NSERC CRSNG
Strategic Networks

NSERC SMART MICROGRID NETWORK
nsmg-net

Canada's Smart Microgrid Research Network

Annual Report 2011 | 2012

Vision

Smart Microgrids are the building blocks of a new electrical grid that, by 2020, will: provide **reliable, low cost and clean power**; **defer investments** in transmission and distribution systems; **improve power quality** and reduce system losses; **improve energy efficiency** and enable conservation; and help **reduce the carbon footprint** of the energy system.

Objectives

Capacity Building

Train personnel with the skills to transform the Canadian electricity industry, as it embraces new business models, renewable sources of energy and new electrical and communication technologies.

Research

Support and conduct multidisciplinary research in electrical engineering, planning and regulatory issues and communication technologies.

Knowledge Transfer

Adapt research activities into constructive forms of information for consumers, manufacturers and policy makers.

Business Development

Translate research into practical products and services for technology companies and electricity utilities.

NSMG-Net logo

Our logo communicates three autonomous but interconnected microgrid nodes, or the three Theme Groups of our collaborative national research network, in a form that connotes the Canadian maple leaf, the 2010 Olympic flame (held in our founding year and host province) and a figure with arms raised in success.

Support

NSMG-Net is made possible by the NSERC Strategic Network Grants program, with its goal of increasing research and training in targeted areas that could strongly enhance Canada's economy, society and/or environment within the next 10 years.

NSMG-Net host institution is the British Columbia Institute of Technology, whose innovative campus Microgrid provides a near-real test environment for Microgrid technologies.

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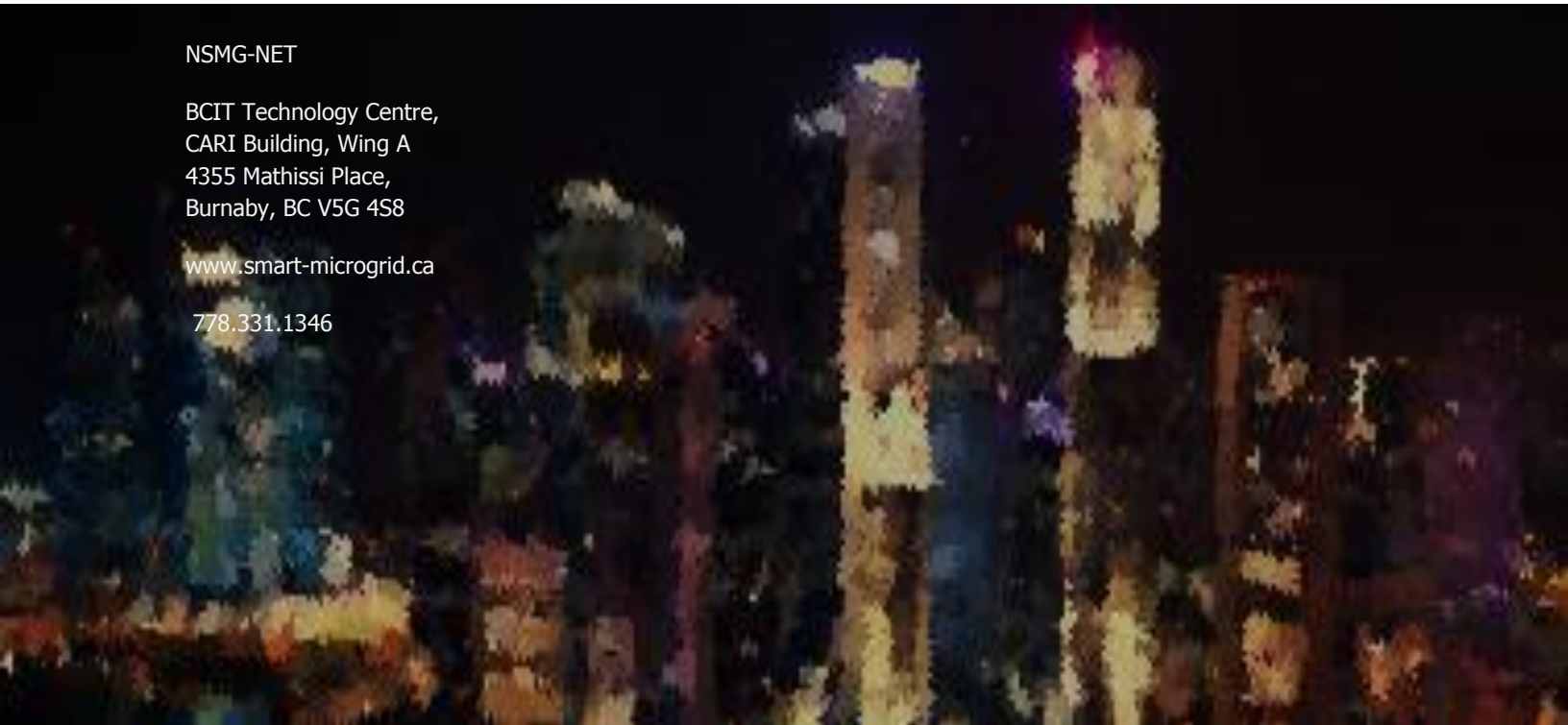

NSMG-NET

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Message from the Network Leader

On behalf of the Scientific Committee

In this second year, our Network has made great strides. We now have 58 students working on Smart Grid related projects ranging from cost-benefit frameworks, to communication technologies to protection and control strategies. The results of our research were captured and presented in 41 conference and journal papers across the globe. Numerous talks, lectures and posters were presented by our researchers in major Smart Grid conferences across the world.

What exemplified our research was its interdisciplinary and industry-focussed nature. The specific areas which our researchers tackled were all selected in close coordination and collaboration with the Canadian utility industry and smart grid technology companies in Canada and beyond. The key to our success was support, active participation and involvement by the industry leaders of Smart Grid sector in Canada.

I would also like to report that NSMG-Net's proposed topic on the linkages between Smart Grid and Energy Independence was selected by the prestigious AAAS 2012 Annual Meeting as a Symposium Topic. The Chair of our Network- Dr. John MacDonald, BC Hydro's CTO- Mr Kip Morison, myself and the three theme leaders – Dr Iravani, Dr Joos and Dr Michelson - were invited to speak at the AAAS meeting, which was held in our host city of Vancouver. This is only the second time the meeting has been held in Canada.

I also had the pleasure of representing the network in various national and international meetings and conferences organized by professional associations across the globe, advocating our research capabilities and Canada's work in Smart Grid.

The campus microgrid at our host institution, BCIT, continues to present network researchers a unique validation and development platform, enabling integration and confirmation of our research results. BCIT's Microgrid has also attracted international attention, with frequent tours and visits from Latin American delegations, and from partners from across Canada.

And finally, we are most grateful to our industry partners for their support of the network, both financial and in kind. This year, for example, 7 projects were able to make use of software licenses from CYME which enabled our researchers model sophisticated power distribution networks. Without their support, our work would literally not be possible.

Hassan Farhangi

Network Leader, NSMG-Net

Year in Review

> *"We have had important discussions with Hydro-Quebec IREQ technical staff regarding the possibility of impulsive noise in the transmission environment."*
>
> Tho Le-Ngoc, Lead Researcher of Project 3.2 at McGill University

During this second year of the network, our researchers have continued to make strong progress along the milestones set out in our Network Research Program.

In **Theme One** students are working on controls for off-grid islanded small hydro-electric systems, as well as algorithms to control microgrids in real-time and to optimize over longer periods. In project 1.3, researchers successfully developed a field discharging scheme to restrict fault currents from asynchronous distributed generation, a technique that will result in two journal papers.

Research Highlights

58 students funded
41 papers

In **Theme Two**, students are participating in the activities of CIGRE Working Group C22, Microgrid Evolution Roadmap, 2011. Project 2.2 is working in collaboration with NREL to quantify the impact of microgrid protection on the choice of control strategies. As part of microgrid use case development, project 2.3 has developed microgrid models for mulit-unit residential units and ice rinks.

Finally **Theme Three**, with a focus on communications, researchers have evaluated IEC 61850 and Power Line Communications for applicability to Advanced Distribution Automation. Additionally, researchers in Project 3.3 have been collaborating with Utility partners and with researchers in Theme 1 regarding robust sensors for fault detection within substations. Project 3.4 has deployed software from NSMG-Net partner CYME to perform distribution network analysis.

Year in Review

Training Highly Qualified People

> *"We received valuable feedback and hints from industrial experts, which will enable our research studies to have maximum practical application."*
>
> Moein Manbachi, PhD candidate at Simon Fraser University, researcher with Project 3.4

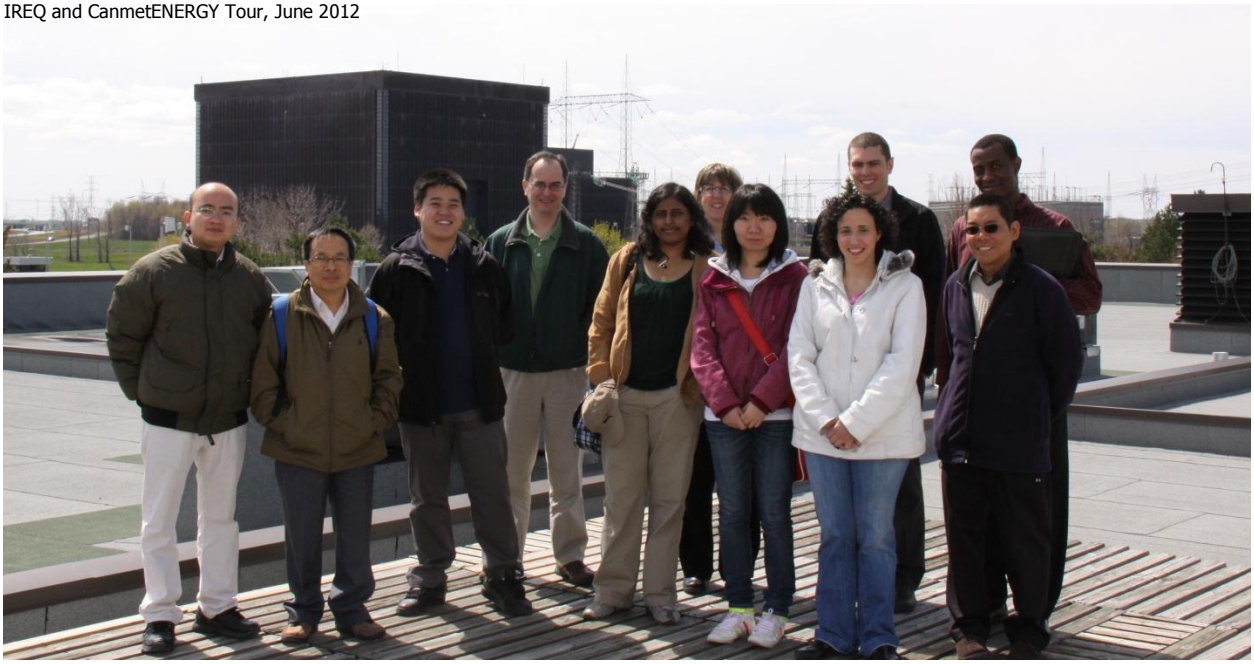
This year, NSMG-Net project leaders mentored a record number of students: 58 in total, at undergraduate, masters and PhD level. Over the course of the network life, 120 students will receive funding through the network, preparing them with the skills needed by Canadian electricity and technology companies.

Students have prepared papers and posters for presentation at events such as Utilities Telecommunications Canada, the Smart Grid Technologies Conference in Washington DC, the Alberta Power & Energy Innovation Forum and IEEE San Diego.

In June, several NSMG-Net students attended the CYMDIST-CYMTCC Users Group 2012 Conference in Montreal, and in April students from Project 3.2 (Intelligent Microgrid Communication and Information Technologies) attended tours of IREQ's and CanmetENERGY's research facilities in Varennes, Quebec (photograph below).

Students have been involved in partnerships and collaborations with industry and government partners such as NRCan, BC Hydro, Hydro Quebec, CYME, Schneider Electric, Hydro One and New Brunswick Power.

IREQ and CanmetENERGY Tour, June 2012



Year in Review

Management and Governance

We had two retirements from the Board of Directors this year. Ralph Zucker retired from Smart Grid Canada and was succeeded as Chairman by Chuck Filewych, who has now been invited to join the Board of NSMG-Net. And Lt. Col. Peter Kouri was posted to the UK: we are working with Lt. Col. Kouri to seek a replacement within the Forces.

Also, at the suggestion of our sponsor NSERC, we have aimed to balance the board through the recruitment of a new member from academia. Prof. Andreas K. Athienitis is the Scientific Director of our sister strategic network, the NSERC Solar Buildings Research Network, and is senior research fellow at Concordia University. He will join the board in 2013.

Once complete the board will have 4 members from government, 4 from academia and 4 from industry.

Outreach

The focus of our outreach activity continues to be online, with students and researchers sharing news through our own website, our LinkedIn group (now with 22 members) and following microgrid events through our Twitter feed (@smartmicrogrid).

Offline, the work of the network has been presented to the public at the American Association for the Advancement of Science annual conference, which was held outside of the US – in Vancouver – for only the second time ever. Theme Leaders Reza Iravani, Géza Joós and Dave Michelson joined Network Leader Hassan Farhangi, Board Chairman John MacDonald and Kip Morrison from Network partner BC Hydro, in a panel chaired by Chris Marney of the Lawrence Berkeley National Laboratory. The event was attended by over fifty participants.

NSMG-Net members at the 2011 AGM

Research

The next generation Smart Grid is the convergence of Information and Communication Technology with Power System Engineering.

The three research themes of NSGM-Net reflect this interdisciplinary nature.

Theme 1 is led by Dr. Reza Iravani at University of Toronto. The four projects in this theme are focused on the electrical engineering issues involved in Canadian urban, rural and remote microgrids.

Theme 2 is led by Dr Geza Joós at McGill University. The four projects in this theme are focused on the overall technical and economic justification of microgrids, and their interactions with the main grid.

Theme 3 is led by Dr David Michelson at University of British Columbia. The four projects in this theme are focus on innovative network architectures to support seamless exchange of data and commands between participants in the smart grid network.

Research

Theme One: Operation, Control and Protection of Smart Microgrids

Theme 1 projects are focused on identifying and addressing technical challenges associated with control, protection, management, operation of and integration of new technologies in microgrids, including pervasive use of information and communication technologies. Theme 1 considers all types of microgrids, i.e., urban, rural and remote (islanded) microgrids. In addition to the project leaders, currently 18 graduate students and research associates are involved in the Theme 1 R&D activities.

Project 1.1, lead by Dr. A. Yazdani, mainly deals with control and operation of autonomous remote microgrids. in this context, Dr. Yazdani has established close collaboration with McGill and University of Toronto, through joint supervision of two doctorate students. As of now, the results from Project 1.1 has resulted in one conference and one journal (under preparation) paper.

Project 1.2, lead by Dr. R. Iravani, deals with protection, control and Energy Management of microgrids under grid-connected, islanded and transition modes. Another major focus in this project is development of an infrastructure for hardware realization and performance verification of developed algorithms in a hardware-in-the-loop environment. The research work of Project 1.2 , as of now, have been published in several journal papers.

Project 1.3, lead by Dr. Xu, focuses on status monitoring and disturbance detection for microgrids. The results from Project 1.3 are complementary to those of Projects 1.1. and 1.2, and necessary to develop a comprehensive operational strategy for the microgrid. Based on Project 1.3 a "decoupled" approach to manage the microgrid protection issues has been developed and evaluated. The results of Project 1.3, as of now, has been reported in two journal and one conference papers.

Theme Leader

Reza Iravani, University of Toronto

Project 1.4 is to identify barriers for high depth of penetration of DG units in the microgrid and address such barriers based on novel operational strategies and/or emerging technologies, e.g., energy storage systems. We anticipate that results of Project 1.4, in conjunction with those of Projects 1 to 3, can provide solutions for large scale integration of Electric Vehicles (EV) in the utility power distribution system.

We look forward to Year Three with great anticipation!

Project Leaders

Amir Yazdani, Ryerson University
Reza Iravani, University of Toronto
Wilsun Xu, University of Alberta
Geza Joos, McGill University

Research

Theme Two: Planning, Optimization and Regulatory Issues

The four projects in the theme are focused on the overall economic justification of microgrids, general technical issues related to energy security, and the potential of load management. Modeling issues and the development of a use case approach are also addressed in support of the various studies of the interactions within the microgrid and with the main grid. The direct contribution of this theme is in helping to demonstrate and quantify the benefits of implementing microgrids in Canada taking into account regulatory issues.

There are 25 students working within the theme. They have published a total of 15 papers.

The first project deals with establishing a cost-benefit framework for microgrids and their feasibility as a new component of distribution system technology. In this last year, work has been done on defining the framework for a cost-benefit analysis, establishing the various stakeholders involved in the operation of microgrids, and a list of benefits, independently of the beneficiary. An approach to monetizing the benefits and costs, and allocating benefits, was proposed.

The methodology was applied to representative microgrids. Key benefits include: reliability improvement, ancillary service provision, investment deferral resulting from peak load reduction and ancillary service provision, and emissions reduction.

The second project focuses on energy and supply security considerations. Among other achievements, researchers identified, classified, and established comparative criteria for various modes of operation of a single microgrid in relation to the host grid. They have developed time-domain and frequency-domain models of the two benchmark systems for eigen-analysis, electromagnetic transient and power quality analysis, and low-frequency time-domain models for transient stability for microgrids in relation to the host main grid.

Theme Leader

Geza Joos, McGill University

The third project deals with demand response technologies and strategies for energy management and the related metering requirements within microgrids. One of the main thrusts has been the development of models of price-responsive loads from the system perspective. The purpose is to study the effect of price signals on load response as well as the effect of price-responsive loads on nodal prices and energy dispatch.

The final project deals with the design guidelines and performance metrics, and proposes study cases to help implement microgrids. Models have been developed that allow studying problems such as power flow, transients and stability issues in microgrids, taking into account, in the same simulation framework, power, control and communications components.

Project Leaders

Geza Joos, McGill University
Reza Iravani, U. Toronto
Kankar Bhattacharaya, U. Waterloo
Ani Gole, U. Manitoba

Research

Theme Three: Communications and Control in Smart Microgrids

Theme 3 supports the establishment of cost effective and efficient communication infrastructure for Canada's intelligent microgrid future.

This year we have had 16 students working on our research projects, and have produced 5 conference papers and 5 journal articles.

Project 3.1 deals with physical impairments that degrade the performance of the heterogeneous networks or HetNets that will form the basis for the Smart Grid's unified communications infrastructure. This year, we have completed studies of impairments such as shadow fading and mutual interference that degrade the performance of the pole-top relay nodes that are commonly used in smart meter and distribution automation systems. We also began preparations for major studies involving wireless noise in electrical substations and both in-building and wide area power line communications.

In Project 3.2 the focus is on grid integration requirements, standards, codes and regulatory considerations in intelligent microgrids. This year researchers have completed studies various potential communications technologies that could be used for HAN/BAN/IAN, NAN/EAN/FAN, and WAN that form the communications infrastructure to effectively support the integration of intelligent microgrids. Furthermore, they have addressed the inter-operability issues in microgrids, surveying existing protocols to identify those that that could be relevant for NAN.

The focus of project 3.3 is the development of smart, remotely re-configurable wireless sensors that can operate in harsh RF environments such as electrical sub-stations.

Theme Leader

David Michaelson,
University of British Columbia

ZigBee-based wireless sensors have been chosen as the main development platform. The architecture of a smart and reconfigurable wireless module (using the ZigBee physical and network layer) has been completed.

Project 3.4 has been broken down into three sub-projects, focusing on i) real-time adaptive data portals for use by VVO/CVR engines; ii) multi-agent systems to allow end-to-end connectivity between nodes; and iii) tunneling for peer-to-peer GOOSE messaging over the PLC network. CYME software has been employed for distribution network analysis, and an experimental test is in progress for characterizing Narrow-Band Power Line Communication.

Project Leaders

Dave Michelson, University of BC
Tho Le-Ngoc, McGill University
Julian Meng, University of New Brunswick
Hassan Farhangi, BC Institute of Technology

Financial Statements

NSMG-Net is a Strategic Network generously funded by the Natural Sciences and Engineering Research Council of Canada, and by our industry, government and academic partners.

Over 80% of our funding goes directly to training the Highly Qualified People required by Canadian electrical utilities and technology companies. The remainder funds equipment, travel, networking events, outreach and management.

NSERC
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Financials

Statement of Operations and Fund Balances

		Year ended September 30, 2012 $	Year ended September 30, 2011 $
Revenue			
Grant from NSERC		739,500	739,500
Universities' Contributions (Note 2)		13,000	13,000
Partner Contributions (Note 3)		165,134	71,944
			824,444
Partner Contributions received after year end (Note 4)			36,410
	A	917,634	860,854
Transfers to Universities			
Universities' Contributions		13,000	13,000
Transfer from Host to Universities (Note 5)		702,800	734,900
Funds withheld at Host in current year		61,800	24,700
Funds withheld at Host from prior year		19,700	-
	B	797,300	772,600
Management Expenses			
Network Manager		83,134	34,944
AGM		6,491	5,987
Board travel		3,142	5,189
Theme travel		9,478	
Outreach and hosting		6,933	9,547
	C	109,178	55,667
Funds carried over (= A – B – C)		11,156	32,587
Funds carried over from prior year		32,587	
		43,743	32,587

Notes

To the Financial Statements, September 30, 2012

1. Project Budgets and Net Transfers

NSMG-Net projects have an annual budget of $64 800, designated as shown.

Students	$54,200
Materials & supplies	$4,600
Conferences & travel	$5,000
Publication costs	$1,000
Total	$64,800

In most cases, projects receive $32 400 per half-year, subject to satisfactory reporting. The $32,400 per half year is $30,812.50 from NSERC and $1587.50 from Partner contributions.

	$30,812.50
Half-years per year	x 2
Number of projects	x 12
Annual NSERC contribution	$739,500

Where partner universities have committed funding, this is netted from the transfer.

2. University Contributions

Several partner universities make annual cash contributions to the network. These are netted from the semi-annual payments to partner universities, made by the host institution.

	Budget $	Actual $
University of New Brunswick	5,000	-
University of Toronto	4,000	4,000
McGill University	3,000	3,000
Ryerson University	3,000	3,000
University of Manitoba	3,000	3,000
	18,000	13,000

According to the agreed budget and Network proposal, University of New Brunswick would contribute $5 000 cash per year to the network. University of New Brunswick has reported that this is in error, and that they will be unable to make this contribution.

Notes

To the Financial Statements, September 30, 2012

3. Partner Contributions – Industry and Government

Several industry and government research partners also contribute to the budget of NSMG-Net. These funds are used to supplement NSERC funds in the training of highly qualified personnel, as well as cover the management and governance expenses of the network. BC Hydro makes the largest single contribution, in supporting the Network Manager.

Industry	Budget $	Actual $
BC Hydro - Manager	80,000	83,134
BC Hydro – Cash Contribution	20,000	20,000
Hydro One	30,000	30,000
Schneider Electric	5,000	5,000
Eion	5,000	-
Endurance	1,000	1,000
Nebula	1,000	1,000
Government		
NRCan	25,000	25,000
	167,000	165,134

At the time of the AGM, this year's contribution from Eion had yet to be received. The Network Management has been assured in writing of Eion's continued commitment to the network, and the issue is merely internal procedure. This is not expected to impact the operation of the network.

4. Partner Contributions received after year end

Two partners made their Year One contributions after the end of Year One. They are included here for ease of comparison between years.

BC Hydro	$20,000
NRCan	$16,410
Total	$36,410

Note that NRCan, despite having a commitment of $25 000, is only able to reimburse for expenses incurred. Due to lower expenses in the relevant period last year, the contribution was reduced. We do not anticipate this reoccurring.

Notes

To the Financial Statements, September 30, 2012

5. Transfers to Universities

The following transfers were made in March 2012 following satisfactory Year Two First Half reporting by all but two projects. Note that the transfer to University of New Brunswick is $5000 more than budgeted due to the removal of university funding (note 2). This difference is made up with prior year holdback funds from other projects.

At the University of Toronto and at McGill a single researcher leads two projects, and so receives double funding.

	Budget $	Actual $
University of Toronto	62,800	62,800
Simon Fraser University	32,400	32,400
McGill University – Joos	63,300	63,300
McGill University – Le Ngoc	32,400	32,400
University of Alberta	32,400	32,400
University of British Columbia	32,400	32,400
University of Waterloo	32,400	32,400
University of New Brunswick	29,900	32,400
		320,500
Ryerson University holdback	30,900	30,900
University of Manitoba holdback	30,900	30,900
		382,300

The following transfers are made in September 2012 following satisfactory Year Two Second Half reporting by all projects.

	Budget $	Actual $
University of Toronto	62,800	62,800
Simon Fraser University	32,400	32,400
McGill University	63,300	63,300
McGill University	32,400	32,400
University of Alberta	32,400	32,400
University of British Columbia	32,400	32,400
University of Waterloo	32,400	32,400
University of New Brunswick	29,900	32,400
Ryerson University holdback	30,900	30,900
University of Manitoba holdback	30,900	30,900
		382,300

Total Transfer	702,800
Total Holdback	61,800
Total Allocation to Universities	764,600

Partners

Our partnerships between industry, government and academia help us translate research into practical real-world applications.

University Partners

British Columbia Institute of Technology
Simon Fraser University
University of British Columbia
University of Alberta
University of Manitoba
University of Toronto
Ryerson University
McGill University
University of New Brunswick

Industry and Government Partners

BC Hydro
Hydro One
NRCan
Schneider Elecctric
Endurance Wind Power
Nebula Communications
Eion Wireless
Cyme
Ballard
Tantalus
Hydro Quebec,
Ontario Power Authority
IESO
New Brunswick Power
Manitoba HVDC
Ontario Centres of Excellence

Researchers

Project Leaders

Amir Yazdani
Reza Iravani
Wilsun Xu
Geza Joos
Kankar Bhattacharaya
Ani Gole
David Michelson
Tho Le-Ngoc
Julian Meng
Hassan Farhangi

Project Collaborators

Ali Palizban
Claudio Canizares

PhD students

Firuz Badrkhani
Ayman Elkasrawy
Pengfei Gao
Aboutaleb Haddadi
Sanjeewa Herath
Jia Jia
Fahimeh Kazempour
Christopher Leung
Sina Mashayekhi
Moein Manbachi
Ali Mehrizi-Sani
Maryam Nasri
Yandy Perez
Mehrdad Pirnia
Andy Polzl
Mike Quashie
Mohamd. Ramadan
Michael Ross
Diogo Salles
Hesam Yazdanpanahi

Masters students

Juan Clavier
Mohammed El-Tayb
Felipe Ramos Gaete
Yue Gao
Soham Ghosh
Bruce Haines
Rupali Jain
Cheng Jiang
Abishek Kar
Keyhan Kobravi
Rajib Kundu
Brian Le
Tristan Losier
Adarsh Madhavan
Andrew Mei
Greg Morris
Dominic Paradis
Gowdemy Rajalingham
Omar Saadeh
Babak Shahabi
Vanessa Shen
Qingxi Shi
Yu Tian
John Wang
Mengwei Wang
Shang Wang
Robert White

Undergraduate students

Chon-Wang Chao
Rita Chen
Peter Chen
Cary Huang
Prajeet GC
J. Lu
Ryan MacDonald
Donald MacNearney
Dmitry Rifkin
Juilan Santorelli

Publications

Refereed Journal Publications

J. Bloemink, R. Iravani, "Control of multiple source microgrid with built-in islanding detection and current limiting", accepted for publication in the IEEE transactions on Power Delivery.

A. Etemadi, E. davison, R. Iravani, "A Decentralized Control Strategy for Multi-DER Microgrids - Part 1 - fundamental concepts", accepted for publications in the IEEE Transactions on Power Delivery.

A. Etemadi, E. Davison, R. Iravani, "A decentralized Robust Control Strategy for a Multi-DG Microgrids - Part II - Performance Evaluation", accepted for publication in the IEEE Transactions on Power Delivery.

A. Etemadi, R. Iravani, "Overcurrent and Overload protection of the voltage-sourced distributed resources in a microgrid", accepted for publication in the IEEE Transactions on Industrial Electronics.

Quang-Dung Ho and Tho Le-Ngoc, "Smart Grid Communications Networks: Wireless Technologies, Protocols, Issues and Standards", Chapter 5 in Handbook on Green Information and Communication Systems (Editors: Mohammad S. Obaidat, Alagan Anpalagan, Isaac Woungang), Elsevier, Summer 2012

K. Kobravi, R. Iravani, H. Kojori, "3-leg/4-leg matrix converters generalized modulation strategy – Part I – A new formulation", accepted for publication in the IEEE Transactions on Industry Applications. (Industry-NSERC)

K. Kobravi, R. Iravani, H. Kojori, "3-leg/4-leg matrix converters generalized modulation strategy – Part II – Implementation and verification", accepted for publication in the IEEE Transactions on Industry Applications. (Industry-NSERC)

S. Lin, D. Salles, W. Freitas, and W. Xu, "An Intelligent Control Strategy for Power Factor Compensation on Distorted Low Voltage Power Systems," IEEE Transactions on Smart Grid, Accepted in May 2012

S. Mashayekhi and D. G. Michelson, "Effect of Terminal or Relay Height on Shadow Fading of Fixed Wireless Channels in Suburban Macrocell Environments," to be submitted to IEEE Transactions on Antennas and Propagation.

S. Mashayekhi, E. Crozier and D. G. Michelson, "Impact of Antenna Directivity on the Performance of Fixed Wireless Networks Deployed in Suburban Environments," to be submitted to IEEE Transactions on Antennas and Propagation.

S. Mashayekhi, E. Crozier and D. G. Michelson, "Assessing Wireless Coexistence in a Wireless Grid Router," to be submitted to IEEE Transactions on Electromagnetic Compatibility.

A. Mehrizi-Sani, R. Iravani, "constrained potential function-based control of microgrids for improved dynamic performance", accepted for publication in the special issue of Trans. on Smart Grid on Microgrids, paper TSG-00282-2011.

A. Mehrizi-Sani, R. Iravani, "On-line set-point adjustment for trajectory shaping in microgrid applications" IEEE Trans. on PWRD, Vol. 27, no.1, pp. 216-223, February 2012.

M. Matar, H. Karimi, E. Etemadi, R. Iravani, "A high performance real-time simulator for controllers hardware-in-the-loop testing", Special Issue of Energies, Vol. 5, no. 6, pp. 1713-1733, June 2012.

A. Tabesh, A. Saadatpoor, R. Iravani, "Space vector slope-based method for fast locating of switched capacitor in power systems", accepted for publication in the IET Gen. Trans. and distribution, paper GTD-2011-0763.R1.

H. Yazdanpanahi, Y. Li, W. Xu, "A New Control Strategy to Mitigate the Impact of Inverter-based DGs on Protection System", IEEE Transaction on Smart Grid, accepted in January 2012.

Publications

R. White, S. Lancashire, and D. G. Michelson, "Measurement-based Estimation of Spectrum Occupancy in ISM Bands in Suburban Neighborhoods," to be submitted to IEEE Transactions on Antennas and Propagation.

R. White, S. Lancashire, and D. G. Michelson, "Spatial Modeling of Spectrum Occupancy in ISM Bands in Suburban Neighborhoods," to be submitted to IEEE Transactions on Antennas and Propagation.

Non-Refereed Journal Publications

M. Kamh, R. Iravani, T. El-Fouly, "Realization of a smart microgrid - Pioneer Candian Experience", IEEE PES GM2002, July 2012, San Diego.

G Morris, C Abbey, S Wong, and G Joos, "Evaluation of the Costs and Benefits of Microgrids with Consideration of Services beyond Energy Supply", IEEE PES GM, San Diego, July 2012

A. Mehrizi-Sani, R.Iravani, "Online set point adjustment for trajectory shaping in microgrid applications", IEEE PES GM2012, July 2012, San Diego

M Ross, C Abbey, Y Brissette, and G Joos, "Photovoltaic Inverter Characterization Testing on a Physical Distribution System", IEEE PES GM, San Diego, July 2012

Refereed Conference Publications

K. Kobravi, R. Iravani, H. Kjori, "A high switching frequency Current-sourced converter with bidirectional power flow", Accepted for APEC 2012

K. Kobravi, r. Iravani, H. Kojori, "A review of Implementation of the Matrix Converter", accepted for ECCE 2012.

K. Kobravi, R. Iravani, "A high-switching frequency and high-efficiency three-level Voltage source converter", to be submitted for APEC 2013.

Invited Conference Presentations

Soham Ghosh, Thanh-Ngon Tran, Tho Le-Ngoc, "Miniaturized MIMO-PIFA with Pattern and Polarization Diversity", IEEE VTC2012-Spring, Yokohama, Japan, May 6-8, 2012

S. P. Herath, Nghi H. Tran, and Tho Le-Ngoc, "On Optimal Input Distribution and Capacity Limit of Bernoulli-Gaussian Impulsive Noise Channels", IEEE ICC 2012, Ottawa, June 10-15, 2012

R. Iravani, G. Hernandez, "an active islanding detection method or multi-DER microgrids", Smart Grid Technologies Conference, January 2012, Washington DC.

R. Iravani, "Smart Microgrids for Industrial remote Loads", Renewables Energy Conference 2012, Santiago, Chile, May 10, 2012

R. Iravani, "Microgrid as a building block for smart grid", Distinguished Lecturer Series, Iowa State University, Aims, Iowa, November, 2011.

R. Iravani, Managing demand through a smart distribution grid", AAAS Conference, Vancouver February 2012

D.G. Michelson, "Advanced Communications Technologies for Smart Microgrids," to be presented as a keynote address at the Annual Research Colloquium of the State University of New York (Albany), 7 May 2012 (Albany, NY). Declined due to a prior commitment at IEEE VTC 2012 Spring in Yokohama, Japan.

D. G. Michelson, "Telecom Challenges for Grid Modernization," presented at 2012 UTC Canada Conf., 10-12 Sep. 2012, Vancouver, BC.

W. Xu, "Information Extraction from PQ Disturbances – An Emerging Direction of Power Quality Research". IEEE PES General Meeting, July 2012.

Publications

Technical Reports, Licenses and Other Intellectual Property

Chon-Wang Chao, Quang-Dung Ho, Tho Le-Ngoc, "Power Line Communications for Advanced Distribution Automation in Smart Grid: Opportunities and Challenges", Technical Report, McGill University, August 2012

M. Kamh, R. Iravani, "Advanced Feeder Automation and Fault Detection Techniques for the BCIT Microgrid", Phase -I Report

M. Kamh, R. Iravani, "Advanced Feeder Automation and Fault Detection Techniques for the BCIT Microgrid", Phase -II r\Report

A. Nabavi-Niaki and R. Iravani, "A Unified Matrix Converter for EV and PHEV Applications in Active distribution systems and Microgrids", University of Toronto IP Disclosure RIS-10001964, patent application in progress.

A. Nabavi-Niaki, H. Kojori, R. Iravani, "Multi-Level Universal Converter Capable of Bidirectional DC-DC, DC-AC, AC-DC, and AC-AC Conversion", Invention disclosure to Honeywell Canada H0026411, patent application in progress.

Gowdemy Rajalingham, Quang-Dung Ho, Tho Le-Ngoc, "Geographic Routing for Smart Grid Bi-Directional Neighbourhood Area Network Communications", Technical Report, McGill University, August 2012

P. Sobotka, D. Shereck and D. G. Michelson, Power Line Communications for Smart Grid Applications, Wiley, IEEE Press, in progress.

Projects

Theme One: Operation, control and protection

Project 1.1 Remote Smart Microgrids
Led by Dr Amirnaser Yazdani at Ryerson University

Project 1.2 Distributed and Hybrid Control
Led by Dr Reza Iravani at University of Toronto

Project 1.3 Disturbance Detection, Diagnosis and Protection
Led by Dr Wilsun Xu at University of Alberta

Project 1.4 Operational Strategies to Address High Penetration of DG Units in Microgrids
Led by Dr Geza Joós at McGill University

Theme Two: Planning, optimization and regulatory issues

Project 2.1 Cost-Benefit Framework: Secondary Benefits and Ancillary Services
Led by Dr Geza Joós at McGill University

Project 2.2 Energy and Supply Security Considerations
Led by Dr Reza Iravani at University of Toronto

Project 2.3 Demand Response Technologies and Strategies
Led by Dr Kankar Bhattacharya at University

Project 2.4 Integration Design Guidelines and Performance Metrics
Led by Dr Ani Gole at University of Manitoba

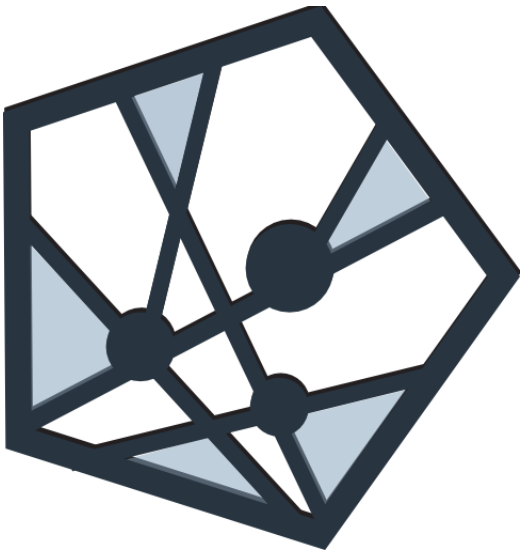
Theme Three: Communication and Information Technologies

Project 3.1 Universal Communication Infrastructure
Led by Dr Dave Michelson at University of British Columbia

Project 3.2 Grid Integration Requirements, Standards, Codes and Regulations
Led by Dr Tho Le-Ngoc at McGill University

Project 3.3 Distribution Automation Communications
Led by Dr Julian Meng at University of New Brunswick

Project 3.4 Integrated Data Management and Portals
Led by Dr Hassan Farhangi at British Columbia Institute of Technology



http://www.smart-microgrid.ca/