WATERLOO



# WISE

WATERLOO INSTITUTE
FOR SUSTAINABLE ENERGY

## 2012/2013 ANNUAL REPORT


CONSERVE
energy through greater efficiency
IMPROVE
conventional generation methods
BRIDGE
supply and demand with better storage
SUSTAINABLE
ENERGY
FUTURE
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TRANSFORM
energy systems through
game-changing technologies
ENABLE
smart policies and planning
DELIVER
energy more intelligently
ILLUSTRATION: UNIVERSITY OF WATERLOO, CREATIVE SERVICES,
DEVELOPED FOR WATERLOO INSTITUTE FOR SUSTAINABLE ENERGY, 2012.

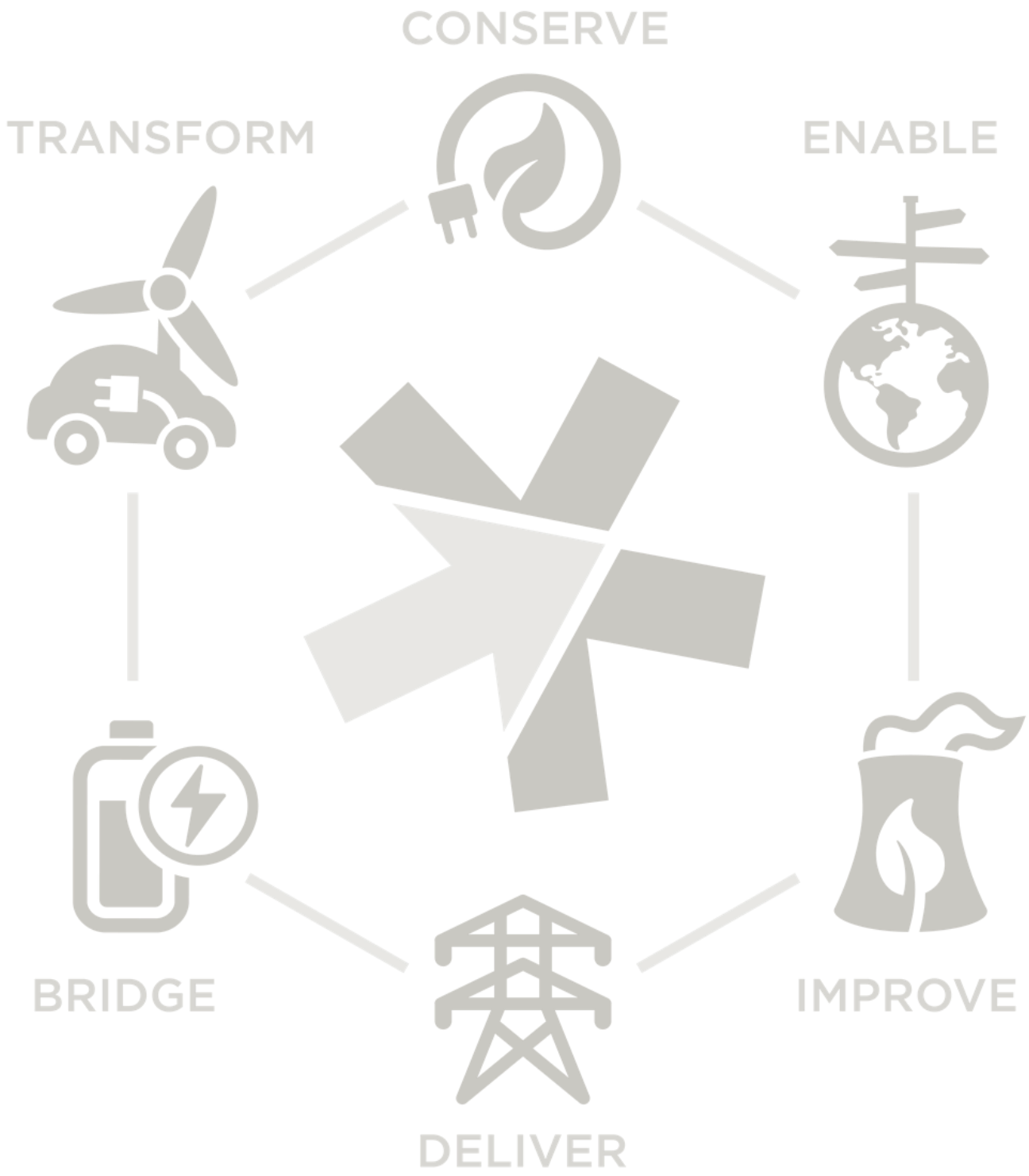
Energy challenges command our world's attention. A healthy energy system requires balance amongst energy resources we know and those we have yet to bring to fruition.

To build a globally sustainable energy future requires us to rethink and then re-fashion the way we produce and use energy. In this critical endeavor, we wish to engage emerging science and technologies to unlock the previously unimagined pathways for the evolution of the energy system.

## At WISE

we focus on integration of social, environmental and economic innovation that can enable rapid diffusion of transformative technologies.

## Our vision: clean energy, accessible and affordable for all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**Mission** conduct original research and develop innovative solutions and policies to help transform the energy system for long-term sustainability.

## Strategic objectives

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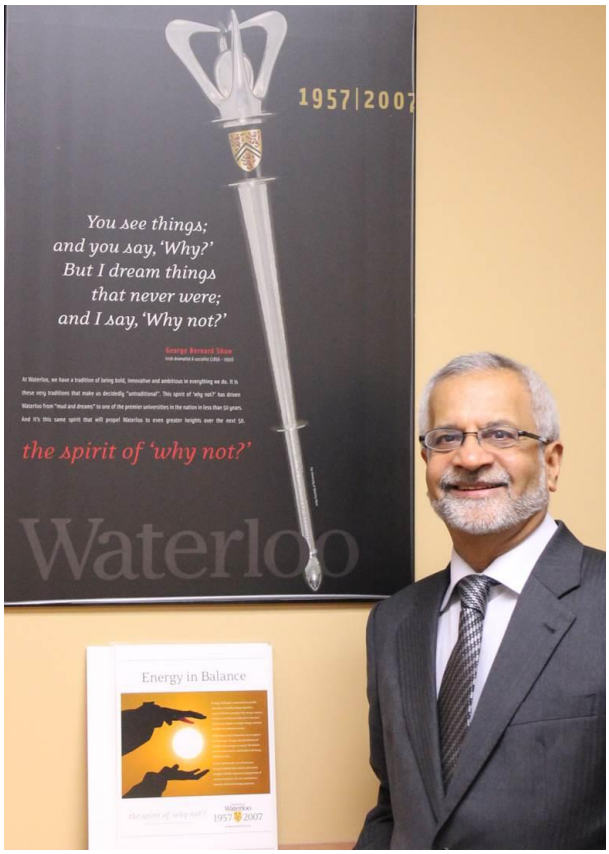
**Collaborate** expand opportunities for multi-disciplinary energy research at Waterloo, improve research productivity – share facilities and resources, and develop HQP through research and education.

**Reach Out** promote engagement of external partners and advance energy research through partnerships and greater access to research funding.

**Influence** establish WISE as the authoritative source of energy insights and analysis, and translate important scientific discoveries for a wide audience, informing energy policy both here and around the globe.




# Note from the Executive Director

WISE was established in 2008 to provide a focal point of energy research at the University of Waterloo. The University's Senate Research and Graduate Council renewed the mandate for another five years in May 2013.

The scope and scale of energy research activities underway at WISE is large and unique in its research coverage across a diverse range of areas (see following page).

The Institute's membership grew to over 100 researchers representing all faculties. WISE continues to attract a diverse group of researchers who wish to apply their traditional expertise towards meeting the challenges of the energy sector. The ultimate goal of the Institute is to make technological breakthroughs that will enhance quality of life through better use of our energy resources.

The overall strength of energy research activity at UW, based on the average annual research dollars per faculty member, is approximately $22 Million.

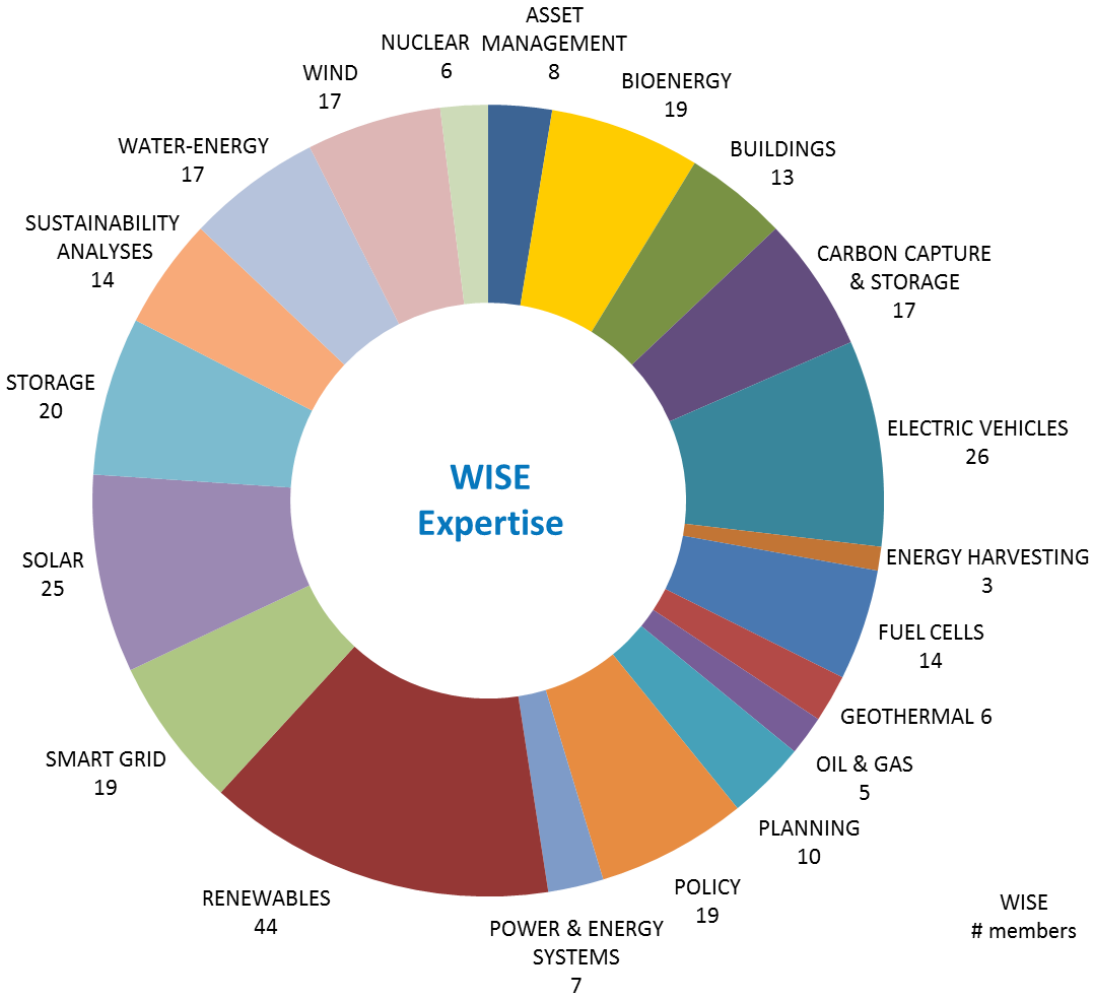
WISE continues to intensify communication and outreach programs to share the knowledge created and to cultivate energy literacy. WISE and the University of Waterloo are becoming internationally recognized as leaders in addressing the global energy challenge.

We look forward to building effective partnerships amongst our faculty and organizations nationally and internationally.

Dr. Jatin Nathwani
Professor and Ontario Research Chair in Public Policy for Sustainable Energy
Executive Director, Waterloo Institute for Sustainable Energy (WISE)

## Areas of Expertise

20




## Number of members

104

## Faculties represented

6

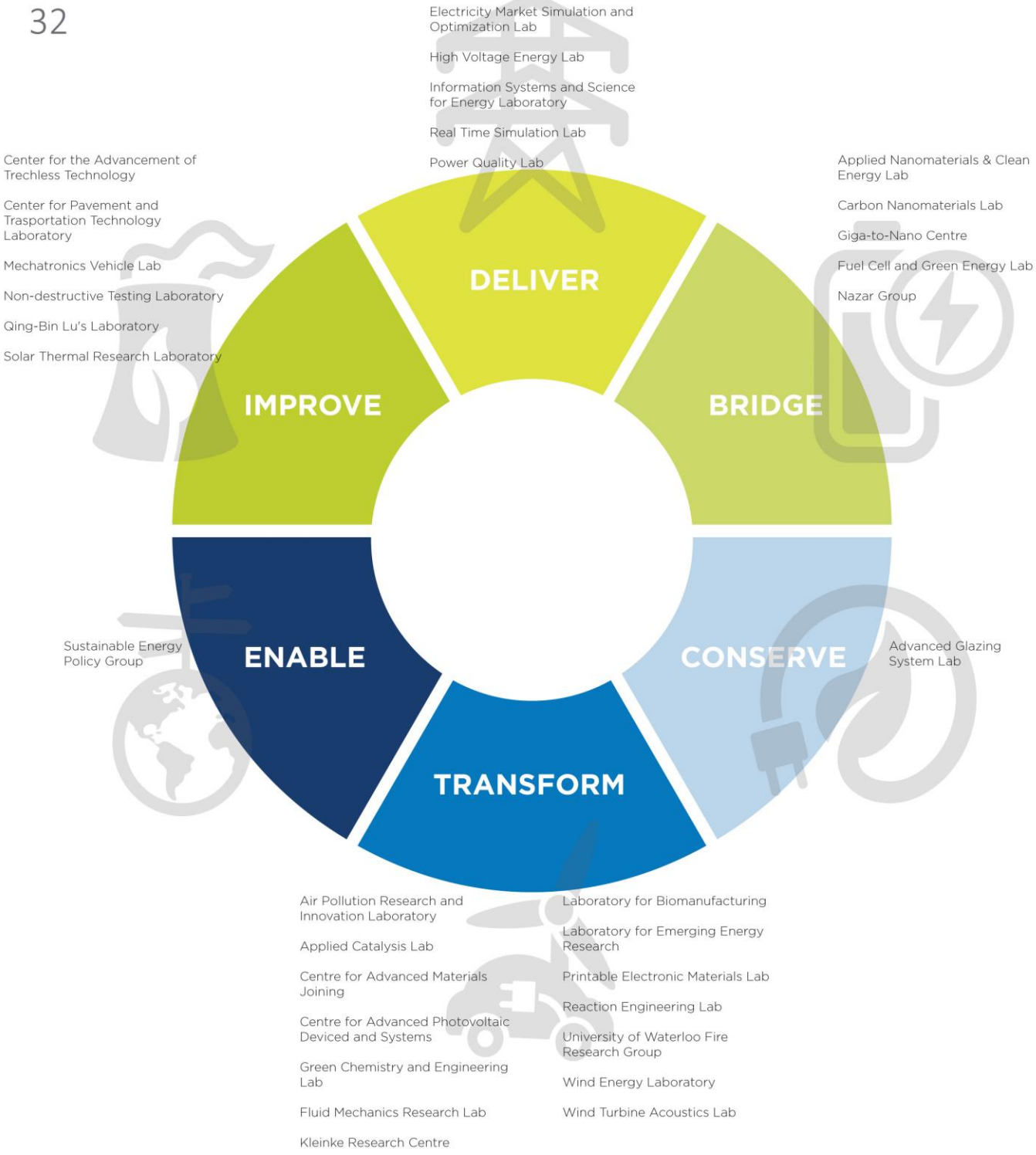
## Number of research chairs

20

# Research Laboratories

## Number of labs

32

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# COLLABORATE

At WISE, we believe the biggest breakthroughs come from uniting leading researchers from dozens of disciplines. Our membership spans 22 departments and encompasses every faculty at the University of Waterloo.

## Large-scale multi-disciplinary projects

19

- Applied Health Sciences
- Arts
- Engineering
- Environment
- Mathematics
- Science

## Energy Research Initiatives

Highlighted below are several major energy research initiatives underway at Waterloo. WISE provides a leadership role in attracting external partners and helps shape the development of the projects to approvals and execution.

### Energy Hub Management System II

- $5.13M collaborative project combines expertise across WISE in the development of an energy management system that allows utilities and customers in various sectors to effectively manage their energy use (Phase 1 complete).
- PI – Phase 2: Claudio Cañizares.
- Project partners: include the Ontario Centres of Excellence, Hydro One Networks Inc., Energent Energy Solutions, Milton Hydro Distribution Inc., Ontario Power Authority.

### Smart Transmission and Distribution Systems with Increasing Renewable Energy Penetration

- $2.5M investment by Hydro One supports numerous research activities in power systems. This project has significantly advanced research in the field of active distribution systems, distributed generation controls and energy management.
- PI – Magdy Salama.

*…. WISE also provides a vital role in helping new faculty gain contacts with industry and government agencies, and in promoting the efforts of established faculty at University of Waterloo in energy-related research.*

LINDA F. NAZAR
Professor, Department of Chemistry and Physics

## Off-Grid Access and Microgrids

- $4.4M collaborative research and development initiative (ecoEnergy and OCE project). Development of a unique controller for use in microgrid applications incorporating renewable energy production and storage as part of the project.
- PI – Claudio Cañizares, with Ehab El-Saadany, Paul Parker, Mehrdad Kazerani and Kankar Bhattacharya.
- Engaging with the Kasabonika Lake First Nations Community.
- Project partners: Natural Resources Canada, Hatch, University of Toronto, Hydro One and Wenvor.
- $1M parallel effort to reduce diesel dependency and financial burden of diesel power in remote Northern Ontario communities.
- PI – David Johnson.
- Project Partner: OCE.

## Operation, Communications and Information Management for Smart Electricity Grids

- $1.6M three-year research initiative brings together, for the first time, a collaborative effort to develop solutions for Smart Grids as three aspects merged to meet the requirements of the day – the power system, the communication system, and the information system are linked.
- Researchers: Kankar Bhattacharya, Catherine Rosenberg, Claudio Cañizares, Srinivasan Keshav and Jatin Nathwani.
- Project partners include NSERC, IBM, ABB and Hydro One.

# Information Systems and Science for Energy

- $1M investment by Cisco Systems Canada Co. towards the next generation development of a Smart Grid characterized by an emerging paradigm shift from a static predictable system to a highly dynamic system with elastic loads, two way power flows and millions of points of control.
- Cisco Chair: Srinivasan Keshav.
- Co-PIs: Srinivasan Keshav and Catherine Rosenberg.
- An additional $1M in research funds through NSERC CRD's will enhance the scope of activities.

# Electric Vehicle Demonstration

- $330K from Transport Canada towards this electric vehicle demonstration project. The findings will provide the insights and tools to designers and prospective operators of electrified fleet vehicles.
- Rapid Electric Vehicle Technologies Inc. developed the motor and drive system technology specifically for the fleet vehicle and the University of Waterloo develops the data analytics and modeling of the electric vehicles, and provides assessment and management tools to assist with the integration of Plug-in Hybrid Electric Vehicles (PHEV's) into the electricity grid.
- PI – Roydon Fraser.
- Research partners: Community Carshare, utilities and the WISE Drive4Data program.

# Large-Scale Solar Photovoltaic (PV) Integration into Electricity Networks

- $4.5M co-operative effort with multiple project partners including Western University to develop a set of comprehensive solutions to help grid operators incorporate large-scale solar farms on to their networks.
- Project researchers: Kankar Bhattacharya, Claudio Cañizares, Ehab El-Saadany, Mehrdad Kazerani, Magdy Salama and Siva Sivoththaman.
- Project partners: Hydro One Networks Inc. (Toronto), OptiSolar Farms Canada (Sarnia), Bluewater Power Distribution Corporation (Sarnia) and London Hydro (London).

# Wind Power Health Impacts

- $1.5M investment by the Province. Research focuses on the prediction of aerodynamic noise produced by wind turbine rhythmic sound. This rhythmic sound is most controversial in terms of health. The studies are highly multidisciplinary in nature with collection of data on noise exposures as well as health information from study subjects.
- Chair and PI: Siva Sivoththaman.
- Research partner: Ontario Research Chair in Renewable Energy Technologies and Health.

# Bioenergy

- Research to enhance the application of anaerobic digestion of farm, agricultural and municipal waste to produce biogas for heat and electricity generation. This research provides a basis for the development of advanced biogas systems that are effective and economically viable in an Ontario context with significant energy generation, ecological and environmental benefits.
- Co-PIs – Wayne Parker and Ray Legge.

# Novel Batteries

- Research focuses on lithium-sulfur and lithium-oxygen batteries to achieve a far higher energy density than their lithium-ion counterparts and paves the way for a new generation of batteries that can power a car for several hundred kilometers on a single charge and cost far less than today's lithium-batteries.
- Canada Research Chair and PI: Linda Nazar.
- Research Partners: BASF and NSERC.

*WISE has been extremely successful in identifying funding opportunities for researchers, connecting with industry partners, obtaining data, and identifying technology transfer opportunities. I cannot imagine continuing my research without the support of WISE.*

LUKASZ GOLAB
Assistant Professor, Department of Management Sciences

# Life Cycle Management of Li-Ion Battery Systems in Electric Vehicles

- $0.5M project to develop an environmental life cycle management study of Lithium ion (Li-Ion) battery packs in electric vehicles. Design and control systems in vehicles will account for the battery state of health (SOH) to optimize use and performance of the battery pack in service while allowing for second use repurposing applications for the batteries.
- Project researchers: Steven Young, Michael Fowler and Roydon Fraser.

Research partners: Mitsui.

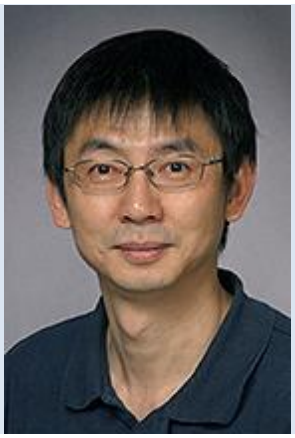
# Novel Processes for Upgrading Bitumen Emulsions

- $618K research program provided support to Flora Ng who has developed nano-catalysts that react with the water to produce hydrogen, removing the water and upgrading the bitumen in a single step. With her team Ng, a pioneer in the field of catalytic distillation, has developed new green energy processes including one that creates biodiesels from waste oils and novel catalysts for bitumen upgrading.
- PI – Flora Ng.

# Research into Solar-Assisted Heat Pumps, Thermal Storage and Natural Refrigerants

- The research advances heat pump technologies for cold climates in three main areas: solar panels to assist space heating in cold weather; use of $CO_2$ or hydrocarbon refrigerant system alone or in combination with other refrigerants; thermal storage to allow at least partial load shifting to take advantage of time of use electric rates.
- PI – Michael Collins.
- Research partner: Ecologix, a local heat pump developer.
- The findings from this work led to a partnership with Emerson Climate Technologies and integrated this technology, with the assistance of the University, into a demonstration project (Solar Decathlon) sponsored by the US DOE.

*WISE has played an important role for me in facilitating communication and collaboration among researchers across disciplines … I look forward to continuing my relationship with WISE.*



## FUE-SANG LIEN
## Professor, Department of Mechanical and Mechatronics Engineering

# Risk-Based Life Cycle Management of Engineering Systems

- $6M over three five-year terms (currently in its second five-year term). The research program aims to improve the life cycle management of nuclear plant systems through the development and application of advanced risk and reliability models. Research outcomes have included critical support to the Canadian Nuclear Safety Commission, the effective and safe operation of Ontario's nuclear reactors and training of regulatory and utility staff.
- NSERC-UNENE Industrial Research Chair in Risk-Based Life Cycle Management of Engineering Systems and PI – Mahesh Pandey.
- Research partners: NSERC, UNENE.

# The Risks of Capturing and Storing Carbon

- $900K grant from Carbon Management Canada. The collaborative project is investigating the risks involved in carbon capture and storage: trap greenhouse gases from big emitters (power plants) and store it deep in the Earth's crust as part of a carbon mitigation strategy to address the challenge of climate change. The objective of the second phase of the three-year project is to develop strategies to minimize those risks.
- PI (UW) – Robert Gracie.
- Research partners: University of Ottawa, University of Calgary, Carbon Management Canada, experts from engineering, social science, economics, policy analysis, and communications.

# Hydrogen & Storage Potential for Grid Application

- $200K project focuses hydrogen-based technologies for electrical and transportation systems in the context of a Hydrogen Economy, addressing the economic and technical aspects of hydrogen production, storage, distribution, and utilization. The improvement and application of electrolysis and fuel cell technologies for the generation and utilization of hydrogen are an integral part of this project.
- PI – Michael Fowler.
- Research Partners: Bruce Power, the Canadian Hydrogen and Fuel Cell Association (CHFCA), NSERC, MITACS and OCE.

# Energy Policy

- 10-year $500K agreement with the Energy Council of Canada (ECC) to establish The Energy Council of Canada Energy Policy Research Fellowship. This collaboration provides funding for annual fellowships valued at $15,000 for Master's students and $25,000 for Doctoral students. WISE in conjunction with ECC will develop further the Energy Policy Research agenda.
- The collaboration between ECC and WISE will pave the path for significant interaction with governments, the public and other stakeholders. The results of the research are expected to facilitate public policy objectives on energy matters.

*WISE has been an invaluable entrée to the research of my colleagues across campus on energy issues. It has also been an important window to the ways in which research can inform policy, both in Canada and on the International stage.*

HEATHER DOUGLAS
Associate Professor, Department of Philosophy

*In our view, WISE is an important hub for energy research and policy advocacy that helps foster the intelligent debate necessary to articulate our looming energy choices and to consider them in the sustainability context.*

BOB OLIVER
Chief Executive Officer, Pollution Probe

## High Performance Graphene Electrochemical Energy Systems

- $600K – as part of this research initiative, investigating and developing a grapheme-based composite for electrochemical energy storage for the automotive and/or portable electronics sectors.
- Co-PIs – Aiping Yu and Gordon Chiu.
- Research Partner: Grafoid Inc.

## Energy Planning Models for Smart Community

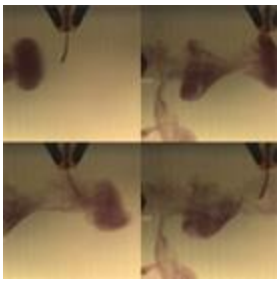
- Apurva Narayan and K. Ponnambalam.
- Planning of decentralized and hybrid power system (microgrid) for a netZero community in London, Ontario.
- Microgrid design has been done using deterministic methods. The challenge – develop joint stochastic models for the design of small microgrids with high renewable penetration – models which incorporate planning and operation considering undispatchability and uncertainty in renewable sources and demands is the prime goal-planning models incorporate a long time horizon with large time intervals while operation models incorporate a short time horizon with smaller time intervals.
- Developed a deterministic optimization model for the planning of microgrids with renewable sources of energy (wind and solar). Given the complexity and large scale nature of the model the researchers needed to develop programs to interact with large scale open source solvers (NEOS) to solve the optimization models. Also, to enable the users and designers a web interface was developed to allow them tweak the parameters to evaluate various configurations of the microgrid and robustness of the optimization model.

## Research Spotlights

Research Spotlights highlight additional research conducted by WISE members.

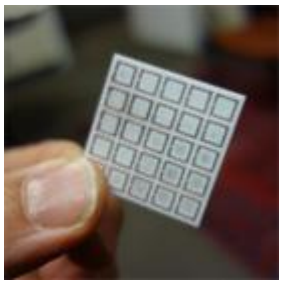
Adding Emissions and Water Resources to the Economic Equation

Good Vibrations: Harvesting Energy While You Do the Chores



Making Waves in Energy Research


Adding Zap to Zinc-Air Batteries



Generating Buzz with Metamaterials

Let There Be Nano-Engineered Light


Producing Propanol: A Microscopic Solution

Bull's eye! How framing Environmental Messages Helps Them Hit Their Target

Making Electricity Grids Smart and Secure

Making the Most of Hybrid Electric Vehicles

Where to Put Wind Turbines

Thinking Small: Assessing the Viability of Microgrids

**Read the Research Spotlights:** wise.uwaterloo.ca/news1/research-stories

## Education and Training

The Green Energy Graduate Diploma is the first of its kind to be offered in Canada.

- ✓ Waterloo's extensive network of private sector partners, utilities, government and the non-profit sector, collaborated on the development of the program in partnership with the Waterloo Institute for Sustainable Energy. [Launching January 2014]

- ✓ WISE has developed a proposal for a graduate program with specialization in Sustainable Energy which builds on the existing strengths of the academic courses on Energy and will help meet an emerging need identified by several industry partners as an area of study and training that needs to be enhanced within academic institutions.

2 Energy Council of Canada Energy Policy Research Fellowships valued $25,000 were awarded in 2013

17 Hydro One Undergraduate Scholarships valued at $2,000 were awarded 2012-2013 to top students in each of the Power & Energy Systems' 4th year courses, in recognition for their academic achievements and their commitment to Power Engineering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# REACH OUT

## Developing Partnerships

Each week, we advise our members about partner opportunities via the members-only section of our website, and we post funding opportunities that are open to the public. In the public section of our website, we also post opportunities on behalf of WISE researchers looking for industry partners and funding.

## In 2012 - 2013 WISE nurtured key partnerships

WISE forges links between academia and industry in many ways. We help our members to shape their research to solve real-world problems by establishing on-going dialogues with external organizations and participating in key energy boards and forums

## Securing Promising New Sources of Research Funding

WISE helps our members secure access to additional funds and/or physical assets and mobilize the necessary commitments. We do this by leveraging our extensive network of partners and our formal collaboration arrangements.

Meanwhile, several WISE members benefitted from 2011 Smart Grid funding from the Ontario Centres of Excellence (OCE). Out of a total OCE investment envelope of $2.86M, WISE researchers were involved in $2.19M of approved projects, representing 77% of the entire fund.

## Driving Research Advancement

WISE launched the Drive4Data initiative in 2012. The research partnership with Grand River CarShare investigates local opportunities for EVs and barriers to their use. This unique initiative that brings together industry and local non-profit organizations captures large-scale real-world data from plug-in vehicles. As a result, WISE researchers have access to information on everything from vehicle use and charging patterns to battery range and powertrain performance.

Already, the initiative is having an impact in Waterloo Region and beyond. We are in talks to expand the reach of the program to nearby municipalities including Kitchener, Cambridge and Guelph – becoming a "Smart Region" initiative. In 2013 the program has expanded to 8 data loggers currently installed and 10 projected in the next 6 months. The Region of Waterloo has strong interest in installing data loggers in their fleet.

*The Waterloo Institute for Sustainable Energy gratefully acknowledges the financial support of the Community Environmental Fund administered by the Regional Municipality of Waterloo.*

- ✓ Natural Resources Canada (NRCan): This partnership has indirectly led to a number of positive outcomes including two EcoEnergy Innovation Initiative projects at Waterloo with a combined value of approximately $3M.
- ✓ Cisco Systems Canada Co.: A five-year $1M agreement provides funding for the Cisco Chair in Smart Grid (Srinivasan Keshav is the Chairholder) and the funding will allow, through leverage with NSERC, to increase the scope of research activities by an additional $1M in the field of smart grid.
- ✓ Hydro One: In the fifth year of a five-year investment of $2.5M. This established an endowed chair (currently held by Claudio Cañizares) including $1M funding for research. Hydro One has committed an additional $210,000 in funding and in-kind support bringing the total number of Hydro One research projects to fourteen.
- ✓ The Energy Council of Canada (ECC): This 10-year $500K agreement sets out the establishment of The Energy Council of Canada Energy Policy Research Fellowships awarded to eligible students at the University of Waterloo.
- ✓ Mitsui & Co. Ltd.: WISE introduced Mitsui to a multi-disciplinary team of WISE members. The team's $500K proposal relating to lifecycle battery management was ranked #1 in North America in competing for the global Mitsui Environment Fund.
- ✓ IBM Southern Ontario Smart Computing Innovation Platform (SOSCIP): IBM approached WISE to advance innovation in the areas of micro-weather forecasting for utility applications and smart meter data analytics. Two proposals were successfully funded.
- ✓ Union Gas Ltd. (Union): Union has provided $118K in funding to support Smart Energy Network research and policy development. A multi-disciplinary team of WISE researchers have benefited from this funding. Aside from research, the funding has also led to the formation of a Smart Energy Network Advisory Panel

comprising senior energy leaders across Canada and a major event hosted in Toronto (Sept. 2013), co-chaired by Ian Rowlands and Tracey Forrest.

- ✓ WWF Canada: WWF Canada has partnered with WISE to develop a renewable energy map for Canada. WWF has raised approximately $75K to-date for WISE members to undertake the preliminary scope under this multi-million dollar initiative.
- ✓ Roxul Inc.: Has provided $20K to WISE for the advancement of building-energy related research at Waterloo.
- ✓ Greater Toronto Airport Authority: In June 2011, GTAA approached WISE to help them develop strategies and approaches for reducing the carbon footprint of their operations and to meet their ambitious emissions targets. In turn, WISE partnered with The Delphi Group to develop a strategic RoadMap, providing GTAA the information they needed to prioritize action and move forward with implementation. Work has since expanded, and several WISE members continue to contribute to this initiative.
- ✓ Toyota Tsusho Canada Inc., Waterloo North Hydro, Union Gas (amongst others): WISE pulled together a multi-disciplinary team of researchers and secured private and utility funding for an OCE-NSERC proposal entitled “Smart Energy City”. The proposal is valued at approximately $250K.
- ✓ City of Abbotsford: WISE spearheaded a partnership with this municipality and three researchers in WISE to analyze the City’s 28,000 water meters and provide insights (including energy-water correlations).

## Making a Global Impact

- ✓ Dalian University of Technology, China: A Memorandum of Understanding with the Institute for Eco-planning and Development of DUT, the International Eco-Safety Research Institute of DUT and WISE to advance collaboration and continuing co-operation.
- ✓ Mahindra Satyam: WISE has teamed up with this multinational systems integration company to advance a smart grid research and innovation centre at the University of Waterloo and launch global training programs (starting in India).

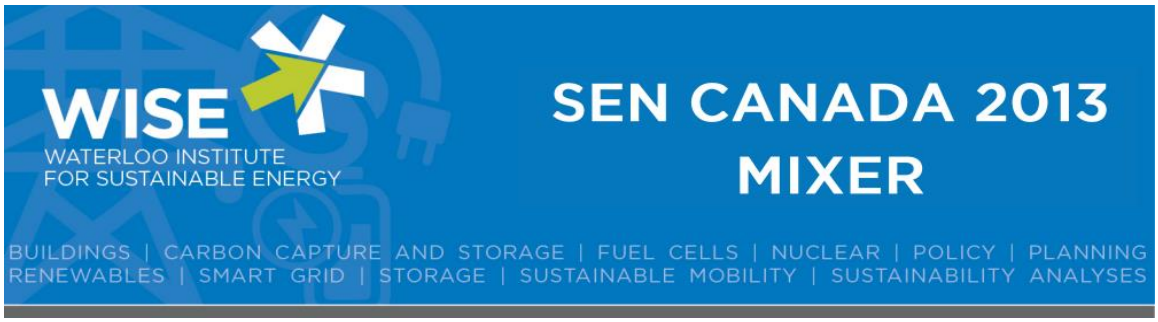
## Hosting Events


**Energy Day 2013, October 4, 2013**


The public was invited to join WISE members, industry experts and students for an enlightening day of energy research lectures, presentations, and discussions. The event provided opportunities to tour labs, meet researchers and make connections.
Advancing public dialogue on energy issues through analysis and evidence-based assessments is an important function of the Institute. A current example is the leadership WISE has shown in developing the concept of a smart energy network.

To advance the Smart Energy Network agenda, Dr. Ian Rowlands, Associate Director, WISE and Tracey Forrest, Director, WISE are co-chairs of a national Advisory Panel on Smart Energy Networks comprised of distinguished energy leaders across Canada.

**Smart Energy Networks Leadership Mixer, October 1, 2013**

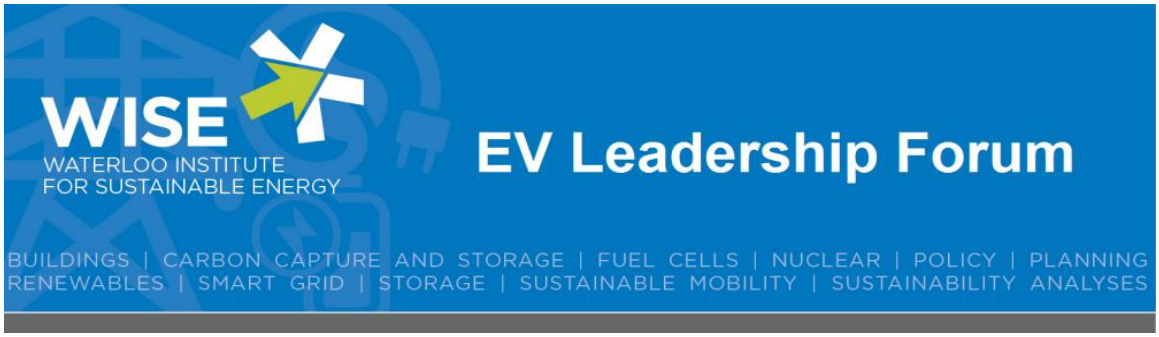


WISE members were joined by senior international leadership from Germany and Japan for an evening of casual conversation. The participants made connections, shared experiences, and learned more about the emerging field of 'smart energy'.

**Smart Energy Networks Leadership Forum, September 30, 2013**


SEN Canada 2013 brought together 65 leaders in government, utilities, business, civil society and academia to start the discussion about the potential role of integrated, multiple-fuel, and communicative systems in Canada's energy future. The event fostered an understanding of SEN, providing an opportunity to participate in discussions that advance SEN in Canada with national and international speakers, researchers and other relevant stakeholders.

**Electric Vehicle Leadership Forum, January 23, 2013**




The forum brought together representatives from local electric distribution companies, Waterloo researchers, and supporting partners to discuss the latest utility-related electric vehicle (EV) research and explore collaboration pathways based on the Drive4Data initiative. Participants indicated they would be willing to share their electric vehicle data with WISE or be directly involved in advancing the initiative.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# INFLUENCE

## Informing Public Policy

By sitting on energy boards and engaging in industry forums, WISE brings evidence-based analysis to the governance and regulation of the energy sector. In the past year, we participated in the Council for Clean and Reliable Electricity, the Ontario Smart Grid Forum and the Ontario Energy Board Chair's Advisory Roundtable for Industry. As a result, we helped to inform smart grid governance, the redesign of feed-in-tariffs, the global adjustment mechanism, technology choices for Ontario's next new nuclear plant, the Auditor General's report on Ontario's renewable energy program, governance models in the electricity sector and biomass energy opportunities.

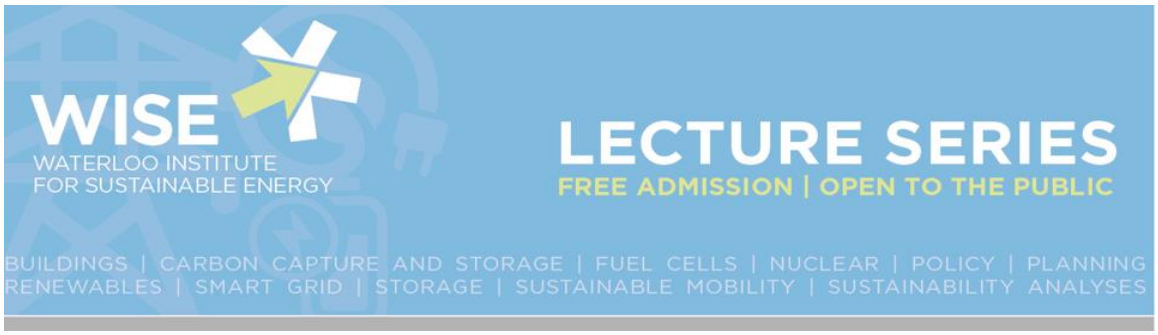
## Event Participation

### Some Key Workshops, Conferences and Public Events that included WISE members

- ✓ Inaugural Launch of the Council of the Great Lakes Region (CGLR), Canada-US Law Institute Conference, *'New Realities in Canada-US Relations Cross Border Collaboration' Panel on Shared Energy Resources and Strategies in the Great Lakes-St Lawrence Region*,' **Cleveland, Ohio**, April 10-12, 2013. (Panelist, Jatin Nathwani)

- ✓ Council for Clean and Reliable Electricity (CCRE), *'Annual Energy Leaders Roundtable – Inter-Regional Electricity Trade'* Hockley Valley Resort, **Orangeville, ON**, April 3-5, 2013. (Panelist, Session Chair, Jatin Nathwani)
- ✓ Public Lecture, '*How Your Energy World Has Changed … and will continue to change …'* **Vancouver,** January 30, 2013 and **Waterloo,** April 15, 2013. (Maurice Dusseault)
- ✓ The COU Symposia of Ontario Research Chairs in Public Policy, '*Smart Grids to Smart Energy Networks: Driving Global Energy Transitions'*. Tackling Ontario's Challenges: Experts and Decision-Makers met to explore Ontario's key policy challenges - Ontario's Sustainability Challenge, **Toronto,** October 17, 2013. (Jatin Nathwani)
- ✓ 'World Energy Council North America Energy Scenarios Workshop', US Energy Association, **Washington DC**, May 29-30, 2013 (Jatin Nathwani).
- ✓ Smart Grid Development in **Shanghai, Beijing, Nanjing, Guangzhou and Hong Kong** in China, June 2012. (Ian Rowlands)
    - Rowlands travelled to China at the invitation of the Department of Foreign Affairs and International Trade and Smart Grid Canada as part of a Canadian 'Smart Grid' trade mission.
- ✓ Smart City Mission to **Yokohama, Tokyo and Nagoya** in Japan, November 1-9, 2012. (Tracey Forrest)
    - A smart city mission to Japan was funded and organized by Toyota Tsusho Canada. The trip focused on 'smart city' related R&D including Smart Grid, Smart Houses/Buildings, Renewable energy, and Next-generation mobility and involved travel to three cities in Japan.
- ✓ NATO Science for Peace & Security Series: 'Environmental Security, Advanced Research Workshop Sustainable Cities and Military Installations: Climate Change Impact on Energy & Security' **Hella, Iceland,** June 3-6, 2012. (Jatin Nathwani, Co-Chair Energy Track)
    - Book In Publication. (Springer Verlag)
- ✓ Canadian Science Policy Conference, CSPC 2012, Building Bridges for the Future of Science Policy, *'Global Energy Transitions: A Canadian View',* **Calgary, Alberta**, November 5, 2012. (Jatin Nathwani)

# Public Lecture Series




Leading energy experts give our members and wider community insights into key issues. Many students attend these events and enjoy the collegial atmosphere and networking opportunities.

## Public lectures in 2013

10

## 2013

*Electric Vehicle Development in China*
Dr. Lifang Wang, Professor, Chinese Academy of Sciences, PR China

*How Your Energy World Has Changed ... And Will Continue to Change...*
Dr. Maurice Dusseault, Professor, Earth and Environmental Sciences, University of Waterloo

*PEM Fuel Cell Catalysis and Supercapacitors at National Research Council of Canada*
Dr. Jiujun Zhang, Principle Research Officer, National Research Council Canada, Vancouver, BC

*CO2 Storage at the Ketzin Pilot Site, Germany: 5th Year of Injection, Multidisciplinary Monitoring and Modelling*
Dr. Sonja Martens, Project Manager Ketzin, Centre for Geological Storage, GFZ German Research Centre for Geosciences, Postdam

*The Role of Hydro in Modern Sustainable Power Grids*
Phil Helwig, M.Sc., P. Eng., Hydropower Consultant, Helwig Hydrotechnique Limited

*Understanding Active Network Management in 40 Minutes*
Prof. Damien Ernst, Associate Professor, University of Liège

*Energy Perspectives for Germany and Europe: A Researcher's View*
Dr.-Ing. Joachim U. Knebel, Chief Science Officer, Karlsruhe Institute of Technology (KIT), Germany

*Behaviour Change: An Untapped Resource in Coping with Climate Change*
Dr. Ron Dembo, Founder and CEO of Zerofootprint, Founder and former CEO of Algorithmics

*Brazil's Energy Plans and Strategies: Challenges Related to Climate Change*
Dr. André Lucena, Professor, Federal University of Rio de Janeiro (UFRJ)

*Alberta's Strategic Research Directions in Energy Development*
Mr. Chris Holly, Branch Head, Research &Technology Resource Development, Policy Division, Alberta Energy

## 2012

*Climate Geopolitics through 2020: Disruptive Issues on the Horizon*
Dr. Jason Blackstock, Institute for Science, Innovation and Society, University of Oxford, England

*Carbonaceous Adsorbents with Unique Bulk and Nanostructured Properties and Their Applications to Improve Air Quality*
Dr. Mark J. Rood, Racheff Professor of Environmental Engineering, Department of Civil and Environmental Engineering, University of Illinois, Urbana-Champaign

*Hybrid Photovoltaic Power Systems and Rural Micro Grids: Lessons Learned and Case Studies in Developing Countries*
Xavier Vallvé, International Consultant and Partner, Trama TecnoAmbiental, Barcelona, Spain

*Do We Pay Too Much for Tap and Bottled Drinking Water?*
Dr. Mark Knight, Executive Director, Centre for Advancement Technology, Waterloo Professor, Department of Civil and Environmental Engineering, University of Waterloo

*Thermochemical and Catalytic Upgrading Biomass into Industrial Bioproducts*
Prof. Charles Xu, Institute for Chemicals and Fuels from Alternative Resources, Faculty of Engineering, Western University

*Solving Energy Loss in Supercapacitive Energy Storage*
Dr. Heather Andreas, Department of Chemistry, Dalhousie University, Nova Scotia

*Computational Chemistry and the Design of Dye Sensitized Solar Cells*
Dr. Carlo Adamo, Chair of Theoretical Chemistry, Senior Member of Institute Universitaire de France (IUF)

*Modeling and Optimization of a Micro-Grid: Huatacondo, Isolated Village in Northern Chile*
Dr. Doris Sáez, Department of Electrical Engineering, University of Chile

*Demand Responsive Buildings: Reducing on-peak electricity use in offices and houses*
Dr. Guy Newsham, Principal Research Officer, National Research Council Canada

*Climate Change: The Corporate and Collective Response*
Michael Gerbis, CEO, The Delphi Group

*Smart Grid Development in China*
Dr. Ian Rowlands, Associate Director, Global Initiatives, Waterloo Institute for Sustainable Energy and Professor, Environment and Resource Studies, University of Waterloo

## Visitors hosted

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## Sample Member Achievements

Not surprisingly, WISE members are making a significant contribution regionally, nationally and globally. We're proud to have played a role in their many successes over the past year.

In February 2014, Professor Maurice Dusseault was chosen to serve on a panel, led by Cape Breton University President David Wheeler, to provide an independent review of the impacts of hydraulic fracturing in Nova Scotia. Four academics, two energy industry businessmen, a health expert, a Membertou First Nation leader and an environmental consultant will also partake in the review.

Professor Armaghan Salehian's research group developed wideband hybrid energy harvesters that use different types of smart material solutions to convert ambient vibrations into electricity. With this technology, Armaghan hopes to dramatically reduce the number of open-heart surgeries for people with pacemakers.

In November 2013, the Ontario Minister of Energy appointed Prof. Ian Rowlands to the newly-established Stakeholder Advisory Committee (SAC). The Committee's purpose is to provide the Ontario Power Authority's (OPA) Board of Directors and Management Team with advice on policy issues related to the OPA's mandate. As one of the Committee's 17 members, Prof. Rowlands represents the OPA's Advisory Council on Conservation (on which he also serves). His appointment to the SAC is for a two-year period.

Professor Zhongwei Chen and his nanotechnology research team invented an innovative zinc-air rechargeable battery that has the potential to create a greener future by storing power from a smart grid or driving the next generation of electric cars. The technology promises cheaper and safer way of storing energy and could be on the market within a year.

In May 2013, Professor Linda Nazar and her research group were awarded $1.8 million over four years to support her research into nanotechnology and the use of different approaches to battery chemistry. Linda's team hopes to move beyond the lithium-ion battery and advance the next generation of more powerful and longer lasting batteries.

Professor Keshav and his team had developed SPOT, a Smart Personalized Office Thermal control system that uses sensors to predict how comfortable you are and then automatically adjusts the heat or the fan in the workspace.

In February 2013, Professor James Craig's work on protecting human and ecosystem health was recognized with an Ontario Early Researcher Award. Craig and his team helps groundwater practitioners to predict the ultimate source of pumped aquifer water using groundwater modelling software and improved design methods for geothermal exchange systems. More

accurate prediction would in turn help local regulators make informed decisions to protect the environment.

Over the course of 2013, Professor David Johnson and his team had worked with aboriginal residents in Kasabonika Lake, in partnership with Hydro one Remote Communities Inc., to erect a 30 kilowatts wind turbine that was easy to transport and maintain. His research group hopes the project would prove to lower the environmental impact of diesel that First Nation communities often depend on in a cost-effective way.

## Sample Impact Publications

# Over 375 energy related publications by members in 2012-2013

O. Yuksel Orhan, G.İs, E. Alper, K. McApline, S. Daly, M. Sycz, and **A. Elkamel,** "Gasification of Oil Refinery Waste for Power and Hydrogen Production", *Proceedings of the 4th International Conference on Industrial Engineering and Operations Management (IEOM 2014)*, paper # 314, pages 1-10, Bali, Indonesia, January 7-9, (2014). **(Awarded the Best IEOM 2014 Track Paper in Technology Management).**

**S. Jayaram** and C. Angammana, "Investigation of the Optimum Electric Field for a Stable Electrospinning Process", IEEE Transactions on Industry Applications, Vol. 48, No. 2, March-April 2012. (**Awarded the IEEE James R. Melcher Prize Paper Award 2013, for technical excellence.)**

P. Srikantha, **S. Keshav**, and **C. Rosenberg**, "Distributed Control for Reducing Carbon Footprint in the Residential Sector", IEEE SmartGridComm, November 2012. **(Winner of Best Paper Award)**

H. Yeo; **H.S**. **Lee** (2013) "The effect of solids retention time (SRT) on dissolved methane concentration in anaerobic membrane bioreactors (AnMBRs)". Invited manuscript, Environmental Technology, 34, 2105-2112.

O. Ardakanian, **C. Rosenberg**, and **S. Keshav**, "Distributed Control of Electric Vehicle Charging", Proc. ACM e-Energy 2013, May 2013. **(Winner of Best Paper award)**

**I. H. Rowlands**, "Smart Energy Networks: The 2013 Leadership Event and Beyond" (Waterloo, ON: Waterloo Institute for Sustainable Energy, SEN Working Paper # 3, November 2013), 30pp.

**E. Prouzet**, "A Closed Photobioreactor for the production of microalgae and cyanobacteria", US Patent Provisional (02/04/2013), US 61/760,136

C. Hoicka, **P. Parker**, J. Andrey (2014). "Residential energy efficiency retrofits: How program design affects participation and outcomes". Energy Policy 65 (0) (Feb.): 594–607. doi:10.1016/j.enpol.2013.10.053.

**O. Weber** (2013). "Social Banks and their Profitability: Is Social Banking in line with Business Success?" In L. San-Jose & J. L. Retolaza (Eds.), Prospective Innovation at Ethical Banking and Finance (pp. 2-19). Sumy: Vinnychenko M.D.

L. Ahmadi, A. Yip, **M. Fowler**, S. B. Young, & R. A. Fraser (2014). "Environmental feasibility of re-use electric vehicle batteries". Sustainable Energy Technologies and Assessments, 6, 64-74.

M. Cuisinier, P. E. Cabelguen, E. S. Evers, G. He, M. Kolbeck, A. Garsuch, T. Bolin, M. Balasubramanian, & **L. F. Nazar** (2013) "Sulfur Speciation in Li-S Batteries Determined by Operando X-ray Absorption Spectroscopy", Journal OF Physical Chemistry Letters, Volume: 4, Issue: 19, Pages: 3227-3232, DOI: 10.1021/jz401763d

D. Olivares, **C. A. Cañizares**, and M. Kazerani, "A Centralized Energy Management System for Isolated Microgrids," to appear in IEEE Transactions on Smart Grid, 2014.

M. Arriaga, **C. Canizares** and M. Kazerani, "Renewable Energy Alternatives for Remote Communities in Northern Ontario, Canada", in the IEEE Transactions on Sustainable Energy, Vol. 4, Issue 3, July 2013, pp. 661-670.

S. Zendehboudi, A. Shafiei, A. Bahadori, **Y. Leonenko**, I. Chatzis (2013), "Droplets evolution during ex situ dissolution technique for geological CO2 sequestration: Experimental and mathematical modelling", International Journal of Greenhouse Gas Control ,13, 201–214.

**J. Nathwani**, Z. Chen, M. P. Case, Z. A. Collier, P. E. Roege, S. Thorne, W. Goldsmith, K. V. Ragnarsdottir, P. M. Marks, M. Ogrodowski (2013). "Sustainable Energy Pathways for Smart Urbanization and Off Grid Access: Options and Policies for Military Installations and Remote Communities" in I. Linkov, (Ed**.),** NATO Science for Peace and Security Series C, Environmental Security, Linkov, Igor (Ed), Springer Verlag, 2014 XVI, 400p, 59 illustrations, ISBN 978-94-007-160-4, Jan, 2014

I. Linkov, T. Bridges, F. Creutzig, J. Decker, C. Fox-Lent, W. Kröger, J. H. Lambert, A. Levermann, B. Montreuil, **Jatin Nathwani**, R. Nyer, O. Renn, B. Scharte, A. Scheffler, M. Schreurs, T. Thiel-Clemen (2014) "Changing the resilience paradigm" Nature Climate Change (in publication)

## In the News

December 9, 2013 If nothing else, green power has to be green. The Green Energy Act's policy directives remain doggedly indifferent to the key question of cost.

December 2, 2013 Smart tech for medical implants. Waterloo researcher hopes technology that turns vibrations into energy will reduce the number of open-heart surgeries for people with pacemakers. CBC Radio featured interview:

http://www.cbc.ca/player/Radio/Local+Shows/Ontario/The+Morning+Edition+-+K-W/ID/2432035467/

November 26, 2013 Ontario's Overpriced Electricity? Ontario Research Chair gives his perspective on electricity prices and energy policy.

October 22, 2013 Science, Expertise, and Democracy. Science and society 2013: Emerging Agendas for Citizens and the Sciences. Plenary summary

http://www.youtube.com/watch?v=IjypXxGFruY&list=PLCIhVjlEbKGPj793wVqC82g08ismHDq3E&index=1

September 28, 2013 Ideals for Responsible Science in Democratic Societies. SUNY, NY. http://www.youtube.com/watch?v=GuZKEnePt1M

May 23, 2013 Will your electric car use a battery with nano-material? Waterloo researcher awarded $1.8 million to move beyond the lithium-ion battery and advance the next generation of more powerful and longer lasting batteries.

May 17, 2013 Building a better electric car. Drive4Data helps Waterloo researchers track real-world driving habits of electric car drivers. Engineers will use data to design the electric car of the future.

May 17, 2013 Solar panels that are good for the environment and for people. As green energy technologies become mainstream, a Waterloo researcher is making sure our health and safety is considered from “desktop to rooftop.”

May 10, 2013 Do you want more control over your energy costs? Homeowners and businesses will automatically get the information they need to cut costs with an innovative tool that’s also good for the environment.

May 10, 2013 Cold at work? SPOT will fix that. A personalized system called SPOT not only keeps office workers comfortable, it can cut overall energy use, says Waterloo researcher.

May 3, 2013 Can smart appliances save you money? The Smart Energy Network (SEN) will allow household appliances to seamlessly "choose" the best and cheapest energy source available.

May 3, 2013 Does a smart charger know better than you when to plug in? Innovative smart charger for electric cars will ultimately bring green vehicles to the masses without overloading the power grid.

February 27, 2013 Engineering prof works to protect drinking water with software. James Craig helps regulators protect human and ecosystem health.

February 12, 2013 Waterloo computer scientist warns banks and investment firms to expect the unexpected. Yuying Li designs algorithms and creates strategies to help avoid losses in an unpredictable economy.

February 12, 2013 Is your future electric? Waterloo researcher is leading the charge to create technologies and policies that will support an electrified energy future.

February 7, 2013 Getting a view of the big picture when banks make decisions. Waterloo prof studies the environmental and social impact of the financial industry.

# Members

William Anderson
Miguel Anjos
Dipanjan Basu
Philip Beesley
Kankar Bhattacharya
Philip Bigelow
Jason Blackstock
Terri Meyer Boake
Paul Calamai
Claudio Canizares
Giovanni Cascante
Trevor Charles
Zhongwei Chen
Pu Chen
Zhewen Chen
Chih Hsiung (Perry) Chou
Michael Collins
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Siva Sivoththaman
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Aiping Yu

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Ontario Research Chair in Public Policy for Sustainable Energy

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**Andrew Teichman**, Executive Director of Investments, OPG Ventures Inc.
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**Mel Ydreos**, VP Marketing & Customer Care, Union Gas Limited
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**William Smith**, Senior Vice President, Energy Sector, Siemens Canada Limited
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**Paul Murphy**, Chair, Advisory Board, Advanced Energy Centre, MaRS Discovery District

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**Iris Strickler**, Administrative Assistant *Finance and Administration*
**Akanksha Halbe**, Project Manager *Smart Energy Networks*
**Janina Bielak**, **Tony Ai, Mary Wu,** Coop Students *Communications and Outreach*

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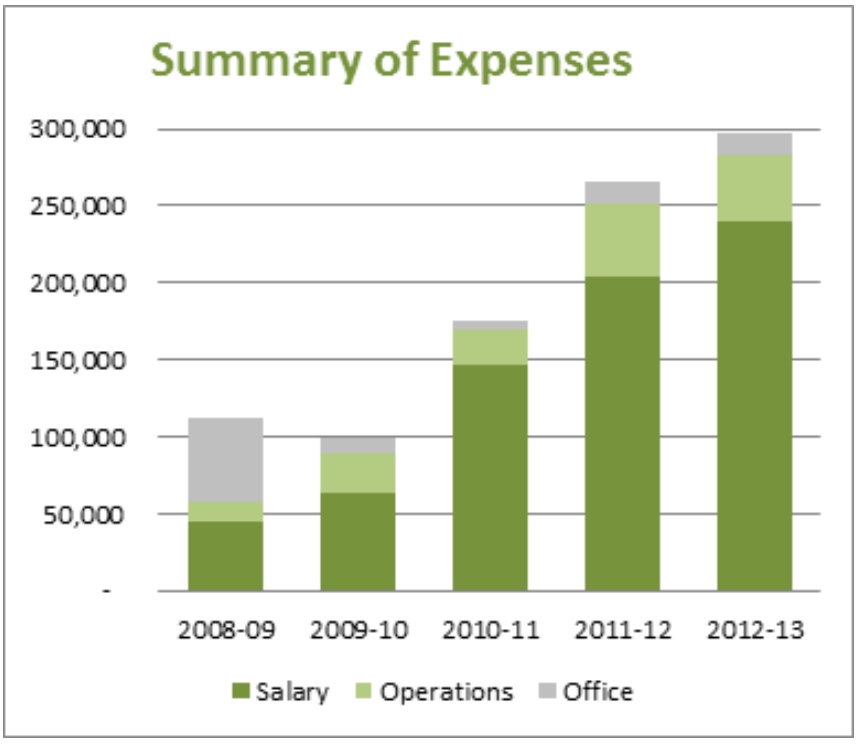
**Ian Rowlands**, Associate Director, Global Initiatives
**Claudio Cañizares**, Associate Director, External Partnerships
**Kankar Bhattacharya**, Associate Director, Advanced Training
**Linda Nazar**, Associate Director, Research

## 2013 Financial Summary

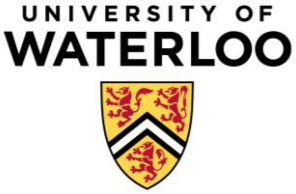



## Waterloo Institute for Sustainable Energy

University of Waterloo
200 University Avenue West
Waterloo ON Canada N2L 3G1

wise.uwaterloo.ca

For more information or additional copies
of this report please contact us at:
info@wise.uwaterloo.ca




April 2014