and generator characteristics might be achievable, particularly for systems that incorporate a power electronic converter. In this talk, a control methodology for a variable-speed, back-to-back converter system is discussed. After visiting a number of modelling issues, the potential of extracting a smooth, slowly varying power and maintaining stored energy in the turbine hub is explored.

Farid Katiraei holds a B.Sc. and M.Sc. in electrical engineering from Isfahan University of Technology (IUT), Iran. He is currently a Ph.D. candidate at the University of Toronto. His special interest is on Application of power electronics in power systems, Integration of Distributed Energy Resources (DR) in electric utility systems, System behavior analysis and design of Micro-Grid**.**

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Subtitle: Grid Interconnection and Power Quality Assessment of Distributed Resources

In the future power grid, distributed energy resources (DR's) will play an important role as a result of decentralization in the electricity generation and deregulation. Presently several economical and environmental factors accelerate integration of DR's in the utility grid. Although a DR unit can present economical merits and power quality advantages, its interconnection to the utility systems and the increase in the level of penetration of the DR units can provoke several technical concerns in the operation of the system. Control and protection, stability issues and safety is some of concerns. Recently several interconnection standards and electrical safety codes have been issued to identify technical requirements and uniform connection process.
This presentation tries to overview DR connection process with special focus on power quality impact assessment of an integrated system. A hybrid study system is used to demonstrate power quality issues may rise through interconnection of the DRs with the utility grid. The study system includes a constant speed wind turbine, an electronically-interfaced DR and a gas-fired diesel generator with aggregated loads. Power quality analysis of the system is conducted for two cases of wind turbine startup and fault occurrence. The studies are performed based on digital computer simulation approach using PSCAD/EMTDC software package.

Ivor da Cunha holds a B.Eng., a MBA, and a P.Eng. He has developed expertise in energy management field providing through progressive experience in the electrical, natural gas, nuclear and process industry sectors. He is currently the Director of Business Development for Emerging Energy Technologies at Kinectrics Inc. in Toronto.

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Subtitle: Challenges and Opportunities with Renewable Distributed Energy Resources.

This presentation will cover some of the practical (political, red tape) issues with connecting to the grid based on experiences with other Distributed Energy projects. He will also address some of the business related issues with Distributed Energy. In addition, he will revise some material that he previously developed to put the emphasis on Wind power.

Miriam Katz is a second year student at U of T, studying political science and environmental studies. In her first year, she joined the Blue Sky Solar Racing team and aided the team by doing fundraising and public relations. This included answering questions at events such as the Canadian International Auto Show and at the Ontario Science Centre during Renewable Energy week. At the beginning of her second year, Miriam co-founded the Energy Sustainability Community with Richard Lam, another member of Blue Sky. The Energy Sustainability Community is now a fully functioning organization with a mandate of bringing sustainable energy use to U of T and to promote renewable technologies.

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Amir Yazdani, Received the B. Dc. Degree (with honors) from Sharif University of Technology, Tehran, Iran, in 1995, and the M. Sc. from the University of Tehran, Iran, in 2001, both in electrical engineering. From 1995 to 2002, he was a deign engineer at Maharan Engineering Corp., Tehran Iran, where he worked on the design and control of switching power supplies, UPS systems, and railway signaling systems. In September 2002, he joined the Power Devices and Systems Group of the University of Toronto, ON, Canada, where he is currently a research assistant, working towards his Ph. D degree. His research interests include design, dynamic modeling and control of switching power converters, electric drives and custom power devices.

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Subtitle: The application of three-level NPC converters in variable-speed wind energy systems

Every variable-speed wind energy system needs a Back-To-Back AC-DC-AC converter to decouple the constant frequency utility grid/load from the variable frequency/voltage generator. Using Voltage-Sourced Converters (VSC) to implement the AC-DC-AC converter offers many technical advantages such as fast response, low harmonic pollution, and voltage/reactive power support to the utility grid. The demand for a better dynamic response during transients and a higher efficiency in the steady state for the wind energy system, require larger DC-link voltages in the AC-DC-AC system of the variable-speed wind energy system. A three-level converter as opposed to the two-level conventional VSCs offers a neat way of wiring the power switches in series, to attain higher DC-link voltage levels. Furthermore, the waveforms generated by a three-level VSC contain lower unwanted harmonics than those of its two-level counterpart.
This presentation is to explain important attributes of three-level converters, their operation and control in the context of wind energy systems.

	Time	Program	Speaker	Title
	12:30	Registration		
	1.00	**Promotional Video**		**The answer is Blowing in the wind**
Opening	1.10	Opening Talk		
Introductory Section 1.15 – 2.30	1.15	Presentation 1	Jim Prall U of T	Canada's Energy Future: What Place for Wind Power?
	1.35	Guest speaker 1	Murray Paterson OPG	Tales from Down on the (Wind) Farm
	1.55	Guest speaker 2	Stewart C. Russell Windshare	Building Canada's First Urban Wind Turbine: WindShare's Experience at the CNE
	2.15	Talk	Miriam Katz U of T	Wind Turbine Installation Project; U of T Campus
	2.25	Discussion 1		Question/Answer 1
Break	2.30	**Movie**		**Out of the Blue**
Technical section 1 3.00 – 4.10	3.00	Guest speaker 3	David Cooke TRUE-NORTH Power Systems	Current Advances in Small Wind Systems; Blade, Controller and Inverter Technology
	3.20	Presentation 2	Amir Yazdani U of T	The Application of Three-Level NPC Converters to Variable-Speed Wind Energy Systems
	3.40	Presentation 3	Barry Rawn U of T	Power Management for Wind Turbines: Modelling and Control Issues
	4.00	Discussion 2		Question/Answer 2
Break	4.10	**Movie**		**Harvesting the Wind**
Technical section 2 4.20 – 5.30	4.20	Guest speaker 4	Ivor da Cunha Kinectrics Inc.	Challenges and Opportunities with Renewable Distributed Energy Resources
	4.40	Presentation 4	Ahmad Reza Tabesh U of T	Frequency Response Modelling and Analysis of Wind Energy Conversion Systems
	5.0	Presentation 5	Farid Katiraei U of T	Grid Interconnection and Power Quality Assessment of Distributed Resources
	5.20	Discussion 3		Question/Answer 3
Closing	5:30	**Supper**		