



Progress Report - Year One

Submitted to the Board of Directors by
Dr Hassan Farhangi
BCIT
Scientific Leader, NSMG-Net

October, 2011

Network Manager
Neil Salmond
neilsalmond@smart-microgrid.ca

Table of Contents

Section 1: Overview

1. Proposed Agenda
2. Minutes of Scientific Committee Meeting
3. Executive Summary
4. Network Researchers and Projects
5. Training of Highly Qualified Personnel (HQP) in the Network
6. List of publications

Section 2: Project Leaders Reports

1. Comments by Theme Leaders
2. Theme 1
3. Theme 2
4. Theme 3

Section 3: Management Report

1. Budget (Year 1 report; Year 2 proposal)
2. Networking
3. Technology Transfer

Agenda of Board of Directors Meeting

Date: Monday, November 14th 2011
Time: 10h00-10h30 EST
Place: By conference call.
Meeting called by: John MacDonald, Chairman.
Invitees: Theme Leaders: Reza Iravani, Geza Joos, Dave Michelson.

Agenda

1. Approval of Agenda
2. Approval of Minutes of previous meeting.
3. Progress Report for Year 1
4. Budget Proposal for Year 2
5. Other business
6. Date and venue of next meeting
7. Adjournment

Minutes of Scientific Committee Meeting

Date: Monday, November 7th 2011
Time: 10h00-11h00 EST
Place: By conference call.
Meeting called by: Hassan Farhangi, Principal Investigator.

Attendees: Reza Iravani, Dave Michelson, Hassan Farhangi, Neil Salmond
Absentee: Geza Joos

1. Progress Report for Year 1
 - Meeting attendees agreed that the consolidated Project Reports reflected the progress of the network in year one.
 - PI reminded the Theme Leaders of key metrics, namely the achievement of proposed milestones, extent of industry engagement, teaching of HQPs and publications.
2. Progress in Theme 1: (Reza Iravani)
 - Dr Iravani reported varied but overall satisfactory year one progress from Theme 1. The obvious exception is Dr Yazdani who moved university, but he has circulated plans to meet all year one and year two milestones by the end of year two.
3. Progress in Theme 2: (Geza Joos)
 - Awaiting.
4. Progress in Theme 3: (Dave Michelson)
 - Dr Michelson reported a good start from Theme 3, with all project leaders making progress towards planned milestones. The AGM had revealed the need for greater coordination among project leaders, which will be a focus in Year Two.
5. Knowledge & Technology Transfer
 - a. Theme Leaders pointed to the various industry partnerships reported in the Project Reports and at the AGM. PI emphasized the importance of industry engagement, and work with HQPs.
6. Brief Reports (PI and/or Network Manager)
 - a. Student involvement, Project Publications
 - i. Covered in Theme and Project Leader reports.
 - b. Budget
 - i. Network manager reported that the second Year One transfer had just been transferred from BCIT, following receipt of NSERC and partner funds.
7. Problems encountered and suggestions for improvement (PI and/or Network Manager)
 - a. PI noted that Theme Leaders should ensure, in the course of the year, that their theme's projects were proceeding according to the agreed research plan.
 - b. Dr Michelson (Theme 3) reported he had established mailing lists for his Theme, and planned for monthly conference calls to ensure knowledge-sharing across between projects in the theme.
8. Year 2 Budget
 - a. Network Manager presented planned Year 2 expenditures, and transfers to Universities (see page 89 of this document).

- b. Only deviation from original five-year plan is reduced transfer to Project 1.1 due to Dr Yazdani's move.
- c. The Year 2 budget was recommended to the board.

9. Other business

- a. There was some discussion about the procedure for amending the research plan.
 - i. Dr Michelson reported that some industry partners now disagreed with milestones established for Theme 3.
 - ii. PI reminded participants that the Research Plan is an interconnected whole, built on the basis of input from all partners.
 - iii. It was agreed that changes to the Research Plan should be proposed in writing and *in advance* of the year of research and funding, for recommendation by the Scientific Committee and approval by the Board.
Therefore:
 - 1. Researchers would be expected to complete planned milestones for Year Two
 - 2. Researchers should submit proposals for changes to Year Three onwards by July 31, 2012 for approval by the Scientific Committee and the Board.
- b. There was also discussion about the potential, procedure and benefits of adding new industry partners.
 - i. Network Manager noted that Founding Partners (i.e. original signatories to the Network Agreement) hold a privileged position against additional later partners, namely:
 - 1. Founding Partners have shown longer commitment to the Network.
 - 2. Founding Partners have helped to shape the Research Plan
 - 3. Founding Partners will be asked by NSERC to explain the value of the Network at the half-way report.
 - ii. Network Manager reported that NSERC had clarified the procedure for adding partners to the Network Agreement, which is simply
 - 1. All existing signatories have the power of veto, with any objections simply collected by email (i.e. approval is assumed unless Network Manager is notified otherwise: no signed positive approval by existing members is required).
 - 2. New partner appends signature to Network Agreement.
 - iii. However, Dr Irvani also noted that bilateral partnerships may be established between Researchers and Industry, including funding contributions for students or particular research projects, that overlap with the work but remain outside the network.
 - 1. In this case industry partners would not have a claim on arising IP, and may or may not contribute IP or in-kind to the network.
 - 2. For example, IBM currently fall under this category, offering their software free to Researchers, but not participating in arising IP.

10. Date and venue of next meeting

- a. Network Manager to circulate exact date, but likely early in the new year by conference call.

11. Adjournment

- a. The meeting was adjourned at 11am.

Section One

Executive Summary

In this first network year most projects have hired a good number of students, begun their research programs and engaged with industrial partners. Some delays at the start of the year meant key hiring dates were missed, but year two begins on much firmer and more prepared footing.

At the administration level, the network has reporting and financial structures established, and a public "face" in its website, logo, flyer and social media presence. The website also includes a password-protected area for real-time research updates, that can develop to a knowledge repository.

List of Projects

Theme 1: Operation and control

1.1 Control Operation and Renewables for Remote Intelligent Microgrids

Dr Amirnaser Yazdani, Ryerson University

1.2 Distributed Control, Hybrid Control and Power Management of Microgrids

Dr Reza Iravani, U. Toronto (Theme Leader)

1.3 Status Monitoring, Disturbance Detection, Diagnostics and Protection

Dr Wilsun Xu, U. Alberta

1.4 Addressing Barriers for Very High Penetration of DG Units

Dr Geza Joos, McGill

Theme 2: Policy and regulation

2.1 Cost-benefits Framework: Secondary Benefits and Ancillary Services

Dr Geza Joos, McGill (Theme Leader)

2.2 Energy and Supply Security Considerations

Dr Reza Iravani, U. Toronto

2.3 Demand Response: Energy Management and Metering

Dr Kankar Bhattacharya, U. Waterloo

2.4 Integration Design Guidelines and Performance Metrics

Dr Ani Gole, U. Manitoba

Theme 3: Communication

3.1 Universal Communication Infrastructure

Dr David Michelson, UBC (Theme Leader)

3.2 Grid Integration Requirements, Standards, Codes and Regulations

Dr Tho Le-Ngoc, McGill

3.3 Distribution Automation: Sensors and Condition Monitoring

Dr Julian Meng, U. New Brunswick

3.4 Integrated Data Management and Portals

Dr Hassan Farhangi, BCIT (Network Scientific Leader)

HQP per Project in Year One

Project	U/G	M	PhD	Other	Total
1.1					0
1.2			2		2
1.3		3	3		6
1.4			2		2
2.1		1			1
2.2			2		2
2.3		3			3
2.4					0
3.1	5.5	3.5	1		10
3.2		2		2	4
3.3	1	2			3
3.4		1	2		3
Total	6.5	15.5	12	2	36

List of HQP Involved Year One

Project	Status (U, M, P)	Name	Email	Start Date	End Date
1.2	P	A.Mehrizi-Sani	Ali.mehrizi.sani@utoronto.ca	Nov 2010	Dec 2012
1.2	P	K. Konravi	Keyhan.Kobravi@utoronto.ca	Nov 2010	Dec 2012
1.3	P	Hesam Yazdanpanahi	yazdanpa@ualberta.ca	Sept 2009	Sept 2013
1.3	P	Ming Dong	mingd@ualberta.ca	Sept 2009	May 2011
1.3	M	Chen Jiang	jiangc08@gmail.com	Sept 2009	Dec. 2011
1.3	P	Andy Polzl	N/A	Sept 2011	
1.3	M	Qingxi Shi	N/A	Sept 2011	
1.3	M	Yu Tian	N/A	Sept 2011	
1.4	P	Ross, Michael	michael.ross2@mail.mcgill.ca	Oct, 2010	Aug, 2013
1.4	P	Haddadi, Aboutaleb	aboutaleb.haddadi@mail.mcgill.ca	April, 2011	Aug, 2012
2.1	M	Morris, Greg	gregory.weyrichmorris@mail.mcgill.ca	Oct, 2010	Aug, 2012
2.2	P	S. Pirooz-Azad	sahar.pirooz-azad@utoronto.ca		
2.2	P	A. Mohammed	ahmed.mohammed@yahoo.com		
2.3	M	Rupali Jain	rupalirjain@gmail.com	Sept 2011	
2.3	M	Rajib Kundu	rkundu@uwaterloo.ca	Sept 2011	
2.3	M	Felipe Ramos Gaete	framosga@uwaterloo.ca	Sept 2011	

3.1	P	Sina Mashayekhi*	sina@ece.ubc.ca	Jan 2011	Dec 2014
3.1	M (p/t)	Boubacar Diallo	Boubacar.Diallo@bchydro.com	Oct 2010	Apr 2011
3.1	M (p/t)	Sol Lancashire	Sol.Lancashire@bchydro.com	Oct 2010	Dec 2014
3.1	M (p/t)	Alex Corbett	alex.corbett@gmail.com	Oct 2010	Apr 2012
3.1	M	Bruce Haines*	bruce.a.haines@gmail.com	Sep 2011	Aug 2014
3.1	M (p/t)	Nina Chen	ninachenchen@gmail.com	Sep 2011	Aug 2014
3.1	U	Andy Tsai*	andytsai2002@gmail.com	Mar 2011	Apr 2011
3.1	U	Ahad Shafiq*	ahad.shafiq@gmail.com	Mar 2011	Apr 2011
3.1	U	Edgar Cave*	edgar.cave@gmail.com	May 2011	Aug 2011
3.1	U	Lawrence Penkar*	lawpenkar@gmail.com	May 2011	Aug 2011
3.1	U	Bruce Haines*	bruce.a.haines@gmail.com	May 2011	Aug 2011
3.1	U (p/t)	Prajeet GC	gcpraj@gmail.com	Sep 2011	Dec 2011
3.2	PhD	Sanjeewa Priyad Herath Mudiyansele	sanjeewa.herath@mail.mcgill.ca	Oct 2010	
3.2	MEng	Ms. Yue Gao	yue.gao2@mail.mcgill.ca	Oct 2010	
3.2	MEng	Mr. Soham Ghosh	soham.ghosh@mail.mcgill.ca	Oct 2010	
3.2	U	Julian Santorelli	julian.santorelli@mail.mcgill.ca	May 2011	Aug 2011
3.2	PDF	Dung Ho (30% time)	quang.ho@mcgill.ca	Oct 2010	
3.2	Research Associate	Thanh-Ngon Tran (15% time)	ngon.tran@mcgill.ca	Oct 2010	
3.3	M	Tristan Losier		May 2011	

3.3	M	Abhishek Kar		Sep 2011	
3.3	U	Tareq Khammmash		May 2011	Aug 2011
3.4	M	Babak Shahabi	bshahabi@sfu.ca	Aug 2011	TBD
3.4	P	Maryam Nasri	maryam_nasri@sfu.ca	Aug 2011	TBD
3.4	P	Moein Manbachi	moeinmanbachi@yahoo.ca	Sept 2011	TBD

Summary of Publications

- 1 refereed Journal Publication
- 4 articles submitted to conferences
- 2 other publications

Summary List of Researchers Publications

Refereed Journal Publications

M. Ross, R. Hidalgo, C. Abbey, **G. Joós**, "Energy storage system scheduling for an isolated microgrid," *Renewable Power Generation, IET* , vol.5, no.2, pp.117-123, March 2011.

Articles submitted to Journals and Conferences

A. Haddadi and **G. Joós**, "Load Sharing of Autonomous Distribution-level Microgrids", in *IEEE Power and Energy Society General Meeting, Detroit, July 2011*.

C. Abbey, C. Marnay, **G. Joos** and **G. Young Morris**, "A Framework for the Evaluation of the Cost and Benefits of Microgrids", in *CIGRE Symposium 'The electric power system of the future - Integrating supergrids and microgrids'*, Bologna, presented in September 2011.

N. Stanchev, A. Corbett, **D. G. Michelson**, "Suppression of Self-Noise in Stepping Correlator Channel Sounders'," presented at *IEEE APS/URSI Symposium, Spokane, WA, 2011*.

Paper presented by **H. Farhangi** at *IEEE Conference in Korea (H. A. Palizban, H. Farhangi, "Low Voltage Distribution Substation Integration in Smart Microgrid", ICPE 2011–ECCE Asia, May 2011*.

Other publications books or patents

Long B. Le, **Tho Le-Ngoc**, "QoS Provisioning for OFDMA-based Wireless Network Infrastructure in Smart Grids", *IEEE Canadian Conference on Electrical and Computer Engineering 2011*, Niagara Falls, Ontario, May 8-11, 2011

Soham Ghosh, Thanh-Ngon Tran, **Tho Le-Ngoc**, "A Dual-layer EBG-based Miniaturized Patch Multi-antenna Structure, *2011 IEEE AP-S International Symposium on Antennas and Propagation*, Spokane, Washington, USA, July 3-8, 2011

Section 2

Progress Reports from Projects

Year 1 (October 1 2010 – September 30, 2011)

Theme Leader Comments

Project 1.1 (Dr. A. Yazdani, Ryerson University) is behind schedule in terms of reaching milestones of Year-1, expenditure, and HQP training. The main reason is that during year -1 of the project Dr. Yazdani moved from the University of western Ontario to Ryerson University and the moved delayed the project progress. Dr. Yazdani has made arrangements to meet the original targets almost by the end of year-2.

Project 1.2 (Dr. R. Iravani, University of Toronto) is progressing well and ahead of scedule in terms of achieving the milestones and HQP training, and the allocated budget has been was fully spent by the end of year-1.

Project 1.3 (Dr. w. Xu, University of Alberta) is progressing according to the schedule in terms reaching the milestones, HQP training, and expenditures.

Project 1.4 (Dr. G. Joos, McGill University) has been on almost on schedule in terms of reaching milestones, HQP training (2 graduate students instead of 3), and expenditures.

2.1

2.2

2.3

2.4

3.1

3.2

3.3

3.4



Annual Progress Report

Project 1.1

Control, Operation and Renewables for Remote Intelligent Microgrids

Project Leader: Amirnaser Yazdani (Ryerson University)

Project Started: Oct 2010

Expected Project Completion Date: Sep 2015

Progress Highlights for October 1st 2010 to September 31st 2011

Please provide a brief high-level summary that outlines the progress, research results or any issues during the reporting period. State the milestones achieved with reference to the research proposal.

In the first year of the project, in September 2010, I admitted an international Ph.D. student for the purpose of engagement in Project 1.1. However, subsequent to his arrival in Canada, the candidate faced some family difficulties and preferred not to commit to be a part of the NSMGNet.

Thereafter, I refrained from hiring another student due to the outlook of my forthcoming move from UWO to Ryerson University; the move took place in August 2010.

At Ryerson University, I am making preparations to hire students for the second year (2011-2012), and propose to complete both the year one and year two milestones by December 31st 2012. My total project budget across years one and two will therefore be half that previously forecast.

Detailed Research Report

Please indicate the status of all milestones as "Not started", "In progress" or "Complete" as appropriate. Milestones and timeframes are based on the research plan: if these have changed please indicate and explain.

- Research and develop control strategies and algorithms (2012)
- Research and develop coordinated control, supervisory and operational strategies (2012)
 - Not started
- Research and Develop protection strategies (2013)
 - Not started
- Develop simulation test cases and benchmark models (2011-2013)
 - Not started
- Perform test cases and evaluation studies and identify the beta site and specify requirements and test cases (2014)
 - Not started
- Perform beta test cases (2015)
 - Not started

Please provide more details for milestones currently in progress. Describe any problems and resolutions.

See progress highlights, page one.

Intellectual Property and Publications

Refereed Journal Publications

--

Non-Refereed Journal Publications

--

Invited conference presentations

Non-Invited conference presentations

Technical reports, patents, licenses and other intellectual property

Research Collaborations and Interactions

Summarize briefly your network-related interactions and activities

Research Partners

Industrial Partners

International Collaborations

Exchanges by Highly Qualified Personnel

Other

Highly Qualified Personnel (HQP)

Please list all HQP since the start of the project. Include forecast End Dates for students currently engaged.

Status (U, M, P)	Name	Email	Start Date	End Date

Discuss any discrepancies between planned HQP and those actually hired

Project Budget

Note and explain any deviations greater than 20% between actual and budgeted project expenses

Describe any cash or in-kind contributions, other than NSMG-Net, in support of this project

	Year 1 Forecast	Year 1 Actual	Year 2 Forecast
Expenditures			
Undergraduate	\$4 300		\$4 300
Masters (2 students)	\$31 000		\$31 000
PhD	\$18 900		\$18 900
Students*	\$54 200	\$ 0	\$54 200
Materials and supplies	\$4 600		\$4 600
Conference travel	\$5 000		\$5 000
Publication costs	\$1 000		\$1 000
Total	\$64 800	\$ 0	\$64 800
Funding			
Own university		\$ 0	\$3 000
Carried over		\$ 0	\$32 100
April transfer		\$32 100	\$29 700
October transfer		\$ 0	\$ 0
Total		\$32 100	\$64 800
		Forecast surplus	\$ 0

Annual Progress Report

Project 1.2

Distributed Control, Hybrid control and Power Management for Intelligent Microgrids

Project Leader: Reza Iravani (University of Toronto)

Project Started: Oct 2010

Expected Project Completion Date: Sep 2015

Progress Highlights for October 1st 2010 to September 31st 2011

Please provide a brief high-level summary that outlines the progress, research results or any issues during the reporting period. State the milestones achieved with reference to the research proposal.

The milestone of project 1.2 for the first year (October 2010-September 2011) of the program is to research, identify and formulate control strategies for urban and rural microgrid systems. In this context:

- We have developed a robust control strategy for a single electronically-interface DER unit for both grid-connected and islanded modes of operation of the urban-type and the rural-type microgrids.
- The overall microgrid and control system models, in the state-space form, were developed, and the corresponding linearized models were deduced to systematically design and optimize the control systems parameters
- All algorithms of the control strategies were developed in s-domain and verified based on time-domain simulation studies, using the PSCAD simulation platform.
- The analog control algorithms were digitized and implemented in an NI-CRIO control platform and their performances, in a hardware-in-the-loop environment based on the RTDS system, were evaluated and verified.
- Currently we are in the process of integrating and evaluating performance of the designed control systems, as the slave controllers, of a centralized microgrid control structure.

Detailed Research Report

Please indicate the status of all milestones as "Not started", "In progress" or "Complete" as appropriate. Milestones and timeframes are based on the research plan: if these have changed please indicate and explain.

- Research, identify and formulate control approaches for urban and rural Microgrids (2011)
 - In progress (90% complete)
- Develop linear dynamic models for the design of centralized and distributed controls for benchmark microgrid systems (2012)
 - In progress (80% complete)
- Research, develop strategies and algorithms for the control of multiple Intelligent Microgrids, and specify the required ICT (2013)
 - In progress (20% complete)
- Evaluate performance of the developed control strategies including ICT using time-domain and hardware in-the-loop simulations of test cases (2014)
 - In progress (25% complete)
- Perform beta site test cases for selected scenarios and validate the R&D results (2015)
 - Not started

Intellectual Property and Publications

Refereed Journal Publications

- K. Kobravi, R. Iravani, "A generalized modulation strategy for 4-Leg MC – Part I: Mathematical Modeling", submitted to the IEEE Trans. on Industrial Electronics
- K. Kobravi, R. Iravani, "A generalized Modulation strategy for 4-Leg MC – Part II: Performance Evaluation", submitted to the IEEE Trans. on Industrial Electronics.
- A. Etemadi, E. Davison, R. Iravani, "A decentralized robust control strategy for multi-DER microgrids", Part I: Fundamental Concepts", submitted to the IEEE Trans. on Power Delivery
- A. Etemadi, E. Davison, R. Iravani, " A decentralized robust control strategy for multi-DER microgrids", Part II: Case studies", submitted to the IEEE Trans. on Power Delivery

Refereed Conference Publications

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

Invited conference presentations

- NA

Non-Invited conference presentations

- NA

Technical reports, patents, licenses and other intellectual property

- NA

Research Collaborations and Interactions

Summarize briefly your network-related interactions and activities

Research Partners

The first year of the project was mostly the R&D of the fundamental concepts which were carried out independently but include consultation with researchers from Projects 1.1, 1.3, 2.3, 2.4, 3.1, 3.2, and 3.3.

From the beginning of the second year, the project will be continued based on close collaboration, contributions, and input from projects 1.1, 1.3, 2.2, 2.3, 2.4, 3.1 and 3.2.

Industrial Partners

The case studies and the system information/data, both the physical layer as well as the cyber layer, were identified and decided upon in close collaboration with engineers from Toronto Hydro and in consultation with engineers from Hydro One and BC Hydro. During the course of the project in the first year, we have managed to establish close collaboration with RTDS Technologies for the development of a real-time simulation environment for microgrids.

International Collaborations

During the first year of the project we have established collaboration with KEPCO and LSIS Industries from South Korea and National Instruments from USA.

Exchanges by Highly Qualified Personnel

NA

Other

We are in the process of establishing a partnership with ABB, Sweden, and GE Digital Energy, Toronto, for the project.

Highly Qualified Personnel (HQP)

Please list all HQP since the start of the project. Include forecast End Dates for students currently engaged.

Status (U, M, P)	Name	Email	Start Date	End Date
P	F. Kazempour	Fahimeh.kazempour@utoronto.ca	May 2011	Dec 2015
M	K.Kobravi	Keyhan.Kobravi@utornto.ca	Nov 2010	May 2012
P	M. Ramadan	m.ramadan2utoronto.ca	May2011	Dec 2015
M	D.Paradis	Dominic.paradis@utoronto.ca	May 2012	Dec 2012
P	E. Etemadi	Amir.etemadi@utoronto.ca	Dec 2010	Aug 2012

Discuss any discrepancies between planned HQP and those actually hired

To avoid any delay in the project progress and in view of (i) the unconventional time of the project start-up date (October 2010), and (ii) the fact that new students mainly start their programs in September of each year, I assigned two Ph.D. students to the project who were already in their Ph.D. programs and hired two more Ph.D. students and one masters student in 2011.

The original program was based on hiring two masters and one Ph.D. for the first year while currently we have 4 Ph.D. students and one masters student in the program.

Project Budget

Note and explain any deviations greater than 20% between actual and budgeted project expenses

We have fully utilized the allocated budget for October 2010 to September 2011.

In view of the fact that we have 5 graduate students in the program rather than 3 and also we are planning to hire two undergraduate students in summer 2012, we would like to request an increase in the budget for year 2, i.e., October 2011 to September 2012 as follows:

Undergraduate (2 students) at \$8600

Masters (1 student) at \$15 500

Ph.D. (3 students) at \$56 700 (the 4th Ph.D. student has funding from other resources)

Material and supplies at \$4 600 (unchanged)

Travel at \$5 000 (unchanged)

Publication at \$1 000 (unchanged)

Total requested budget for year 2 = \$91,400

Describe any cash or in-kind contributions, other than NSMG-Net, in support of this project

The university has provided the contributions to the stipends of 4 Ph.D. students and 1 masters students for the project.

	Year 1 Forecast	Year 1 Actual		Year 2 Forecast
Expenditures				
Undergraduate	\$4 300			\$8 600
Masters (2 students)	\$31 000	\$6 000		\$15 500
PhD	\$18 900	\$28 000		\$56 700
Students*	\$54 200	\$34 000	-37%	\$80 800
Materials and supplies	\$4 600		-100%	\$4 600
Conference travel	\$5 000	\$1 800	-64%	\$5 000
Publication costs	\$1 000	\$ 0	-100%	\$1 000
Total	\$64 800	\$35 800	-45%	\$91 400
Funding				
Own university		\$2 000		\$2 000
Carried over		\$ 0		\$29 000
April transfer		\$32 200		\$31 400
October transfer		\$30 600		\$31 400
Total		\$64 800		\$93 800
			Forecast surplus	\$2 400

Annual Progress Report

Project 1.3

Status Monitoring, Disturbance Detection, Diagnostics and Protection for Intelligent Microgrids

Project Leader: Wilsun Xu (University of Alberta)

Project Started: Oct 2010

Expected Project Completion Date: Sep 2015

Progress Highlights for October 1st 2010 to September 31st 2011

Please provide a brief high-level summary that outlines the progress, research results or any issues during the reporting period. State the milestones achieved with reference to the research proposal.

- Met with the facility management staffs of U of Alberta to understand the needs and problems of commercial electrical systems which are the platform to build MicroGrid (MG). Visited the electric systems of some buildings. This meeting helped to fine-tune research strategies for the project.
- Fine-tuned research strategies for the project. Developed specific ideas on how to address the issues faced by the project. Summarized the ideas in a document. The document has been submitted to the NSMG-Net Scientific Committee
- Moved one existing PhD and one MSc student to work on the tasks of the project. Recruited three new students.

Detailed Research Report

Please indicate the status of all milestones as "Not started", "In progress" or "Complete" as appropriate. Milestones and timeframes are based on the research plan: if these have changed please indicate and explain.

- Identify benchmark system and worst case scenarios, and research and develop protection strategies and algorithms of adaptive protection for rural and urban Microgrids (2011)
 - In progress (50% complete)
- Research and develop strategies, algorithms and identify technologies of the information technology and communications (2012)
 - Not started
- Research and develop strategies and algorithms for detection, discrimination and diagnostic functions (2013)
 - Not started
- Develop islanding detection, synchronization strategies, fault type/location identification (2014)
 - Not started
- Validate the results based on simulation test studies and provide verification based on beta site tests (2015)
 - Not started

Please provide more details for milestones currently in progress. Describe any problems and resolutions.

Fine-tuned research strategies for the project. The proposed research work will pursue the following two ideas: 1) Developing methods to control/limit the fault current contributions of DERs as a way to resolve the protection problem. 2) Developing a MG "state estimation" concept/method as a universal approach for MG status/disturbance monitoring and diagnosis. In addition, I propose a 3rd research activity (Home-based nanogrids) for consideration by the Scientific Committee.

Intellectual Property and Publications

Refereed Journal Publications

-

Non-Refereed Journal Publications

-

Invited conference presentations

-

Non-Invited conference presentations

-

Technical reports, patents, licenses and other intellectual property

Research Collaborations and Interactions

Summarize briefly your network-related interactions and activities

Research Partners

Industrial Partners

International Collaborations

Exchanges by Highly Qualified Personnel

Other

Highly Qualified Personnel (HQP)

Please list all HQP since the start of the project. Include forecast End Dates for students currently engaged.

Status (U, M, P)	Name	Email	Start Date	End Date
P	Hesam Yazdanpanahi	yazdanpa@ualberta.ca	Sept 2009	Sept 2013
P	Ming Dong	mingd@ualberta.ca	Sept 2009	May 2011
M	Chen Jiang	jiangc08@gmail.com	Sept 2009	Dec. 2011
P	Andy Polzl	N/A	Sept 2011	
M	Qingxi Shi	N/A	Sept 2011	
M	Yu Tian	N/A	Sept 2011	

Discuss any discrepancies between planned HQP and those actually hired

I have to move some of my current well-trained students to work on this project to ensure its successful completion. Actual student allocation for the project will be done based on the interest and strength of the new and existing students. Decision will be made in December this year.

Project Budget

Note and explain any deviations greater than 20% between actual and budgeted project expenses

New students for the project will arrive on September 2011.

Describe any cash or in-kind contributions, other than NSMG-Net, in support of this project

	Year 1 Forecast	Year 1 Actual		Year 2 Forecast
Expenditures				
Undergraduate	\$4 300			\$4 300
Masters (2 students)	\$31 000	\$16 400		\$31 000
PhD	\$18 900	\$18 000		\$18 900
Students*	\$54 200	\$34 400	-37%	\$54 200
Materials and supplies	\$4 600	\$2 500	-46%	\$4 600
Conference travel	\$5 000	\$3 000	-40%	\$5 000
Publication costs	\$1 000	\$ 0	-100%	\$1 000
Total	\$64 800	\$39 900	-38%	\$64 800
Funding				
Own university		\$ 0		\$ 0
Carried over		\$ 0		\$24 900
April transfer		\$32 400		\$32 400
October transfer		\$32 400		\$32 400
Total		\$64 800		\$89 700
			Forecast surplus	\$24 900

Annual Progress Report

Project 1.4

Operational Strategies and Storage Technologies to Address Barrier for Very High Penetration of DG Units in Intelligent Microgrids

Project Leader: Geza Joos (McGill University)

Project Started: Oct 2010

Expected Project Completion Date: Sep 2015

Progress Highlights for October 1st 2010 to September 31st 2011

Please provide a brief high-level summary that outlines the progress, research results or any issues during the reporting period. State the milestones achieved with reference to the research proposal.

- Progress made in the following areas:
 - Energy management strategies, from the control viewpoint, for multiple static power converter based DGs fed from renewable energy sources

 - Energy management strategies, from the energy balancing and dispatch perspective, for managing a distribution grid with renewable energy sources, using energy storage devices

- Research results are in the form of paper and report related to the above work
- Paper published
 - A. Haddadi and G. Joós, "Load Sharing of Autonomous Distribution-level Microgrids", in IEEE Power and Energy Society General Meeting, Detroit, July 2011 (to be presented)

 - M. Ross, R. Hidalgo, C. Abbey, G. Joós, "Energy storage system scheduling for an isolated microgrid," Renewable Power Generation, IET , vol.5, no.2, pp.117-123, March 2011.

- Problems are only associated with the availability of research personnel (see financial

report)

Detailed Research Report

Please indicate the status of all milestones as "Not started", "In progress" or "Complete" as appropriate. Milestones and timeframes are based on the research plan: if these have changed please indicate and explain.

- Research and develop energy management strategies and identify barriers associated for large number of renewable DGs (2011)
 - *(Copy to remaining milestones and delete as appropriate)*
 - Not started
 - In progress (XX% complete)
 - Complete
- Establish performance merits considering cost optimization and provide evaluation based on simulation test cases (2012)
- Evaluate storage technologies, modes of operations, ancillary service functions and values (2013)
- Research and develop strategies and algorithms to address barriers for penetration of large number of renewable based on storage technologies and ICT (2014)
- Evaluate performance of the strategies based computer simulation test cases, and validate the storage and the ICT performance in the BCIT beta site (2015)

Please provide more details for milestones currently in progress. Describe any problems and resolutions.

Intellectual Property and Publications

Refereed Journal Publications

M. Ross, R. Hidalgo, C. Abbey, G. Joós, "Energy storage system scheduling for an isolated microgrid," Renewable Power Generation, IET , vol.5, no.2, pp.117-123, March 2011.

Non-Refereed Journal Publications

-

Invited conference presentations

A. Haddadi and G. Joós, "Load Sharing of Autonomous Distribution-level Microgrids", in IEEE

Power and Energy Society General Meeting, Detroit, July 2011 (to be presented)

Non-Invited conference presentations

-

Technical reports, patents, licenses and other intellectual property

Research Collaborations and Interactions

Summarize briefly your network-related interactions and activities

Research Partners

Industrial Partners

International Collaborations

Exchanges by Highly Qualified Personnel

Other

Highly Qualified Personnel (HQP)

Please list all HQP since the start of the project. Include forecast End Dates for students currently engaged.

Status (U, M, P)	Name	Email	Start Date	End Date
P	Ross, Michael	michael.ross2@mail.mcgill.ca	Oct 1, 2010	Aug 31, 2013
P	Haddadi, Aboutaleb	aboutaleb.haddadi@mail.mcgill.ca	April 1, 2011	Aug 31, 2012

Discuss any discrepancies between planned HQP and those actually hired

Since recruited students at McGill start in September (students accepted in March) or January (students recruited in July), no students could be recruited specifically for this project.

The students appearing in the reporting year are the students working in a research area related to the project and subsequently assigned to the project. Only PhD students were available.

Project Budget

Note and explain any deviations greater than 20% between actual and budgeted project expenses

The students appearing in the reporting year are the students working in a research area related to the project and subsequently assigned to the project.

This explains why all the funds were not spent or allocated and why there are 2 partially funded PhD students appearing in the financial report, rather than one PhD and 2 Masters. No PhD student was paid more than the maximum allowed for a Masters student (\$15 500).

Note that one student has a McGill scholarship, which explains why his stipend is not the maximum allowed.

Details of expenditures:

- Student # 1 – Ross, Michael (PhD, McGill scholarship) – expenses 1 Oct 2011 to 19 July 2011: \$ 9 133; 20 July 2011 to 30 Sept 2011: \$ 2 977

- Student # 2 – Haddadi, Aboutaleb (PhD, no Masters student available) – expenses 1 Apr 2011 to 19 July 2011: \$ 6 333; 20 July 2011 to 30 Sept 2011: \$ 1 583

Describe any cash or in-kind contributions, other than NSMG-Net, in support of this project

One student has a McGill scholarship.

	Year 1 Forecast	Year 1 Actual		Year 2 Forecast
Expenditures				
Undergraduate	\$4 300	\$4 300		\$4 300
Masters (2 students)	\$31 000			\$31 000
PhD	\$18 900	\$20 026		\$18 900
Students*	\$54 200	\$24 326	-55%	\$54 200
Materials and supplies	\$4 600	\$4 200	-9%	\$4 600
Conference travel	\$5 000	\$4 962	-1%	\$5 000
Publication costs	\$1 000	\$1 000	0%	\$1 000
Total	\$64 800	\$34 488	-47%	\$64 800
Funding				
Own university		\$1 000		\$1 000
Carried over		\$ 0		\$30 312
April transfer		\$32 300		\$31 900
October transfer		\$31 500		\$31 900
Total		\$64 800		\$95 112
			Forecast surplus	\$30 312

Annual Progress Report

Project 2.1

Cost-benefits framework - secondary benefits and ancillary services

Project Leader: Geza Joos (McGill University)

Project Started: Oct 2010

Expected Project Completion Date: Sep 2015

Progress Highlights for October 1st 2010 to September 31st 2011

Please provide a brief high-level summary that outlines the progress, research results or any issues during the reporting period. State the milestones achieved with reference to the research proposal.

- Progress was made in establish the list of beneficiaries and benefits and the framework for quantifying direct, energy supply benefits and ancillary benefits
- Research result: stakeholders were identified; information and data were collected; the researchers are participating in a technical society working group and interacting with specialists (utilities, manufacturers, consultants) and researchers (university,, government laboratories) on the international scene. Context: CIGRE (International Council on Large Electric Systems, membership from all countries, utilities, industries and universities), Study Committee C6 (Distribution systems and distributed generation), Working Group C6.22 (started August 2010), Microgrid evolution roadmap, in charge of the topic (chapter) pertaining to Benefits and business case (with Masters student G. Morris).
- Paper published
C. Abbey, C. Marnay, G. Joos and G. Young Morris, "A Framework for the Evaluation of the Cost and Benefits of Microgrids", in CIGRE Symposium 'The electric power system of the future - Integrating supergrids and microgrids', Bologna, to be presented in September 2011.
- Problem encountered: none technical

Detailed Research Report

Please indicate the status of all milestones as “Not started”, “In progress” or “Complete” as appropriate. Milestones and timeframes are based on the research plan: if these have changed please indicate and explain.

- Establish the list of benefits and the framework for quantifying direct, energy supply benefits, taking into account utility interconnection requirements (2011)
 - *(Copy to remaining milestones and delete as appropriate)*
 - Not started
 - In progress (XX% complete)
 - Complete
- Develop the methodology for quantifying the monetary value of the direct benefits (2012)
- Develop a framework for implementing and quantifying ancillary services (2013)
- Planning and optimization approaches to maximize Microgrid benefits (2014)
- Application of the methodology to Microgrid demonstrations in commercial, industrial and remote community settings (2015)

Please provide more details for milestones currently in progress. Describe any problems and resolutions.

Intellectual Property and Publications

Refereed Journal Publications

-

Non-Refereed Journal Publications

-

Invited conference presentations

C. Abbey, C. Marnay, G. Joos and G. Young Morris, “A Framework for the Evaluation of the Cost and Benefits of Microgrids”, in CIGRE Symposium 'The electric power system of the future – Integrating supergrids and microgrids', Bologna, presented in September 2011.

Non-Invited conference presentations

-

Technical reports, patents, licenses and other intellectual property

Research Collaborations and Interactions

Summarize briefly your network-related interactions and activities

Research Partners

Industrial Partners

International Collaborations

Exchanges by Highly Qualified Personnel

Other

Highly Qualified Personnel (HQP)

Please list all HQP since the start of the project. Include forecast End Dates for students currently engaged.

Status (U, M, P)	Name	Email	Start Date	End Date
M	Morris, Greg	gregory.weyrichmorris@mail.mcgill.ca	Oct 1, 2010	Aug 31, 2012

Discuss any discrepancies between planned HQP and those actually hired

Project Budget

Note and explain any deviations greater than 20% between actual and budgeted project expenses

The student appearing in the reporting year are the students working in a research area related to the project and subsequently assigned to the project. This explains why all the funds were not spent or allocated.

There is one partially funded Masters student appearing in the financial report, rather than one PhD and 2 Masters.

Describe any cash or in-kind contributions, other than NSMG-Net, in support of this project

The student, Greg Morris, holds a one year NSERC scholarship, which explains why his stipend is not the maximum allowed

	Year 1 Forecast	Year 1 Actual		Year 2 Forecast
Expenditures				
Undergraduate	\$4 300			\$4 300
Masters (2 students)	\$31 000	\$4 300		\$31 000
PhD	\$18 900	\$5 000		\$18 900
Students*	\$54 200	\$9 300	-83%	\$54 200
Materials and supplies	\$4 600	\$4 500	-2%	\$4 600
Conference travel	\$5 000	\$4 800	-4%	\$5 000
Publication costs	\$1 000	\$1 000	0%	\$1 000
Total	\$64 800	\$19 600	-70%	\$64 800
Funding				
Own university		\$1 000		\$1 000
Carried over		\$ 0		\$45 200
April transfer		\$32 300		\$31 900
October transfer		\$31 500		\$31 900
Total		\$64 800		\$110 000
			Forecast surplus	\$45 200

Annual Progress Report

Project 2.2

Energy and Supply Security Considerations

Project Leader: Reza Iravani (University of Toronto)

Project Started: Oct 2010

Expected Project Completion Date: Sep 2015

Progress Highlights for October 1st 2010 to September 31st 2011

Please provide a brief high-level summary that outlines the progress, research results or any issues during the reporting period. State the milestones achieved with reference to the research proposal.

The project milestone at the end of the first year of the project (Oct 2010- Sept 2011) is to quantify the effects of electrically-close multiple microgrids (high depth of utilization of microgrid) on the host electrical grid in terms of steady state, dynamic and transient phenomena of the host system. In this context we:

- Investigated and identified various modes of operation of a microgrid with respect to the host grid, e.g., virtual power plant mode of operation, frequency-voltage control mode of operation, and real-reactive power injection mode of operation, and the corresponding communication technologies.
- Determined potential scenarios for islanding and resynchronization of microgrids and the corresponding measurement requirements and the communication technologies requirements
- Developed a benchmark system which includes multiple microgrids in electrical vicinity of each other and hosted by an interconnected electrical system. (Such benchmark systems have not been reported in the technical literatures.)
- Developed strategies to represent the communication hub of each microgrid and the associated energy management system in system studies.
- Developed a real-time power flow analysis that represents three-phase sequence-frame model of each microgrid and can be used to specify steady state operational conditions of multiple microgrids under various control strategies, including operational limits of electronically coupled DER units within each microgrid.
- Currently are in the process of developing time-domain and frequency-domain models of the benchmark system for transient studies.

Detailed Research Report

Please indicate the status of all milestones as "Not started", "In progress" or "Complete" as appropriate. Milestones and timeframes are based on the research plan: if these have changed please indicate and explain.

- Quantify the effects of high-depth of conventional Microgrid penetration on the steady-state, dynamic, and transient phenomena of interconnected power systems (2011)
 - In progress (90% complete)
- Determine the potential violations and/or infringements of the regulations, standards and guideline requirements from high penetration of conventional Microgrids (2011)
 - In progress (50% complete)
- Develop models to investigate the requirements, intelligence and technologies to mitigate the adverse impact of multiple Microgrids on the host power system (2012)
 - In progress (50% complete)
- Develop supervisory control and power management strategies and algorithms to enable inter-Microgrid partial and/or full autonomy and minimize intra-Microgrid adverse impacts (2013)
 - In progress (40% complete)
- Develop benchmark systems and operational scenarios to investigate and verify the envisioned strategies (2013)
 - In progress (20% complete)
- Investigate and quantify the impacts of the various strategies and, in particular, their associated ICT and the market signals, on the security of supply (2014)
 - In progress (15% complete)
- Develop specifications for improvements and the required technologies to mitigate the identified impacts (2014)
 - In progress (20% complete)
- Select test cases and beta site(s) to experimentally (even with a limited scope) verify the results of the previous milestones (2015)
 - In progress (10% completed)
- Perform beta site tests and computer simulation results to verify/modify the proposed strategies and the corresponding algorithms (2015)
 - Not started

Please provide more details for milestones currently in progress. Describe any problems and resolutions.

The main challenge in the progress of this project is impact of microgrid protection on the selection of control strategies and performance of control. This issue becomes even of more significance since microgrid protection strategies are not currently defined.

Intellectual Property and Publications

Refereed Journal Publications

- A. Mehrizi-Sani, R. Iravani, "Online set point modulation to enhance microgrid dynamic performance: theoretical foundation", Submitted to the IEEE Trans. on Power Systems.

- A. Merrizi-sani, R. Iravani, "Constrained potential function-based control of microgrid for improved dynamic performance", accepted for publication in the IEEE Trans. on Power Systems.

Non-Refereed Journal Publications

- NA

Conference presentations

- A. Mehrizi-Sani, R.Iravani, "Performance evaluation of auxiliary distributed control scheme for overvoltage mitigation", International symposium on Electric Power System of the Future on Integration supergrids and microgrids, September 13-15, 2011, Bologna, Italy

Non-Invited conference presentations

- NA

Technical reports, patents, licenses and other intellectual property

- NA

Research Collaborations and Interactions

Summarize briefly your network-related interactions and activities

Research Partners

The first year of the project was primarily dealing with identification of the existing and near-future trends in control of multi-microgrids and interactions between control and protection. Another major focal point of the project was to identify communication infrastructure for realization of control (and protection).

Thus, collaborations were with two distribution utilities in Denmark and Spain who have prototype installations and few years of practical experience in the field.

However, the subsequent years activities of the project, which are based on the development of year-one, would be carried out in close collaboration with projects 1.1, 1.2, 1.3, 2.1, 2.4, 3.1, 3.2, 3.3.

Industrial Partners

We have been actively engaged in collaborative R&D with Toronto Hydro for hardware realization of a specific version of our envisioned microgrid control system for based on a mixture of fiber-optics and SCADA for testing in late 2012. Our collaborations with BC Hydro, Hydro One, Hydro Quebec and other industrial partners has been at the level of discussions and information gathering.

International Collaborations

We have managed to establish close collaborative efforts with two partners (one power utility and one manufacturing company) in south Korea, two power utility companies in Denmark and Spain.

Exchanges by Highly Qualified Personnel

NA

Other

We have established close collaboration with RTDS Technologies and National Instruments for hardware and HIL test-bed developmet.

Highly Qualified Personnel (HQP)

Please list all HQP since the start of the project. Include forecast End Dates for students currently engaged.

Status (U, M, P)	Name	Email	Start Date	End Date
P	F. Badrkhan	firuz.badrkhani@utoronto.ca	July 2011	Dec2014
P	M.Ramadan	Mohamd.ramadan@utoronto.ca	July 2011	Dec 2014
M	S. Wang	Shang.wang@utoronto.ca	May 2011	Dec 2012
P	A.Mehrizi-Sani	Ali.mehrizi.sani@utoronto.ca	Oct 2010	Fen 2012

Discuss any discrepancies between planned HQP and those actually hired

To avoid any delay in the project progress and in view of

(i) the unconventional time of the project start-up date (October 2010), and
(ii) the fact that new students mainly start their programs in September of each year
I assigned one Ph.D. student to the project who was already in her Ph.D. programs and his work was closely related to the subject matter.

We have assigned one masters program and two Ph.D. program students to the project between April and August 2011.

Project Budget

Note and explain any deviations greater than 20% between actual and budgeted project expenses

We have fully utilized (except travel budget) the allocated budget for October 2010 to September 2011 and have overspent the budget for graduate students.

In view of the fact that we have two Ph.D. students and one masters students (instead of one Ph.D. and two masters) and will hire two undergraduate students in Summer 2012, we would like to request an increase in the budget for year 2, i.e., October 2011 to September 2012 as follows:

Undergraduate (2 students) at \$8600

Masters (1 student) at \$15 500

Ph.D. (2 students) at \$37 800 (the 3th Ph.D. student has funding from other resources)

Material and supplies at \$4 600 (unchanged)

Travel at \$5 000 (unchanged)

Publication at \$1 000 (unchanged)

Total requested budget for year 2 = \$72 500

Describe any cash or in-kind contributions, other than NSMG-Net, in support of this project

We have received equipment donation and cash contribution from RTDS Technologies (in-kind), National Instruments (in-kind) and our partners in Korea (Cash).

	Year 1 Forecast	Year 1 Actual		Year 2 Forecast
Expenditures				
Undergraduate	\$4 300			\$8 600
Masters (2 students)	\$31 000	\$6 000		\$15 500
PhD	\$18 900	\$27 000		\$37 800
Students*	\$54 200	\$33 000	-39%	\$61 900
Materials and supplies	\$4 600		-100%	\$4 600
Conference travel	\$5 000	\$2 000	-60%	\$5 000
Publication costs	\$1 000	\$ 0	-100%	\$1 000
Total	\$64 800	\$35 000	-46%	\$72 500
Funding				
Own university		\$2 000		\$2 000
Carried over		\$ 0		\$29 800
April transfer		\$32 200		\$31 400
October transfer		\$30 600		\$31 400
Total		\$64 800		\$94 600
			Forecast surplus	\$22 100

Annual Progress Report

Project 2.3

Demand response technologies and strategies - energy management and metering

Project Leader: Kankar Bhattacharya (University of Waterloo)

Project Started: Oct 2010

Expected Project Completion Date: Sep 2015

Progress Highlights for October 1st 2010 to September 31st 2011

Please provide a brief high-level summary that outlines the progress, research results or any issues during the reporting period. State the milestones achieved with reference to the research proposal.

Spring 2011:

- a. Mehrdad Pirnia (PhD student) worked on the project on stochastic optimization methods applied to penetration of distributed generation units to power systems.
- b. We hired one MASC student (Adarsh Madhavan). He carried out literature survey on Demand Response and took graduate courses, as per uWaterloo requirements.

Fall 2011:

- a. We hired three MASC students (Rupali Jain, Rajib Kundu and Felipe Ramos Gaete). They have been assigned their research problems within Demand Response, and they are working on their respective tasks, currently. Rajib Kundu and Felipe Ramos Gaete are also taking their graduate courses this term, to meet their academic requirements.
- b. Adarsh Madhavan is also working within this project in Fall 2011
- c. We hired another MASC student in Fall 2011 (Brian Le), who is currently taking graduate courses. These two additional students (Adarsh and Brian) are being funded through this project, for Fall 2011, because of the available unused student funds from previous term.

- Research result: Mehrdad Pirnia has made substantial progress in his research.
- Papers published:
 - M. Pirnia, C. Canizares and K. Bhattacharya, "Revisiting the Power Flow Problem Based on a Mixed Complementarity Formulation Approach" Submitted to IEEE Transactions on Power Systems.
 - M. Pirnia, C. Canizares and K. Bhattacharya, "A Novel Optimization Approach to Solve Power Flow Problem Using Complementarity Conditions" Poster presentation at IEEE PES General Meeting, Detroit, July 2011
 - M. Pirnia, C. Canizares and K. Bhattacharya, "An Affine Arithmetic Method for stochastic Power Flow Analysis" Canadian Operation Research conference, St. John's, June 2011

Detailed Research Report

Please indicate the status of all milestones as "Not started", "In progress" or "Complete" as appropriate. Milestones and timeframes are based on the research plan: if these have changed please indicate and explain.

- Sustainability consequences (environmental, economic and social impacts) of increased use of microgrids (2011)
 - In progress (80% complete)
- Modelling and scenario analyses, data collection (2012)
 - Not started
- Determining cost and benefits (2013)
 - Not started
- Energy-aware scheduling algorithms - proposing an algorithm for internal Microgrid load balancing capability (2013)
 - Not started
- Formulation of the optimization problem with constraints on reliability and network capacity (2014)
 - Not started
- Policy recommendations (2015)
 - Not started

Please provide more details for milestones currently in progress. Describe any problems and resolutions.

Intellectual Property and Publications

Refereed Journal Publications

M. Pirnia, C. Canizares and K. Bhattacharya, "Revisiting the Power Flow Problem Based on a Mixed Complementarity Formulation Approach" Submitted to IEEE Transactions on Power Systems.

Non-Refereed Journal Publications

Invited conference presentations

Non-Invited conference presentations

- M. Pirnia, C. Canizares and K. Bhattacharya, "A Novel Optimization Approach to Solve Power Flow Problem Using Complementarity Conditions" Poster presentation at IEEE PES General Meeting, Detroit, July 2011
- M. Pirnia, C. Canizares and K. Bhattacharya, "An Affine Arithmetic Method for stochastic Power Flow Analysis" Canadian Operation Research conference, St. John's, June 2011

Technical reports, patents, licenses and other intellectual property

Research Collaborations and Interactions

Summarize briefly your network-related interactions and activities

Research Partners

Industrial Partners

Dr. Steve Wong (from NRCAN) will be collaborating with us in this project, and our first meeting will be held on 28th October 2011, to discuss the research problem and some ideas and directions.

International Collaborations

--

Exchanges by Highly Qualified Personnel

--

Other

--

Highly Qualified Personnel (HQP)

Please list all HQP since the start of the project. Include forecast End Dates for students currently engaged.

Status (U, M, P)	Name	Email	Start Date	End Date
M	Adarsh Madhavan	a2madhav@uwaterloo.ca	May 2011	April 2012
P	Mehrdad Pirnia	mpirnia@uwaterloo.ca	May 2011	December 2012
M	Rupali Jain	rupalirjain@gmail.com	Sept 2011	August 2012
M	Rajib Kundu	rkundu@uwaterloo.ca	Sept 2011	December 2012
M	Felipe Ramos Gaete	framosga@uwaterloo.ca	Sept 2011	August 2015
M	Brian Le	b2le@engmail.uwaterloo.ca	Sept 2011	April 2012

Discuss any discrepancies between planned HQP and those actually hired

Felipe Ramos Gaete, has joined as a MASc student and will be transferred to the PhD program subsequently.

We have not been able to hire UG student so far. In lieu of that, we have funded two extra MASc students, Adarsh and Brian for an additional term, for their MASc research through this project, for Winter 2012, as shown in the table above.

Project Budget

Note and explain any deviations greater than 20% between actual and budgeted project expenses

All expenses are within the budget.

Describe any cash or in-kind contributions, other than NSMG-Net, in support of this project

Adarsh and Brian has been paid \$4334/= per term, from this project, instead of the stipulated \$5167/= because the University paid a \$5000/= support, because they being Canadian/PR graduate students.

	Year 1 Forecast	Year 1 Actual		Year 2 Forecast
Expenditures				
Undergraduate	\$4 300			\$4 300
Masters (2 students)	\$31 000	\$28 502		\$31 000
PhD	\$18 900	\$6 333		\$18 900
Students*	\$54 200	\$34 835	-36%	\$54 200
Materials and supplies	\$4 600		-100%	\$4 600
Conference travel	\$5 000	\$1 180	-76%	\$5 000
Publication costs	\$1 000		-100%	\$1 000
Total	\$64 800	\$36 015	-44%	\$64 800
Funding				
Own university		\$ 0		\$ 0
Carried over		\$ 0		\$28 785
April transfer		\$32 400		\$32 400
October transfer		\$32 400		\$32 400
Total		\$64 800		\$93 585
			Forecast surplus	\$28 785



Annual Progress Report

Project 2.4

Integration design guidelines and performance metrics - study cases

Project Leader: Ani Gole (University of Manitoba)

Project Started: Oct 2010

Expected Project Completion Date: Sep 2015

Progress Highlights for October 1st 2010 to September 31st 2011

Please provide a brief high-level summary that outlines the progress, research results or any issues during the reporting period. State the milestones achieved with reference to the research proposal.

-

Detailed Research Report

Please indicate the status of all milestones as "Not started", "In progress" or "Complete" as appropriate. Milestones and timeframes are based on the research plan: if these have changed please indicate and explain.

- Identify various existing component models (2011)
 - *(Copy to remaining milestones and delete as appropriate)*
 - Not started
 - In progress (XX% complete)
 - Complete
- Collaborate with the other themes/projects to define various Microgrid topologies and configurations and develop preliminary models (2011)
- Define the control/communication layer and determine modeling requirements, including technical aspects such as communication latency and spread, failure modes, durations, etc. (2012)
- Construct a highly detailed electromagnetic simulation of a small microgrid to be used for additional studies to determine adequacy of reduced order models, stability study models (2013)
- Develop a range of models based on the above experience that are able to model different operating scenarios (2012)
- Determine the modeling details required to refine the models (2014)

Please provide more details for milestones currently in progress. Describe any problems and resolutions.

Intellectual Property and Publications

Refereed Journal Publications

•

Non-Refereed Journal Publications

•

Invited conference presentations

-

Non-Invited conference presentations

-

Technical reports, patents, licenses and other intellectual property

Research Collaborations and Interactions

Summarize briefly your network-related interactions and activities

Research Partners

Industrial Partners

International Collaborations

Exchanges by Highly Qualified Personnel

Other

Highly Qualified Personnel (HQP)

Please list all HQP since the start of the project. Include forecast End Dates for students currently engaged.

Status (U, M, P)	Name	Email	Start Date	End Date

Discuss any discrepancies between planned HQP and those actually hired

Project Budget

Note and explain any deviations greater than 20% between actual and budgeted project expenses

Describe any cash or in-kind contributions, other than NSMG-Net, in support of this project

	Year 1 Forecast	Year 1 Actual	Year 2 Forecast
Expenditures			
Undergraduate	\$4 300		\$4 300
Masters (2 students)	\$31 000		\$31 000
PhD	\$18 900		\$18 900
Students*	\$54 200	\$ 0	\$54 200
Materials and supplies	\$4 600		\$4 600
Conference travel	\$5 000		\$5 000
Publication costs	\$1 000	\$ 0	\$1 000
Total	\$64 800	\$ 0	\$64 800
Funding			
Own university		\$3 000	\$3 000
Carried over		\$ 0	\$64 800
April transfer		\$32 100	\$32 400
October transfer		\$29 700	\$32 400
Total		\$64 800	\$132 600
		Forecast surplus	\$67 800

Annual Progress Report

Project 3.1

Universal Communication Infrastructure

Project Leader: David Michelson (University of British Columbia)

Project Started: Oct 2010

Expected Project Completion Date: Sep 2015

Progress Highlights for October 1st 2010 to September 31st 2011

Please provide a brief high-level summary that outlines the progress, research results or any issues during the reporting period. State the milestones achieved with reference to the research proposal.

- During this initial reporting period, we have focused on recruiting students, engaging companies, involving company employees, securing complementary funding from other agencies, developing research infrastructure and producing initial results.
- At the request of BC Hydro and Huawei Technologies and with support from Mentum, our initial efforts have focused on deployment of wireless infrastructure for Smart Meter and Distribution Automation backhaul in suburban neighbourhoods where base stations located atop tall buildings or towers connect to remote terminal units (RTUs) or collector relays located atop utility poles or lamp standards (at 6-7 m in height) that may approach local rooftop or treetop height.
- Although past work has considered a variety of macrocell configurations (different environments, cell sizes, base station heights, etc.), most previous work has assumed that the RTUs are located between 1 and 2 m off the ground – well below local rooftop or treetop height.
- In the future, a variety of wireless communication systems, including Smart Metering and Distribution Automation systems for Smart Grid, Roadside Units for Intelligent Transportation Systems (ITS), and gap-filling Relays for Advanced Cellular systems such as LTE, will use RTUs or collector relays located atop utility poles or lamp
- Our objective is to determine the manner in which the depth of shadow fading and the angle of arrival distribution vary with terminal height in typical suburban neighbourhoods.
- It is well known that path loss generally decreases with terminal height.
- Contrary to popular expectation, we have found that the depth of shadow fading actually increases as terminal height increases and reaches a maximum near the mean building/treetop height.
- We are currently developing the measurement equipment required to assess the manner

- in which delay spread and angle of arrival vary with terminal height.
- The results have important implications for link design, link reliability and the performance of directional antennas at RTUs and will influence both industry best practices and Industry Canada requirements for deploying WiMAX and similar wireless infrastructure in suburban environments.

Detailed Research Report

Please indicate the status of all milestones as "Not started", "In progress" or "Complete" as appropriate. Milestones and timeframes are based on the research plan: if these have changed please indicate and explain.

1. Develop interim guidelines for single dwelling units, multiple dwelling units, neighborhood and wide area environments based upon best available information (2011)
 - a. In progress (50% complete)
 - b. At the request of industrial partners, our current focus is on neighbourhoods and wide area environments.
2. Conduct wireless measurement campaigns in single and multiple dwelling units (2011)
 - a. In progress (10% complete)
 - b. Deferred at the request of industrial partners. (exchanged in sequence with Tasks 6 and 8)
3. Conduct interference studies and develop deployment guidelines for wired and wireless networks in single and multiple dwelling units (2012)
 - a. In progress (10% complete)
 - b. Current focus is on developing measurement equipment suitable for both characterizing and identifying interference types. Will likely use custom version of CRC's Spectrum Explorer together with Agilent's N6841A RF Sensors to collect field measurement data.
4. Assess current techniques for exchanging data and commands through hybrid networks and schemes for authentication, authorization and accounting (2012)
 - a. Not Started.
5. Propose and evaluate alternative techniques for exchanging data and commands through hybrid networks and schemes for authentication, authorization and accounting (2013)
 - a. Not Started.
6. Conduct measurement campaigns in neighborhoods (2013)
 - a. In progress (30% complete)
 - b. Will use channel measurement equipment developed for Task 3 and our mobile propagation van to collect field measurement data.
7. Conduct interference studies and develop deployment guidelines for neighborhoods (2014)
 - a. Not started.
 - b. Will use interference measurement equipment developed for Task 3 and our mobile propagation van to collect field measurement data.
8. Conduct measurement campaigns in wide area environments (2014)
 - a. In progress (10% complete)
 - b. Will use BC Hydro's WiMAX test bed in conjunction with our own mobile propagation van to collect field measurement data.
9. Conduct interference studies and develop deployment guidelines for wide area environments (2015)
 - a. In progress (10% complete)
 - b. Will use interference measurement equipment developed for Task 3 and our mobile propagation van to collect field measurement data.
10. Develop recommendations for spectrum allocation policy (2015)

- a. In progress (10% complete)
- b. Current focus is on consultation with Industry Canada SITT (Spectrum, Information Technologies and Telecommunications), UTC (Utilities Telecom Council) Canada, RABC (Radio Advisory Board of Canada) and industry partners regarding detailed milestone objectives.

Please provide more details for milestones currently in progress. Describe any problems and resolutions.

- Project 1 – Determine the manner in which the Distribution Automation (DA) assets in BC Hydro’s distribution system are geographically clustered and how this affects the ease with which such assets can be formed into either conventional base-station-to-pole-top macrocell networks or pole-top-to-pole-top mesh networks.
 - Status - Completed
 - Outcome - The manner in which the capacitor banks, reclosers and voltage regulators in BC Hydro’s distribution grid and the BC Hydro substations and microwave repeater sites that could host macrocell base stations are geographically dispersed throughout the province affects the ease with which these assets can be formed into either conventional base-station-to-pole-top fixed wireless macrocell networks or pole-top-to-pole-top fixed wireless mesh networks. Only three-quarters of these assets are located within 10 km of BC Hydro’s existing substations or microwave repeater sites. Thus, additional base station sites will need to be acquired if conventional WiMAX-based base-station-to-pole-top fixed wireless macrocell networks are used to implement Distribution Automation. However, almost none of the distribution assets are located within 1 km of another. Thus, using a ZigBee-based mesh network to implement DA is problematic. While private wireless networks present many advantages, it seems likely that they must be supplemented by other techniques if DA is to reach the entire province.
- Project 2 - Characterize the depth of fading on fixed wireless macrocell channels in neighbourhood and wide area environments and its implications for Distribution Automation (DA).
 - Status – Completed
 - Outcome - Regulators have allocated several frequency bands between 200 MHz and 2 GHz for use by electrical power utilities in DA networks. Although the bandwidth available at lower frequencies is considerably less than what is available at higher frequencies, the depth of fading experienced on fixed wireless macrocell channels drops off rapidly as frequency decreases (or as wavelength increases). A simple relationship between carrier frequency and mean Ricean K-factor in a given environment has been revealed. A link that experiences severe fading at 2 GHz is often relatively unaffected at 200 MHz. Thus, selection of a particular frequency band for a particular DA application represents a tradeoff between link quality and available bandwidth and must be carefully considered.
- Project 3 - Characterize the effect of terminal height on the location variability experienced on fixed wireless macrocell channels in typical neighbourhood and wide area environments and its implications for Distribution Automation.
 - Status –
 - Initial Measurement Campaign Completed.
 - Initial Simulation Studies Completed

- Further Work Planned.
 - To date - As the degree of shadow fading experienced on fixed wireless macrocell channels increases, the number of holes and gaps in the coverage of a base station increases, particularly at greater ranges. While it is often assumed that the degree of shadow fading will decrease monotonically as the height of the remote terminal increases, we have presented convincing evidence that the degree of shadow fading actually reaches its maximum value when the remote terminal is at or near the mean height of the buildings and other obstructions in the local environment. Thus, raising the terminal height from pedestrian to pole-top level may not improve the system link budget as much as the increase in mean path gain might otherwise suggest. Additional work is required to demonstrate that these results are broadly applicable to other neighbourhoods
- Project 4 – Characterize inter-base station interference in a WiMAX Utility Network with base stations installed throughout Metro Vancouver
 - Status – In Progress.
 - To date – In collaboration with BC Hydro, we have collected an extensive series of measurements of signals emitted by base stations in a WiMAX utility network deployed throughout Metro Vancouver in order to compare the performance of alternative channel assignment schemes. The results suggest that when links are obstructed, i.e., non-line-of-sight, using directional antennas at remote terminal units may be less effective at suppressing interference from other base stations than previously expected. The effective pattern of a terminal antenna is the convolution of its free space pattern and the angle of arrival distribution observed at the site. Accordingly, we are currently designing a follow up experiment that will directly measure the angle of arrival distribution observed at different terminal heights across a broad range of terminal locations. If the angle of arrival distribution is sufficiently broad, we will have grounds to suggest that Industry Canada relax its requirement that remote terminal units employ directional antennas.
- Project 5 – Characterize the interference in the 915 MHz and 2450 MHz ISM bands in typical household environments.
 - Status – In Progress.
 - To date – We have begun to measure emissions from common household devices in order to classify them according to their power levels, time structure and broadband spectrum. We will use the results to develop interference models suitable for assessing the performance of ultralow power wireless networks in household environments.
- Project 6 – Characterize the interference in the 915 MHz and 2450 MHz ISM bands in typical neighbourhood and wide area environments.
 - Status – In Progress.
 - To date – When paired with a suitable RF front end such as Agilent’s N6841A RF Sensors, the Spectrum Explorer software developed by John Lodge and colleagues at the Communications Research Centre in Ottawa is ideally suited to characterizing the interference in the 915 MHz and 2450 MHz ISM bands in typical neighbourhood and wide area environments. In August, we approached CRC regarding the possibility of pursuing a collaborative effort to port Spectrum Explorer to the N6841A RF Sensor and acquiring a licence to use the software. CRC was extremely helpful and agreed to pursue the porting effort with us and provide us with a complimentary software licence at no charge.

Intellectual Property and Publications

Refereed Journal Publications

- In progress.

Non-Refereed Journal Publications

- In progress.

Invited conference presentations

- None.

Non-Invited conference presentations

- N. Stanchev, A. Corbett, D. G. Michelson, "Suppression of Self-Noise in Stepping Correlator Channel Sounders'," presented at IEEE APS/URSI Symposium, Spokane, WA, 2011.

Technical reports, patents, licenses and other intellectual property

- In progress.

Research Collaborations and Interactions

Summarize briefly your network-related interactions and activities

Research Partners

1. We are working with V. Leung (UBC) and his student Ruby Rukhsana to set up and use Communication Research Centre Canada's CORAL Cognitive Radio Platform for use in interference characterization studies. http://www.crc.gc.ca/en/html/crc/home/wifi_cr/wifi_cr
2. We are working with BCIT Research Associate Nikola Stanchev to develop the stepping correlator channel sounder that will be used to characterize channels in neighbourhood and wide area environments.

Industrial Partners

- We've encouraged our industry partners to contribute significantly to our research agenda. We are gratified that five companies in particular (BC Hydro, Corinex, Mentum, Huawei Technologies and General Electric) have taken advantage of the opportunity.
- BC Hydro, Huawei Technologies and Mentum have expressed particular interest in the effect of terminal height on propagation in macrocell environments. The results have significant implications for wireless system deployment.
- BC Hydro and Corinex have shown particular interest in the use of power line channel sounding and related techniques to predict mechanical failure of transmission lines.

- General Electric has shown particular interest in development of fast and efficient channel sounders suitable for fast and efficient characterization of transmission paths for Smart Energy applications.

International Collaborations

- In Aug. 2011, I met Dr. S.M. Shajedul Hasan of the RF Instrumentation & Systems Laboratory of GE Global Research in Niskayuna, NY at a training session in San Jose, CA that was sponsored by Remcom, developers of the Wireless InSite wireless coverage prediction software.
- Dr. Hasan has expressed strong interest in working with us to develop channel sounders suitable for fast and efficient characterization of transmission paths for Smart Energy applications. Given the GE Canada is already an industrial partner of NSMG-nete, such collaboration will not be difficult to arrange. There has been a delay, however, while a replacement for our principal GE contact, Dr. Mihai Huzmezan, is found.

Exchanges by Highly Qualified Personnel

- BC Hydro employees Boubacar Diallo and Sol Lancashire are also contributing to this project through their pursuit of part time MASc studies.

Other

- Communications Research Centre in Ottawa is assisting us by porting their Spectrum Explorer software to our Agilent N6841A RF Sensors and providing us with a complimentary Spectrum explorer software licence at no charge. This represents an unplanned in-kind contribution of approximately \$15,000 including waived license fees (\$12,000 VIK) and at least 40 hours of staff time (John Lodge, Francois Patenaude and Alexis Bose) (\$3200 VIK).
- Utilities Telecom Council Canada invited me to give a presentation on industry-university cooperation in utility telecom research through NSMG-Net at their annual conference in St. John's, NL in Sep. 2011. While I was unable to attend due to illness, Alexandre Prieur of Natural Resources Canada gave the presentation on my behalf.

Highly Qualified Personnel (HQP)

Please list all HQP since the start of the project. Include forecast End Dates for students currently engaged.

Status (U, M, P)	Name	Email	Start Date	End Date

P	Sina Mashayekhi*	sina@ece.ubc.ca	Jan 2011	Dec 2014
M (p/t)	Boubacar Diallo	Boubacar.Diallo@bchydro.com	Oct 2010	Apr 2011
M (p/t)	Sol Lancashire	Sol.Lancashire@bchydro.com	Oct 2010	Dec 2014
M (p/t)	Alex Corbett	alex.corbett@gmail.com	Oct 2010	Apr 2012
M	Bruce Haines*	bruce.a.haines@gmail.com	Sep 2011	Aug 2014
M (p/t)	Nina Chen	ninachenchen@gmail.com	Sep 2011	Aug 2014
U	Andy Tsai*	andytsai2002@gmail.com	Mar 2011	Apr 2011
U	Ahad Shafiq*	ahad.shafiq@gmail.com	Mar 2011	Apr 2011
U	Edgar Cave*	edgar.cave@gmail.com	May 2011	Aug 2011
U	Lawrence Penkar*	lawpenkar@gmail.com	May 2011	Aug 2011
U	Bruce Haines*	bruce.a.haines@gmail.com	May 2011	Aug 2011
U (p/t)	Prajeet GC	gcpraj@gmail.com	Sep 2011	Dec 2011

* hired by the project

Discuss any discrepancies between planned HQP and those actually hired

In Sep 2011, Master's applicant Nina Chen elected to enroll part-time rather than full-time.

In Sep 2011, PhD applicant Kasra Asadzadeh deferred enrolment for at least four months in order to resolve an immigration issue that had developed.

I strongly suggest that NSERC consider announcing major funding in March or April and start projects in September in order to coincide with the recruitment and enrolment cycles at most Canadian universities.

Project Budget

Note and explain any deviations greater than 20% between actual and budgeted project expenses

- Undergraduates – we hired several undergraduates in spring and summer 2011 in order to get a head start on configuring our various wireless test beds, collecting data and engaging industry
- Graduate students – the funding announcement was made after our January 2011 recruitment and enrolment cycle had closed. In September 2011, Master's applicant Nina Chen elected to enroll part-time rather than full-time so that she could support her parents financially.
- Publication costs – No page charges were assessed during Year One.

Describe any cash or in-kind contributions, other than NSMG-Net, in support of this project

- Communications Research Centre (Ottawa, ON) is assisting us by porting their Spectrum Explorer software to our Agilent N6841A RF Sensors and providing us with a complimentary Spectrum explorer software licence at no charge. This represents an unplanned in-kind contribution of approximately \$15,000 including waived license fees (\$12,000 VIK) and at least 40 hours of staff time (John Lodge, Francois Patenaude and Alexis Bose) (\$3200 VIK).
- Menteum (Gatineau, QC) is providing us with a complimentary licence to their Menteum Planet wireless system planning software used in neighbourhood or wide area planning (\$4000/year VIK).
- Menteum invited me to participate in their Menteum User Conference in Dallas on 4-5 May 2011 at no charge. (I was responsible for travel and accommodation expenses.)
- Dr. Yann LeHelloco, CTO of Menteum (Gatineau, PQ) provided our students (and other members of the local wireless community) with an 8-hour training session on Wireless System Planning Tools at UBC on Tue, 19 Jul 2011. He developed the course materials (450+ slides) specifically for us. (50 hours of his time at \$80/hr = \$4000 VIK.) See the photo of the training session at right.
- TELUS Tech Strategy Office (Edmonton, AB) contributed \$1500 towards Dr. LeHelloco's travel and accommodation expenses during his visit on Tue, 19 Jul 2011.
- Rhombic Consulting of Vancouver (Sid Kemp, President) took several of our students to typical building rooftops and training them in base station site survey procedures. (20 hours of his time at \$80/hr = \$1600 VIK.)
- Planetnetworks Consulting of Vancouver (Karl Reardon, PEng and Susana Reardon, PEng) trained several of our students in the interpretation of Health Canada's Safety Code 6 guidelines for RF exposure and the use of Narda RF Exposure Meters. (8 hours of their time at \$80/hr = \$640 VIK.)
- Utilities Telecom Council (UTC) Canada invited me to give a presentation on industry-university cooperation in utility telecom research through NSMG-net at their annual conference in St. John's, NL in Sep. 2011. After I was unable to attend due to illness, Alexandre Prieur of Natural Resources Canada gave the presentation on my behalf.

	Year 1 Forecast	Year 1 Actual		Year 2 Forecast
Expenditures				
Undergraduate	\$4 300	\$21 546		\$4 300
Masters (2 students)	\$31 000	\$1 375		\$31 000
PhD	\$18 900	\$14 250		\$18 900
Students*	\$54 200	\$37 171	-31%	\$54 200
Materials and supplies	\$4 600	\$1 800	-61%	\$4 600
Conference travel	\$5 000	\$2 315	-54%	\$5 000
Publication costs	\$1 000	\$ 0	-100%	\$1 000
Total	\$64 800	\$41 286	-36%	\$64 800
Funding				
Own university		\$ 0		\$ 0
Carried over		\$ 0		\$23 514
April transfer		\$32 400		\$32 400
October transfer		\$32 400		\$32 400
Total		\$64 800		\$88 314
			Forecast surplus	\$23 514

Annual Progress Report

Project 3.2

Grid Integration Requirements, Standards, Code and Regulatory Considerations

Project Leader: Tho Le-Ngoc (McGill)

Project Started: Oct 2010

Expected Project Completion Date: Sep 2015

Progress Highlights for October 1st 2010 to September 31st 2011

Please provide a brief high-level summary that outlines the progress, research results or any issues during the reporting period. State the milestones achieved with reference to the research proposal.

- The milestone set for the first year (2010-2011) is "preliminary studies to characterize different information types in intelligent microgrids to establish their QoS parameters and to classify their dynamic QoS requirements (2011)". We have studied emerging communications standards/technologies applicable to various heterogeneous communications segments (e.g., HAN/BAN/IAN, NAN/EAN/FAN, WAN) that form the communications infrastructure to effectively support the integration of intelligent microgrids. We have investigated various possible information types in intelligent microgrids, and their communications traffic characteristics to derive their QoS parameters and to classify their QoS requirements. This work is completed as planned.
- We have studied a QoS provisioning scheme and its throughput performance for a wireless network segment in smart grids. The developed analytical framework can be used in dimensioning a two-way communications infrastructure between utility control centers and electric customers or grid elements. Specifically, it provides a systematic approach to decide how wireless bandwidth is allocated to different users so that QoS requirements are satisfied considering stochastic nature of grid data traffic and error-prone wireless channels. This work has been done in collaboration with our collaborator, Prof. Long Le of INRS-EMT and reported in [C1].
- For robust wireless communications, Multi-Input Multi-Output (MIMO) systems employ multiple antennas to exploit the spatial diversity and/or multiplexing gains. With the

trend of miniaturization of communications devices suitable for a smart-grid environment, low profile and compact multi-antenna structures are very beneficial. We have developed, implemented and tested a dual-layer EBG-based miniaturized patch multi-antenna structure. Based on the concept of slow wave propagation, a dual-layer electromagnetic band gap (EBG) mushroom structure is used to reduce the area of a patch multi-antenna sub-system. While the inner layer aids in the antenna miniaturization, the more compact upper layer helps in further reduction of the mutual coupling between the miniaturized patch antennas which is otherwise not possible for a single-layer EBG. This work has been reported in [C2].

- We have had discussions with Hydro-Quebec IREQ technical staff members about the project and technical issues, especially about transmission environment (e.g., possibility of impulsive noise), QoS characteristics and requirements, wireless communications standards/technologies applicable to communications infrastructures to support power distribution and monitoring systems.

Detailed Research Report

Please indicate the status of all milestones as "Not started", "In progress" or "Complete" as appropriate. Milestones and timeframes are based on the research plan: if these have changed please indicate and explain.

- Preliminary studies to characterize different information types in Intelligent Microgrids to establish their QoS parameters and to classify their dynamic QoS requirements (2011)
 - Complete
- Investigation of issues of grid integration requirements, and standards, codes and regulatory issues of emerging communications systems in supporting Intelligent Microgrids (2012)
 - In progress (just started)
- Development of robust transmission techniques suitable for information exchange in intelligent Microgrids (2013)
 - Not started
- Development of jointly reconfigurable transmission and intelligent information processing schemes of heterogeneous wireless/wireline communications networks for integration of Microgrids (2014)
 - Not started
- Development and evaluation of integration strategies for transmission, information processing and networking architectures, based on available and emerging communications technologies (2015)
 - Not started

Please provide more details for milestones currently in progress. Describe any problems and resolutions.

- As a continuation, we just started our work to investigate grid integration requirements, and standards, codes and regulatory issues of emerging communications systems in supporting Intelligent Microgrids.

Intellectual Property and Publications

Refereed Journal Publications

--

Non-Refereed Journal Publications

--

Invited conference presentations

--

Non-Invited conference presentations

- | |
|--|
| <p>[C1] Long B. Le, Tho Le-Ngoc, "QoS Provisioning for OFDMA-based Wireless Network Infrastructure in Smart Grids", <i>IEEE Canadian Conference on Electrical and Computer Engineering 2011</i>, Niagara Falls, Ontario, May 8-11, 2011</p> <p>[C2] Soham Ghosh, Thanh-Ngon Tran, Tho Le-Ngoc, "A Dual-layer EBG-based Miniaturized Patch Multi-antenna Structure, <i>2011 IEEE AP-S International Symposium on Antennas and Propagation</i>, Spokane, Washington, USA, July 3-8, 2011</p> |
|--|

Technical reports, patents, licenses and other intellectual property

--

Research Collaborations and Interactions

Summarize briefly your network-related interactions and activities

Research Partners

<p>We have worked with our collaborator, Prof. Long Le of INRS-EMT, to investigate a QoS provisioning scheme and its throughput performance for a wireless network segment in smart grids. We have developed, implemented and tested a dual-layer EBG-based miniaturized patch multi-antenna structure, using facilities at the Broadband Communications Lab at McGill. In performing our preliminary studies to investigate various possible information types in intelligent microgrids, and their communications traffic characteristics, we have prepared a number of issues to be discussed with other researchers in Projects 1.2, 1.3, 1.4, 2.2, 2.3, 3.1, 3.3, especially at our coming AGM in October 2011.</p>
--

Industrial Partners

<p>We have had discussions with Hydro-Quebec IREQ technical staff members about the project and</p>

technical issues, especially about transmission environment (e.g., possibility of impulsive noise), QoS characteristics and requirements, wireless communications standards/technologies applicable to communications infrastructures to support power distribution and monitoring systems.

International Collaborations

Exchanges by Highly Qualified Personnel

Other

Any other partnerships.

Highly Qualified Personnel (HQP)

Please list all HQP since the start of the project. Include forecast End Dates for students currently engaged.

Status (U, M, P)	Name	Email	Start Date	End Date
PhD	Sanjeewa Priyad Herath Mudiyanselage	sanjeewa.herath@mail.mcgill.ca	October 1 st 2010	
PhD	Christopher Leung	christopher.leung@mail.mcgill.ca	January 1 st 2011	
MEng	Ms. Yue Gao	yue.gao2@mail.mcgill.ca	October 1 st 2010	
MEng	Mr. Soham Ghosh	soham.ghosh@mail.mcgill.ca	October 1 st 2010	
U	Julian Santorelli	julian.santorelli@mail.mcgill.ca	May 2011	Aug 2011
PDF	Dung Ho (30% time)	quang.ho@mcgill.ca	October 1 st 2010	
Research Associate	Thanh-Ngon Tran (15% time)	ngon.tran@mcgill.ca	October 1 st 2010	

Discuss any discrepancies between planned HQP and those actually hired

Notes: As the project deals with the various aspects of communications, in addition to graduate students, we also need experienced PDF and Research Associate.

Project Budget

Note and explain any deviations greater than 20% between actual and budgeted project expenses

Describe any cash or in-kind contributions, other than NSMG-Net, in support of this project

--

Year Two Forecast – Proposed

	Year 1 Forecast	Year 1 Actual		Year 2 Forecast
Expenditures				
Undergraduate	\$4 300	\$4 000		\$4 300
Masters (2 students)	\$31 000	\$29 000		\$31 000
PhD	\$18 900	\$19 000		\$21 700
Students*	\$54 200	\$52 000	-4%	\$57 000
Materials and supplies	\$4 600	\$4 500	-2%	\$4 600
Conference travel	\$5 000	\$4 500	-10%	\$5 000
Publication costs	\$1 000	\$1 000	0%	\$1 000
Total	\$64 800	\$62 000	-4%	\$67 600
Funding				
Own university		\$1 000		\$1 000
Carried over		\$ 0		\$2 800
April transfer		\$32 300		\$31 900
October transfer		\$31 500		\$31 900
Total		\$64 800		\$67 600
			Forecast surplus	\$ 0



Annual Progress Report

Project 3.3

Distribution Automation: Sensors and Condition Monitoring

Project Leader: Julian Meng (University of New Brunswick)

Project Started: Oct 2010

Expected Project Completion Date: Sep 2015

Progress Highlights for October 1st 2010 to September 31st 2011

Please provide a brief high-level summary that outlines the progress, research results or any issues during the reporting period. State the milestones achieved with reference to the research proposal.

- Two MSc and one Phd graduate students have been recruited.
- Preliminary research has begun and a literature review of possible wireless sensor network protocols has started. Focus is on redundancy and reliability.
- An Ember ZigBee sensor development platform has been purchased.
- Initial research on impulsive noise impact on ZigBee sensors with Sub-stations as a focus has started.
- Hardened weatherproof cases for the sensors have been investigated.

Detailed Research Report

Please indicate the status of all milestones as "Not started", "In progress" or "Complete" as appropriate. Milestones and timeframes are based on the research plan: if these have changed please indicate and explain.

- Conduct wireless measurement tests in Sub-stations (2012).
- Develop a test bench to determine the impact of impulsive noise on ZigBee sensors.
- Determine relevant measurement parameters in Sub-stations, e.g. temperature, vibration, interference, etc.
- Develop a robust and redundant sensor topology using ZigBee sensor protocols. Focus on plug and play, ease of deployment, robustness and low-cost.
- Develop a simulation for the IEEE 802.15.4 standard and determine the effects of impulsive noise.
- Engineer/design environmentally resistant sensor casings for outdoor deployment.
- Deploy sensor network within a harsh Sub-station environment.

Please provide more details for milestones currently in progress. Describe any problems and resolutions.

No issues.

Intellectual Property and Publications

Refereed Journal Publications

Non-Refereed Journal Publications

Invited conference presentations

Non-Invited conference presentations

T. Losier et al. "Distribution Automation: Sensors and Condition Monitoring", Poster, Smartgrid Canada Conference, Toronto, Ontario, October, 2011.

Technical reports, patents, licenses and other intellectual property

Research Collaborations and Interactions

Summarize briefly your network-related interactions and activities

Research Partners

Collaborations will be with Project 1.3 (Dr. Xu), Project 3.1 (Dr. Michelson) and Project 3.4 (Dr. Farhangi)

Industrial Partners

We will work closely with NBPower and Saint John Energy to perform Sub-station channel measurements, and in the future, deploy sensor networks in Sub-stations.

International Collaborations

Exchanges by Highly Qualified Personnel

Other

Highly Qualified Personnel (HQP)

Please list all HQP since the start of the project. Include forecast End Dates for students currently engaged.

Status (U, M, P)	Name	Email	Start Date	End Date
M	Tristan Losier		May 2011	
M	A. Kar		Sept 2011	
P	Yandy Perez		Jan 2012	
U	Tareq Khammash		May 2011	Aug 2011

Discuss any discrepancies between planned HQP and those actually hired

Project Budget

Note and explain any deviations greater than 20% between actual and budgeted project expenses

Describe any cash or in-kind contributions, other than NSMG-Net, in support of this project

Other UNB grants will used when needed to purchase equipment.

Year Two Forecast – Proposed

	Year 1 Forecast	Year 1 Actual		Year 2 Forecast
Expenditures				
Undergraduate	\$4 300	\$3 600		\$4 300
Masters (2 students)	\$31 000	\$23 284		\$31 000
PhD	\$18 900	\$ 0		\$18 900
Students*	\$54 200	\$26 884	-50%	\$54 200
Materials and supplies	\$4 600	\$4 941	7%	\$4 600
Conference travel	\$5 000	\$5 000	0%	\$5 000
Publication costs	\$1 000	\$ 100	-90%	\$1 000
Total	\$64 800	\$36 925	-43%	\$64 800
Funding				
Own university		\$ 0		\$ 0
Carried over		\$ 0		\$27 875
April transfer		\$31 900		\$32 400
October transfer		\$32 900		\$32 400
Total		\$64 800		\$92 675
			Forecast surplus	\$27 875



Annual Progress Report

Project 3.4

Integrated Data Management and Portals

Project Leader: Hassan Farhangi (BCIT)

Project Started: Oct 2010

Expected Project Completion Date: Sep 2015

Progress Highlights for October 1st 2010 to September 31st 2011

Please provide a brief high-level summary that outlines the progress, research results or any issues during the reporting period. State the milestones achieved with reference to the research proposal.

- Defined the outlines for two PhD projects and one Masters project
- Supervisory team was assembled (H Farhangi & A Palizban from BCIT, M. Saif from SFU)
- Project concepts were published in a paper presented at IEEE Conference in Korea (H. A. Palizban, H. Farhangi, "Low Voltage Distribution Substation Integration in Smart Microgrid", ICPE 2011–ECCE Asia, May 2011.
- Problem with hiring students

Detailed Research Report

Please indicate the status of all milestones as “Not started”, “In progress” or “Complete” as appropriate. Milestones and timeframes are based on the research plan: if these have changed please indicate and explain.

- Use cases, and development of Intelligent Agents (2011)
 - *(Copy to remaining milestones and delete as appropriate)*
 - Not started
 - In progress (XX% complete)
 - Complete
- Efficient database structure development (2011-2012)
- Development of portals for Customer and Utility use (2012-2014)
- End-to-end data system developed, integrated with hardware and tested (2014-2015)
- Load Side Energy Management Portal for optimization of power/service dispatch to Residential and Enterprise loads
- Feeder Side Energy Management Portal for optimization of power/service dispatch to fleet of Electrical Vehicle Charging Stations
- Anatomy of cost-effective & real-time Intelligent Agents required for a Distributed Energy Management System

Please provide more details for milestones currently in progress. Describe any problems and resolutions.

Intellectual Property and Publications

Refereed Journal Publications

•

Non-Refereed Journal Publications

•

Invited conference presentations

- Paper presented at IEEE Conference in Korea (H. A. Palizban, H. Farhangi, “Low Voltage Distribution Substation Integration in Smart Microgrid”, ICPE 2011–ECCE Asia, May 2011.

Non-Invited conference presentations

-

Technical reports, patents, licenses and other intellectual property

Research Collaborations and Interactions

Summarize briefly your network-related interactions and activities

Research Partners

Industrial Partners

International Collaborations

Exchanges by Highly Qualified Personnel

Other

Highly Qualified Personnel (HQP)

Please list all HQP since the start of the project. Include forecast End Dates for students currently engaged.

Status (U, M, P)	Name	Email	Start Date	End Date
M	Babak Shahabi	bshahabi@sfu.ca	1/8/11	TBD
P	Maryam Nasri	maryam_nasri@sfu.ca	1/8/11	TBD
P	Moein Manbachi	moeinmanbachi@yahoo.ca	1/9/11	TBD

Discuss any discrepancies between planned HQP and those actually hired

Students are normally hired in the fall. Given the start date of the network (i.e. Oct 2010), the window to hire students for the defined projects was already closed. The next window to hire students will be in Sept 2011.

Nevertheless, we worked with our research collaborators at Simon Fraser University to look for students who were already on board, having completed their mandatory courses and were looking for projects.

Two such students were identified, one at the Masters level (Babak Shahabi), and another at the PhD level (Maryam Nasri), who expressed interest in working on projects related to Smart Grid. The two were signed up for two research topics under Project 3.4 and have started their literature research.

The third student (Moein Manbachi) has applied to SFU to do a PhD in Electrical Engineering. We have interviewed him and found him a string candidate for one of the defined topics under Project 3.4. We have made our recommendations to SFU admissions and await the outcome of their review.

Project Budget

Note and explain any deviations greater than 20% between actual and budgeted project expenses

Difficulty in hiring students was the major reason for failing to fully consume the allocated funds. Moreover, due to the complexity of the project, it was decided to hire two PhD students and one Masters student.

Presently, we do not anticipate a need to hire undergraduate students. However, given the progress of the project and in the likelihood of the need to make certain experiments or prototypes, we will consider hiring undergraduate students as well.

Describe any cash or in-kind contributions, other than NSMG-Net, in support of this project

	Year 1 Forecast	Year 1 Actual		Year 2 Forecast
Expenditures				
Undergraduate	\$4 300			\$4 300
Masters (2 students)	\$31 000	\$7 600		\$31 000
PhD	\$18 900	\$19 500		\$18 900
Students*	\$54 200	\$27 100	-50%	\$54 200
Materials and supplies	\$4 600	\$4 600	0%	\$4 600
Conference travel	\$5 000	\$5 000	0%	\$5 000
Publication costs	\$1 000	\$1 000	0%	\$1 000
Total	\$64 800	\$37 700	-42%	\$64 800
Funding				
Own university		\$ 0		\$ 0
Carried over		\$ 0		\$27 100
April transfer		\$32 400		\$32 400
October transfer		\$32 400		\$32 400
Total		\$64 800		\$91 900
			Forecast surplus	\$27 100

Section 3

- Budget
- Networking
- Technology Transfer

Year 1 Budget Report

Income

Cash Contributions from Supporting Organizations

	Expected	Received	Awaiting	Comments
NSERC	\$ 554,625	\$ 554,625	\$ -	
Universities				
U New Brunswick	\$ 5,000	\$ -	\$ -	\$ 5,000 misunderstanding re cash and in-kind contribution
U of Toronto	\$ 4,000	\$ 4,000	\$ -	
McGill	\$ 3,000	\$ 3,000	\$ -	
Ryerson	\$ 3,000	\$ 3,000	\$ -	
U of Manitoba	\$ 3,000	\$ 3,000	\$ -	
Government				
NRCan	\$ 25,000	\$ -	\$ 25,000	expected April 2012
Industry				
BC Hydro	\$ 100,000	\$ 34,944	\$ 20,000	\$ 45,056 reduction due to later start of Network Manager expected October 2011
Hydro one	\$ 30,000	\$ -	\$ 30,000	
Schneider	\$ 5,000	\$ 5,000	\$ -	expected October 2011
Eion	\$ 5,000	\$ -	\$ 5,000	
Endurance Power	\$ 1,000	\$ 1,000	\$ -	
Nebula	\$ 1,000	\$ 1,000	\$ -	
Total cash from industry	\$ 142,000	\$ 41,944	\$ 55,000	
Total cash from universities	\$ 18,000	\$ 13,000	\$ -	
Total cash from other sources	\$ 25,000	\$ -	\$ 25,000	
Total cash from NSERC	\$ 554,625	\$ 554,625	\$ -	
Total income	\$ 739,625	\$ 609,569	\$ 80,000	\$ 50,056 reduction in total ultimate expected income

Transfers to Universities

Transfers made to participants

	Planned	Actual	Difference	
Income	\$ 739,625	\$ 609,569	\$ 80,000	
U Western Ontario	\$ 30,900	\$ 32,100	\$ (1,200)	
U Toronto	\$ 62,800	\$ 64,400	\$ (1,600)	
U Alberta	\$ 32,400	\$ 32,400	\$ -	
McGill	\$ 95,700	\$ 96,900	\$ (1,200)	
U Waterloo	\$ 32,400	\$ 32,400	\$ -	
U Manitoba	\$ 30,900	\$ 32,100	\$ (1,200)	
UBC	\$ 32,400	\$ 32,400	\$ -	
U New Brunswick	\$ 29,900	\$ 31,900	\$ (2,000)	
BCIT (SFU)	\$ 32,400	\$ 32,400	\$ -	
Total	\$ 379,800	\$ 387,000	\$ (7,200)	Over-transfer to universities
Administration	\$ 146,900	\$ 63,012	\$ 83,888	Administration underspend
Funds remaining at BCIT	\$ 212,925	\$ 159,557		
In NSERC account		\$ 152,557		
In Partner account		\$ 7,000		

Planned October transfers to participants

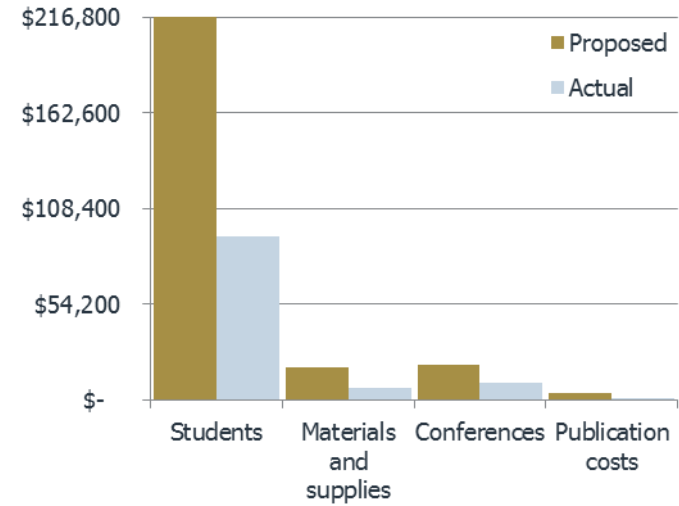
	Planned	Actual	Difference	
Additional NSERC income	\$ 184,875	\$ 184,875	\$ -	
Ryerson University	\$ 30,900	\$ -	\$ (30,900)	Insufficient progress
U Toronto	\$ 62,800	\$ 61,200	\$ (1,600)	Correcting for over-transfer
U Alberta	\$ 32,400	\$ 32,400	\$ -	
McGill	\$ 95,700	\$ 94,500	\$ (1,200)	Correcting for over-transfer
U Waterloo	\$ 32,400	\$ 32,400	\$ -	
U Manitoba	\$ 30,900	\$ 29,700	\$ (1,200)	Correcting for over-transfer
UBC	\$ 32,400	\$ 32,400	\$ -	
U New Brunswick	\$ 29,900	\$ 32,900	\$ 3,000	Correcting for under-transfer
BCIT (SFU)	\$ 32,400	\$ 32,400	\$ -	
Funds remaining at BCIT after transfer		\$ (3,468)		

Expenditure

Theme 1

Expenditures for direct cost of research

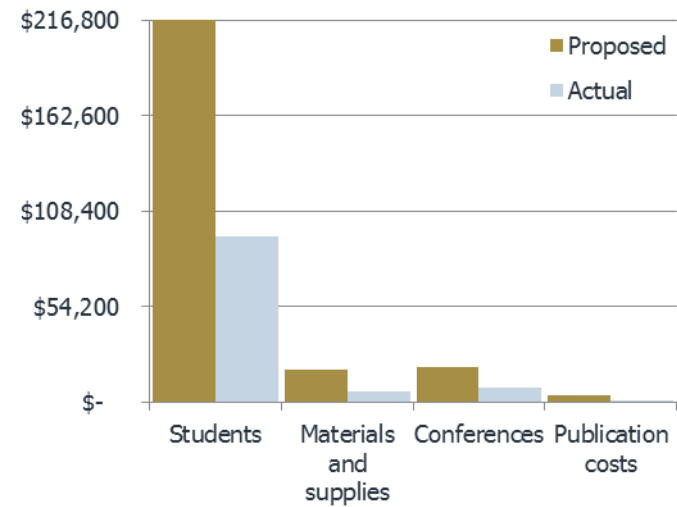
Theme 1	Proposed	Actual	Underspend
Salaries and benefits			
Students	\$ 216,800	\$ 92,726	\$ 124,074
Postdoctoral fellows	\$ -	\$ -	\$ -
Technical/professional assistants	\$ -	\$ -	\$ -
Network Manager	\$ -	\$ -	\$ -
Equipment or facility	\$ -	\$ -	\$ -
Purchase or rental	\$ -	\$ -	\$ -
Operation and maintenance costs	\$ -	\$ -	\$ -
User fees	\$ -	\$ -	\$ -
Materials and supplies	\$ 18,400	\$ 6,700	\$ 11,700
Travel	\$ -	\$ -	\$ -
Conferences	\$ 20,000	\$ 9,762	\$ 10,238
Field work	\$ -	\$ -	\$ -
Collaboration/consultation	\$ -	\$ -	\$ -
Dissemination costs	\$ -	\$ -	\$ -
Publication costs	\$ 4,000	\$ 1,000	\$ 3,000
Other activities	\$ -	\$ -	\$ -
Other	\$ -	\$ -	\$ -
Board	\$ -	\$ -	\$ -
Technology transfer	\$ -	\$ -	\$ -
Total expenditures	\$ 259,200	\$ 110,188	\$ 149,012



Theme 2

Expenditures for direct cost of research

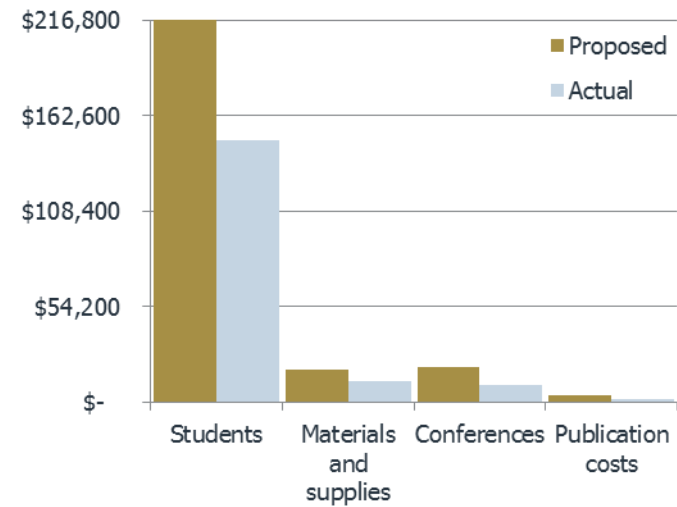
Theme 2	Proposed	Actual	Underspend
Salaries and benefits			
Students	\$ 216,800	\$ 93,835	\$ 122,965
Postdoctoral fellows	\$ -	\$ -	\$ -
Technical/professional assistants	\$ -	\$ -	\$ -
Network Manager	\$ -	\$ -	\$ -
Equipment or facility	\$ -	\$ -	\$ -
Purchase or rental	\$ -	\$ -	\$ -
Operation and maintenance costs	\$ -	\$ -	\$ -
User fees	\$ -	\$ -	\$ -
Materials and supplies	\$ 18,400	\$ 6,500	\$ 11,900
Travel	\$ -	\$ -	\$ -
Conferences	\$ 20,000	\$ 7,980	\$ 12,020
Field work	\$ -	\$ -	\$ -
Collaboration/consultation	\$ -	\$ -	\$ -
Dissemination costs	\$ -	\$ -	\$ -
Publication costs	\$ 4,000	\$ 1,000	\$ 3,000
Other activities	\$ -	\$ -	\$ -
Other	\$ -	\$ -	\$ -
Board	\$ -	\$ -	\$ -
Technology transfer	\$ -	\$ -	\$ -
Total expenditures	\$ 259,200	\$ 109,315	\$ 149,885



Theme 3

Expenditures for direct cost of research

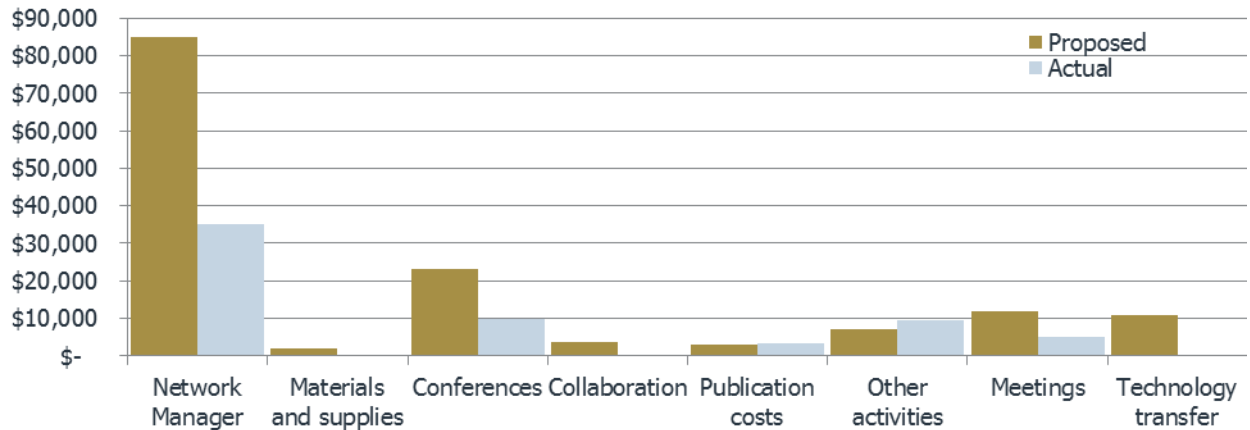
Theme 3	Proposed	Actual	Underspend
Salaries and benefits			
Students	\$ 216,800	\$ 148,565	\$ 68,235
Postdoctoral fellows	\$ -	\$ -	\$ -
Technical/professional assistants	\$ -	\$ -	\$ -
Network Manager	\$ -	\$ -	\$ -
Equipment or facility	\$ -	\$ -	\$ -
Purchase or rental	\$ -	\$ -	\$ -
Operation and maintenance costs	\$ -	\$ -	\$ -
User fees	\$ -	\$ -	\$ -
Materials and supplies	\$ 18,400	\$ 12,020	\$ 6,380
Travel	\$ -	\$ -	\$ -
Conferences	\$ 20,000	\$ 10,000	\$ 10,000
Field work	\$ -	\$ -	\$ -
Collaboration/consultation	\$ -	\$ -	\$ -
Dissemination costs	\$ -	\$ -	\$ -
Publication costs	\$ 4,000	\$ 2,000	\$ 2,000
Other activities	\$ -	\$ -	\$ -
Other	\$ -	\$ -	\$ -
Board	\$ -	\$ -	\$ -
Technology transfer	\$ -	\$ -	\$ -
Total expenditures	\$ 259,200	\$ 176,700	\$ 82,500



Administration

Expenditures for direct cost of research

Administration Expenditure	Proposed	Actual	Underspend
Salaries and benefits			
Students	\$ -	\$ -	\$ -
Postdoctoral fellows	\$ -	\$ -	\$ -
Technical/professional assistants	\$ -	\$ -	\$ -
Network Manager	\$ 85,100	\$ 34,944	\$ 50,156
Equipment or facility	\$ -	\$ -	\$ -
Purchase or rental	\$ -	\$ -	\$ -
Operation and maintenance costs	\$ -	\$ -	\$ -
User fees	\$ -	\$ -	\$ -
Materials and supplies	\$ 2,000	\$ -	\$ 2,000
Travel	\$ -	\$ -	\$ -
Conferences	\$ 23,000	\$ 10,000	\$ 13,000
Field work	\$ -	\$ -	\$ -
Collaboration/consultation	\$ 3,825	\$ -	\$ 3,825
Dissemination costs	\$ -	\$ -	\$ -
Publication costs	\$ 3,000	\$ 3,322	\$ (322)
Other activities	\$ 7,000	\$ 9,557	\$ (2,557)
Other	\$ -	\$ -	\$ -
Board/committee meetings	\$ 12,000	\$ 5,189	\$ 6,811
Technology transfer	\$ 10,975	\$ -	\$ 10,975
Total expenditures	\$ 146,900	\$ 63,012	\$ 83,888



Combined Researcher and Administration Expenditures

Consolidated Expenditures

Sum Total	Proposed	Actual	Underspend
Salaries and benefits			
Students	\$ 650,400	\$ 335,126	\$ 315,274
Postdoctoral fellows	\$ -	\$ -	\$ -
Technical/professional assistants	\$ -	\$ -	\$ -
Network Manager	\$ 85,100	\$ 34,944	\$ 50,156
Equipment or facility	\$ -	\$ -	\$ -
Purchase or rental	\$ -	\$ -	\$ -
Operation and maintenance costs	\$ -	\$ -	\$ -
User fees	\$ -	\$ -	\$ -
Materials and supplies	\$ 57,200	\$ 25,220	\$ 31,980
Travel	\$ -	\$ -	\$ -
Conferences	\$ 83,000	\$ 37,742	\$ 45,258
Field work	\$ -	\$ -	\$ -
Collaboration/consultation	\$ 3,825	\$ -	\$ 3,825
Dissemination costs	\$ -	\$ -	\$ -
Publication costs	\$ 15,000	\$ 7,322	\$ 7,678
Other activities	\$ 7,000	\$ 9,557	\$ (2,557)
Other	\$ -	\$ -	\$ -
Board/committee meetings	\$ 12,000	\$ 5,189	\$ 6,811
Technology transfer	\$ 10,975	\$ -	\$ 10,975
Total expenditures	\$ 924,500	\$ 459,216	\$ 465,284

Overall Budget Summary Year One

There has been an underspend of greater than 20% in all three themes, which is principally due to hiring fewer students than forecast. Please find attached notes of explanation from the relevant project leaders.

Of note is Dr Yazdani, leader of project 1.1, who has moved from University of Western Ontario to Ryerson University. Knowing his move was likely, he did not hire students, so that the move could be made cleanly.

Underspend of the network-level budget is also due to the later than forecast start of the Network Manager.

There were administrative delays in the first half of the network year. The network agreement was not sent for signing until mid-May 2011 and was not signed by all parties until July 2011. The first fund transfer was not made from BCIT to researchers until April 2011.

Researchers have expressed confidence and enthusiasm in the research program, which was strongly communicated at the AGM.

The network begins its second year on much firmer footing. Reporting and financial structures are in place, and with the launch of the website both outreach and internal communication will be much more frequent and transparent. The website includes a password protected knowledge repository for researchers and their students to capture weekly progress, thus facilitating biannual reporting.

Year 2 Budget Forecast

Some funds are currently forecast to remain at BCIT due to reduced budget in Project 1.1

Forecast Cash Contributions from Supporting Organizations

NSERC	\$	739,500
Universities		
U New Brunswick	\$	-
U of Toronto	\$	4,000
McGill	\$	3,000
Ryerson	\$	3,000
U of Manitoba	\$	3,000
Government		
NRCan	\$	25,000
Industry		
BC Hydro	\$	100,000
Hydro one	\$	30,000
Schneider	\$	5,000
Eion	\$	5,000
Endurance Power	\$	1,000
Nebula	\$	1,000
		Expected
Total cash from industry	\$	142,000
Total cash from universities	\$	13,000
Total cash from other sources	\$	25,000
Total cash from NSERC	\$	739,500
 Total income	\$	 919,500

Transfers Planned Year Two

	Apr-11	Oct-12	Total	Y1 Carry-Over
Y2 Income			\$ 919,500	
Ryerson University	\$ 29,700	\$ -	\$ 29,700	\$ 32,100
U Toronto	\$ 62,800	\$ 62,800	\$ 125,600	\$ 58,800
U Alberta	\$ 32,400	\$ 32,400	\$ 64,800	\$ 24,900
McGill	\$ 95,700	\$ 95,700	\$ 191,400	\$ 75,512
U Waterloo	\$ 32,400	\$ 32,400	\$ 64,800	\$ 28,785
U Manitoba	\$ 30,900	\$ 30,900	\$ 61,800	\$ 46,100
UBC	\$ 32,400	\$ 32,400	\$ 64,800	\$ 23,514
U New Brunswick	\$ 32,400	\$ 32,400	\$ 64,800	\$ 31,886
BCIT (SFU)	\$ 32,400	\$ 32,400	\$ 64,800	\$ 27,100
Sub-total	\$ 381,100	\$ 351,400	\$ 732,500	\$ 348,697
Administration			\$ 146,900	
Total			\$ 879,400	
Forecast surplus at BCIT			\$ 40,100	

Higher forecast student expenditure in Themes 1 and 2 covered by held-over funds from Year One.

Expenditures for direct cost of research

	Theme 1	Theme 2	Theme 3	Admin	
Salaries and benefits					
Students	\$ 243,400	\$ 224,500	\$ 216,800	\$ -	
Postdoctoral fellows	\$ -	\$ -	\$ -	\$ -	
Technical/professional assistants	\$ -	\$ -	\$ -	\$ -	
Network Manager	\$ -	\$ -	\$ -	\$ 85,100	
Equipment or facility	\$ -	\$ -	\$ -	\$ -	
Purchase or rental	\$ -	\$ -	\$ -	\$ -	
Operation and maintenance costs	\$ -	\$ -	\$ -	\$ -	
User fees	\$ -	\$ -	\$ -	\$ -	
Materials and supplies	\$ 18,400	\$ 18,400	\$ 18,400	\$ 2,000	
Travel	\$ -	\$ -	\$ -	\$ -	
Conferences	\$ 20,000	\$ 20,000	\$ 20,000	\$ 23,000	
Field work	\$ -	\$ -	\$ -	\$ -	
Collaboration/consultation	\$ -	\$ -	\$ -	\$ 3,825	
Dissemination costs	\$ -	\$ -	\$ -	\$ -	
Publication costs	\$ 4,000	\$ 4,000	\$ 4,000	\$ 3,000	
Other activities	\$ -	\$ -	\$ -	\$ 7,000	
Other	\$ -	\$ -	\$ -	\$ -	
Board	\$ -	\$ -	\$ -	\$ 12,000	
Technology transfer	\$ -	\$ -	\$ -	\$ 10,975	
Total expenditures	\$ 285,800	\$ 266,900	\$ 259,200	\$ 146,900	<u><u>\$ 958,800</u></u>

Networking

Summary of Annual Network Meeting

Network meeting took place Monday October 24th at Allstream Centre. Forty attendees, including ten students and over a dozen industry partners, gathered to hear reports from Project Leaders.

Meetings of Network Researchers

At the AGM Researchers met in Theme groups and planned for meetings and collaborations in the coming year.

Student Exchanges & Internships

No student exchanges or internships took place in this first year of the Network.

Other Student Activities and/or Training

Ten students attended the AGM and Smart Grid Canada, meeting industry and government participants as well as, in many cases, meeting each-other face to face for the first time.

Conference Participation

Dr Joós, Dr Iravani and Dr Farhangi presented at the CIGRE Symposium 'The electric power system of the future – Integrating supergrids and microgrids', Bologna, presented in September 2011.

Dr Bhattacharya presented at IEEE PES General Meeting, Detroit, July 2011 and at Canadian Operation Research conference, St. John's, June 2011

Dr Michelson, Dr Le-Ngoc at IEEE APS/URSI Symposium, Spokane, WA, 2011

Dr Le-Ngoc at *IEEE Canadian Conference on Electrical and Computer Engineering 2011*, Niagara Falls, Ontario, May 8-11, 2011

Dr Farhangi presented at IEEE Conference in Korea, ICPE 2011–ECCE Asia, May 2011.

International Collaborations

Project 1.2 established collaboration with KEPCO and LSIS Industries from South Korea and National Instruments from USA. Dr Iravni is also in the process of establishing partnership with ABB, Sweden, and GE Digital Energy, Toronto, for the project.

Project 2.2 has established close collaborative efforts with two partners (one power utility and one manufacturing company) in south Korea, two power utility companies in Denmark and Spain.

Technology Transfer

Interactions with Partner Organizations

List of Researchers and Organizations participating

BC Hydro	Giuseppe Stanciulescu
Hydro One	Charles Esendal
NRCan	Lisa Dignard-Bailey
Eion	Anand Srinivasan
Endurance Power	David Rankin
Nebula	Lee Vishloff
CYME International	Daniel Desrosiers
Schneider Electric	John Toffler
Manitoba HVDC	Roberta Desserre
Xantrex	Mark Edmunds
NRC-IFCI	Francois Girard
Powertech labs	Andrew Klimek
Hydro Quebec	Chad Abbey
IESO	Mike Falvo
Ballard Power	Terry Howe
OPA	Jenni Myllynen
OCE	Carole Champion
UBC	David Michelson
U. Alberta	Wilsun Xu
U. Manitoba	Ani Gole
Ryerson U.	Amirnaser Yazdani
U. Toronto	Reza Iravani
U. Waterloo	Kankar Bhattacharaya
McGill	Géza Joós
McGill	Tho Le-Ngoc
UNB	Julian Meng
BCIT	Hassan Farhangi

Summary of Planned vs Actual Collaborations

Most projects carried out background research in the first year, which involved more individual work than collaborative. However, several projects have engaged with partners, and even sought new relationships to benefit the network.

Project 1.2 case studies and the system information/data were identified and decided upon in close collaboration with engineers from Toronto Hydro and in consultation with engineers from

Hydro One and BC Hydro. Furthermore close collaboration was established with RTDS Technologies for the development of real-time simulation environment for microgrids.

Project 2.2 has been actively engaged in collaborative R&D with Toronto Hydro for hardware realization of a specific version of our envisioned microgrid control system for based on a mixture of fiber-optics and SCADA for testing in late 2012. Collaborations with BC Hydro, Hydro One, Hydro Quebec and other industrial partners has been at the level of discussions and information gathering. Finally, Dr Iravani has established close collaboration with RTDS Technologies and National Instruments for hardware and HIL test-bed developmet.

Project 2.3 will collaborate with Dr. Steve Wong (from NRCAN) in this project, and our first neeting will be held on 28th October 2011, to discuss the research problem and some ideas and directions.

Project 3.1 BC Hydro and Huawei Technologies and with support from Mentum. Also Communications Research Centre in Ottawa is porting their Spectrum Explorer software to UBC's Agilent N6841A RF Sensors and providing the project with a complimentary Spectrum explorer software licence at no charge.

Project 3.2 has had discussions with Hydro-Quebec IREQ technical staff members about the project and technical issues.

Project 3.3 will work closely with NBPower and Saint John Energy to perform Sub-station channel measurements, and in the future, deploy sensor networks in Sub-stations.

Technology Transfer Activities

No tangible activities in this inaugural year.

Contribution to Policy or Standards

None reported.

Network Publicity and Media Coverage

The website was launched in September 2011, and the Network Manager plans to step up online presence from November 2011. A twitter account and linkedin company page were also created.

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

<http://twitter.com/#!/smartmicrogrid>

<http://www.linkedin.com/company/nsmg-net>

Partner Cyme issued a press release in June 2011

http://www.cooperindustries.com/content/dam/public/news/en/power_systems/CYME_NSERC_SmartMicrogrid_PR.pdf