WISE annual report

2014-2015

Waterloo Institute for Sustainable Energy

UNIVERSITY OF WATERLOO | WISE WATERLOO INSTITUTE FOR SUSTAINABLE ENERGY

BRIDGE
supply and demand
with better storage

CONSERVE
energy through
greater efficiency

TRANSFORM
energy systems through
game-changing technologies

ENABLE
smart policies
and planning

WATERLOO INSTITUTE FOR SUSTAINABLE ENERGY

SUSTAINABLE ENERGY

IMPROVE
conventional
generation methods

vision

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.

DELIVER
energy more
intelligently

Building 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.

TABLE OF CONTENTS

mission

Conduct original research and develop innovative solutions and policies to help transform the energy system for long-term sustainability.

strategic objectives

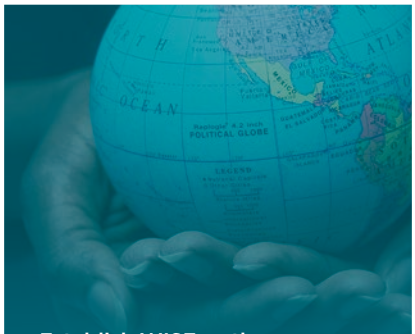
COLLABORATE

Expand opportunities for multidisciplinary 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.

WISE EXECUTIVE DIRECTOR

A NOTE FROM THE EXECUTIVE DIRECTOR

Since 2008, WISE has grown and responded to meet the emerging challenges of an energy sector that must deliver secure and reliable energy services consistent with a shift to a low carbon energy system that is also affordable.

Our members, drawn from all the faculties at the University of Waterloo, are involved in a wide spectrum of energy research and educational activities promoting active interactions with business and industry, government agencies and civil society groups.

With the launch of a major global change initiative — Affordable Energy for Humanity (AE4H.org) — WISE has forged a partnership with one of the world's leading applied science and engineering universities, the Karlsruhe Institute of Technology (KIT) in Germany and brought together over 100 leading international researchers from 27 institutions in 12 countries around the world.

Our goal in promoting the development of strategic partnerships is to meet the challenge of global energy access and make energy affordable for the billions who have very little.

We are committed to making a contribution to the two most important challenges of this century — a clean (low carbon) energy future and affordable access to critical energy services for all global citizens.

JATIN NATHWANI
Executive Director

WISE MANAGERS

A NOTE FROM WISE

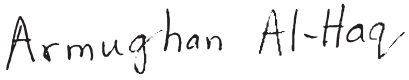
We are excited by the challenge of harnessing enthusiasm in order to make a high-impact contribution to urgent global energy issues.

This year we continued to engage with our faculty and students to help them make new connections and **reach out** to other researchers, business and industry, government agencies and civil society groups to help shape future paths and options for the energy sector through collaborative research. In this way we are also helping to produce highly qualified professionals for the Canadian economy and beyond.

We assist our researchers by managing the details: working closely with WISE researchers we help them write applications, facilitate related site visits, and continue to support them to the approval stage. Along the way we've established a strong network of industrial partners to **collaborate** across a broad range of sectors including utilities, construction and manufacturing, information technology, infrastructure and transport architecture, finance, automation and even digitalization.

We are working closely with a host of new partners through AE4H. Our growing base of contributors shares a common mission: to apply their considerable knowledge and resources to **influence** the cause of universal access to affordable energy. You'll read more about this initiative in the following pages.

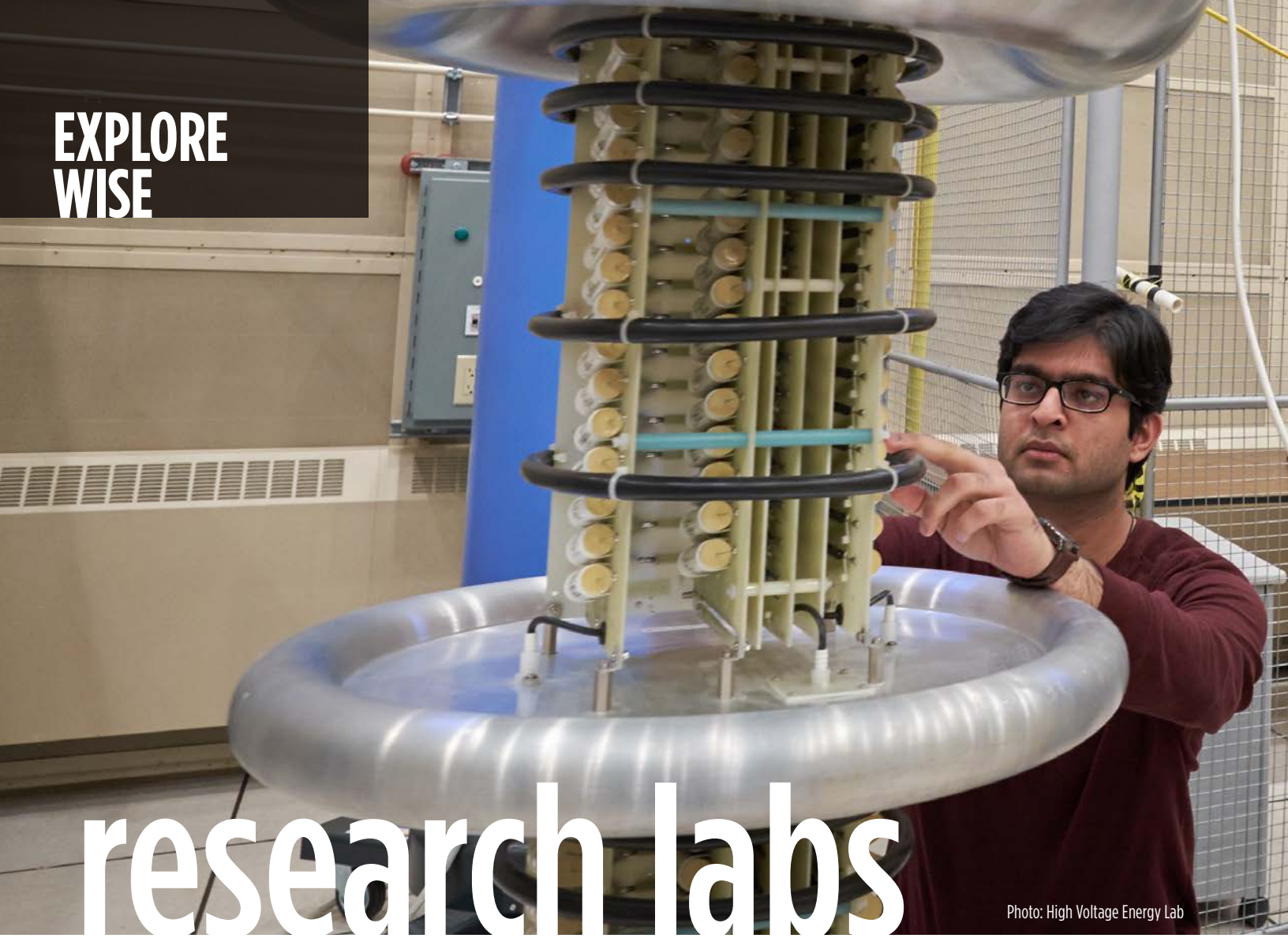
We welcome and encourage interested participation of the Waterloo community and beyond in this important initiative as we face the global challenge of finding new ways to meet our growing energy needs while simultaneously protecting the planet that sustains us.



ARMUGHAN AL-HAQ
Manager, Program Development
and Partnerships

NIGEL MOORE
Manager, Global Programs
and Initiatives

EXPLORE WISE



research labs

Photo: High Voltage Energy Lab

BRIDGE

Applied Nanomaterials and Clean Energy Lab

Carbon Nanomaterials Lab

Fuel Cell & Green Energy Lab

Giga to Nano Center

Nazar Research Group

CONSERVE

Advanced Glazing Systems Lab

DELIVER

Electricity Market Simulation and Optimization Lab

High Voltage Energy Lab

Information Systems and Science for Energy Lab

Real Time Simulation Lab

ENABLE

Sustainable Energy Policy Group

IMPROVE

Center for Pavement and Transportation Technology Lab

Center for the Advancement of Trenchless Technology

Mechatronics Vehicle Lab

Non-destructive Testing Lab

Qing-Bin Lu's Lab

Solar Thermal Research Center

TRANSFORM

Air Pollution Research and Innovation Lab

Center for Advanced Photovoltaic Devices and Systems

Center for Advanced Materials Joining

Fluid Mechanics Research Lab

Lab for Biomanufacturing

Emerging Energy Research Lab

Printable Electronic Materials Lab

UW Live Fire Research Facility

Wind Energy Lab

Energy Harvesting Lab

Kleinke Research Center

COLLABORATE

energy research

Research Themes

1. Affordable Energy for Humanity (AE4H)
2. Off-Grid Energy Access for Northern Remote Communities in Canada
3. Smart Grid Applications
4. Geothermal Energy Technologies
5. Sustainable Mobility
6. Energy Harvesting
7. Wind Energy

initiatives

1 affordable energy for humanity (AE4H)

Remote and impoverished communities that are without access to reliable and affordable sources of electricity are forced to spend far too much of their already limited disposable income on dirty fuels that inadequately provide basic human needs such as lighting and heating. When clean electricity can be provided at an affordable price, and is coupled with efficient and useful appliances and other end-use technologies, these same individuals, families and communities are better able to pull themselves out of persistent poverty and can hope for a much brighter future.

There are currently 1.2 billion people in the world who still do not have access to electricity. While this number is currently falling, it is estimated that without significant innovation, aggressive investment and invigorated political will, the world will not achieve universal energy access by 2030 — a target now enshrined as one of the new UN Sustainable Development Goals.

Through founding this new initiative, WISE has made a commitment to advancing the global energy access agenda. At the heart of this commitment is the recognition that access to an affordable supply of clean electricity is a fundamental stepping stone to human development in the 21st century.

AE4H was launched in September 2015 as a collaboration between founding institutions WISE and the Karlsruhe Institute of Technology (KIT) in Germany, as well as approximately 100 energy access and technology experts from other leading research and non-profit institutions all over the world who have joined the initiative as active participants.

The mission of AE4H is to harness this growing global consortium in order to spur innovations that will significantly reduce the barriers to clean electricity provision in remote and impoverished areas. These include Technological innovations in the areas of distributed renewable generation, micro-grid design and ICT platforms for energy service management, as well as social innovations such as models for private sector involvement and community participation in the management of these technologies, and knowledge transfer and human capital building to support off-grid energy provision on a global scale.

The initiative will contribute to the development of these innovations through supporting and investing in people who are motivated to collaborate to achieve them. Given the global and context-dependent nature of energy poverty, a particular emphasis is on developing and supporting avenues of knowledge transfer and co-operation between individuals in the global North and South, as well as between those working in the field and in the lab.

A foundational event to kick-start this process is the OpenAccess Energy Summit, to be held in Waterloo in April 2016. WISE is deeply involved in the summit process, which is central to guiding and informing our efforts at AE4H as well as providing additional opportunities for collaboration and pathways to impact.

Over the course of the coming years, WISE aims to become internationally recognized as a champion and enabler of universal clean electricity access through the innovative and highly collaborative AE4H initiative.

2 off-grid access for northern remote communities in Canada

KASABONIKA LAKE FIRST NATION PROJECT

There are nearly 300 remote communities across Northern Canada — about 170 of them First Nations. Most of these remote communities are only accessible by air although some can be reached by barge or winter roads. The majority of these communities rely on imported diesel fuels for electricity production. It's not only environmentally damaging but incredibly expensive — up to $1 per kilowatt hour — so building capacity to get energy from renewable sources is the preferred option.

Dr. Claudio Cañizares and his research team are working with the Kasabonika Lake First Nation community and industry partners to develop a commercially viable utility-grade controller for remote microgrids with high penetration of renewable energy. The aim is to optimize the electricity generation and dispatch of power at the lowest cost possible in remote locations. The next steps in the project include commercialization of the controller and a decision by the Indigenous and Northern Affairs Canada to proceed to the Design and Implementation Phase.

RENEWABLE ENERGY IN REMOTE CANADIAN ARCTIC COMMUNITIES

The Waterloo Institute for Sustainable Energy, along with six organizations, have formed the 'Arctic Renewable Energy Expert' Committee in a project to help develop large scale renewable energy projects in at least three northern communities of Canada by 2020.

The Committee will work with provincial and municipal governments to increase the share of renewable energy in indigenous and northern communities of Canada and thereby help reduce their dependency on imported hazardous and high-cost driven diesel fuel. Partner organizations are:

» Waterloo Institute for Sustainable Energy (WISE)
» Alaska Centre for Energy and Power (ACEP)
» Borden Ladner Gervais LLP (BLG)
» Qikiqtani Inuit Association (QIA)
» Tugliq Energy Co.
» Pembina Institute
» World Wildlife Fund Canada (WWF-Canada)

3 smart grid applications

INFORMATION AND COMMUNICATIONS TECHNOLOGIES IN SMART GRID APPLICATIONS

Dr. Sherman Shen and Dr. Kankar Bhattacharya are working on specific areas of Information and Communications Technologies (ICT) in Smart Grid applications that will result in significant benefits to Canadian users and will foster a vital competitive edge to Canadian ICT and power industries in the international market place.

The end goal is to develop innovative information and communication solutions for the smart power grid in order to facilitate integration of renewable energy sources and energy storage devices in microgrids, planning of electric vehicle (EV) charging infrastructure including vehicle-to-grid (V2G) systems to balance power generation and demand. In addition, novel cyber-physical security and customer privacy protection techniques will be developed to enhance smart grid communications. The research outcomes will help to increase the market share of renewable energy in Canada.

HYBRID SMART DISTRIBUTION SYSTEMS

The smart grid set-up is anticipated to be one that is equipped with an alternating/direct current (AC/DC) hybrid configuration that will manage a variety of DC technologies i.e. renewable distributed generations (DGs), energy storage systems (ESSs), and Electric Vehicle (EV) charging stations.

Dr. Kumaraswamy Ponnambalam and Dr. Ehab El-Saadany have developed a two-stage stochastic centralized dispatch scheme for AC/DC hybrid smart grids to reduce the expected high operating cost while satisfying the operational and technical constraints of interaction among several components of smart grid. The scheme will coordinate the operations of a number of distributed energy resources (DERs) and ensures the harmonized charging of EVs and models to address degradation of batteries over time. The approach, if successful, will also solve scheduling problems associated with an intermittent supply, variable demand and fluctuating real time energy pricing issues.

4 geothermal energy technologies

COMPRESSED AIR ENERGY STORAGE IN SALT CAVERNS

Solar and wind energy are increasingly being integrated into Ontario and Alberta power grids, however, their intermittent and variable nature of output requires availability of large-scale storage for effective grid operation. Large-scale, cost-effective storage is needed to help balance local and regional generation sources to enable a larger share of renewable energy generation into the power grid.

Compressed Air Energy Storage (CAES) is a solution that offers a variety of socio-economic and environmental benefits for the energy economy as a whole. The CAES storage reservoir can be constructed in pre-existing formations i.e. salt caverns, aquifers and abandoned mines. As a result, the capital cost of adding an incremental amount of storage capacity can be much lower than for other comparable storage technologies. Not only is CAES financially practical for bulk storage, it is a promising storage solution that:

» **Accommodates Large Scale Integrated Renewables** through the ability to store and combine intermittent solar and wind power in underground salt caverns

» **Enhances Grid Performance** by providing stability, reliability, and additional peak capacity to the grid infrastructure

» **Leads to Environmental Sustainability** by maximizing environmentally friendly forms of electricity generation

» **Contributes to Economic Benefits** since this technology would allow cost effective operation of wind resources when demand during the night is low

Dr. Maurice Dusseault is the principal investigator with a robust team of investigators from the University of Waterloo, including Drs. Claudio Cañizares, Kankar Bhattacharya, Roydon Fraser, Jatin Nathwani, and Dipanjan Basu and researchers from the University of Alberta and the University of Calgary. The team will study the various technical, economical, and environmental barriers in the deployment of CAES in Canada. The research will be of interest to utilities and solar and wind farm operators.

geothermal energy technologies
(continued)

INTERMEDIATE GRADE GEOTHERMAL ENERGY

Intermediate grade geothermal energy is an abundant, low carbon base load energy source that does not require high temperature gradients or heat sources and can be extracted by using the latest drilling technology at an affordable cost. The typical range of intermediate grade geothermal energy is 80-150°C found several kilometers beneath the Earth's surface. Drs. Dipanjan Basu, Roydon Fraser, and Maurice Dusseault have collaborated to assess the geothermal resources in Canada with an eye to harvesting this energy.

GROUND SOURCE HEAT PUMP SYSTEMS

Ground Source Heat Pump Systems (GSHPs) are among the most efficient and sustainable methods to provide space heating, cooling, and hot water to residential and commercial buildings. The technology has a great potential to reduce carbon emissions and address energy demands of the different dwelling types in Canada by delivering energy access to residential and commercial buildings at a low cost. Dr. Dipanjan Basu leads the project to identify the technical constraints and to perform a detailed life cycle assessment of GSHPs in Northern Ontario.

5 sustainable mobility

ELECTRIC VEHICLE CHARGING STATIONS

Electric Vehicles (EVs) are increasingly recognized as a significant form of green transport alternative to internal combustion gasoline engines. However, an important constraint to the massive deployment of EVs in Canada is the severe lack of public EV battery charging infrastructure.

Dr. Magdy Salama and his PhD student, Yassir Alhazami, are developing a planning model to implement EV charging infrastructure in electric power distribution systems. This is the final stage of delivering electricity. The results of this study will help to identify the most ideal locations of charging stations in Canada and thereby optimize the distribution system to meet the charging demands of EVs. A direct result would be a design for a well sustainable and profitable business model for the owners of the EV charging stations which should increase the share of EVs in the automobile industry as a final goal.

ELECTRIC BIKES

E-Bikes are becoming the world's fastest growing mode of low-carbon urban transportation. Dr. Srinivasan Keshav and his colleagues have initiated the WeBike project in which they have deployed a fleet of about 30 sensor-equipped electric bicycles or e-bikes to University of Waterloo faculty, staff, and students. The aim is to study electric cars at a much lower price point (~$2,000 vs. ~$30,000) but also to study e-bikes in their own right. Insights gained from this project will be helpful in understanding the scope and impact of e-bikes on transportation infrastructure in the Canadian context and how people would buy them in concert with mass transit developments such as the LRT.

6 energy harvesting

PIEZOELECTRIC MICROELECTROMECHANICAL SYSTEMS (MEMS)

The goal of MEMS is to create a self-sustainable integrated system for smart grid monitoring and active management of electrical demand. In this way, issues related to grid capacity, reliability and efficient distribution of power can be monitored and controlled through sensing units as they have the capability to measure current and identify failures across the grid.

Compared with the traditional technology, the MEMS technological concept is highly competitive due to its non-invasive properties, low maintenance and significantly reduced costs. Dr. Armaghan Salehian and her research team are developing a system-on-chip solution to monitor electric power in smart grids using a piezoelectric based MEMS current sensor. In addition to a much smaller footprint, once developed, the proposed technology will have many advantages over its opponents in the market including superior accuracy for high current measurements — a limitation for available technologies due to their saturation problems.

ELECTROMAGNETIC ENERGY WIRELESS TRANSFER

Energy Harvesting is a ground breaking technology that can be used to transfer energy wirelessly from one location to another. This is a method of capturing minute amounts of energy in the form of heat, light, sound, vibrations, and electromagnetic fields. Such electromagnetic energy is abundantly available from sunlight, radio waves, and infrared radiation. Dr. Omar Ramahi and his associates have proposed the concept of etching to harvest up to 97 per cent of the electromagnetic energy that falls onto the surface of sheets of copper by etching repeating patterns on a sheet of metamaterial and adjusting the dimensions of the patterns. The ultra-efficiency of the process makes it a potential low cost option for energy harvesting.

7 wind energy

WIND POWER FORECASTING

Wind power offers a clean, sustainable, and free source of electricity that can lead to grid-wide energy savings and reductions in greenhouse gas (GHG) emissions. One of the biggest challenges for wind farm operators is to determine the amount of electricity that can be produced by wind turbines on any given day to meet the desired energy demand as wind speeds vary from hour to hour.

Dr. Fue-Sang Lien and his team of graduate students have developed a model of feeding the best statistical and meteorological data into an interconnected framework of artificial neural networks to forecast wind speed and turbine power. The result is an advanced 72 hour accurate forecast that will help operators and utilities to manage the power supply more efficiently.

WIND TURBINE PERFORMANCE ANALYSIS

Wind turbines frequently operate in multifaceted atmospheric conditions due to continually changing wind direction and magnitude. These conditions can impact the performance of the wind turbines due to unstable airloads on the blades that can result in turbine rotors that are misaligned with the wind (yawed). Dr. David Johnson and his group of academic researchers are analyzing different technical parameters of various blade designs by studying the wind turbine rotor under yaw loads.

COLLABORATE

education and training

THE ENERGY COUNCIL OF CANADA Energy Policy Research Fellowship Program supports original research to help develop innovative solutions and policies to transform the energy system for long-term sustainability. Fellowships totalling $184,500 have been awarded since 2013.

139 MEng graduates *(from 2008-2015*

391 MEng electric power graduates

8 Fellowships awarded by The Energy Council of Canada since 2013

WISE is cultivating research agreements worldwide

international agreements

KARLSRUHE INSTITUTE OF TECHNOLOGY

A framework co-operation agreement in the field of scientific and technological research

This collaboration with the Karlsruhe Institute of Technology is associated with the development of joint research projects and exchange programs for academic and technical staff within the scope of: solar energy and large area electronics, energy storage, power system integration, automotive and electric mobility systems, bioenergy and the AE4H Initiative.

ENERGY AND FUEL USERS ASSOCIATION OF INDIA

Promotion and development of sustainable urban and rural infrastructure development in the renewable energy sector

This strategic partnership facilitates the development of state-of-the-art research facilities and commercialization of research projects in addition to the international creation of jobs in engineering, business and finance, renewable energy policy, and environmental planning.

DALIAN UNIVERSITY OF TECHNOLOGY

International Comparison of Theories and Best Practices on Green Growth (ICTPG)

As a part of this five year agreement, WISE, the University of Waterloo and Dalian University in China will share research achievements related to theories and best practices on green growth gained in China, North America, the UK and EU, Russia, and the Commonwealth of Independent States. Participants have the opportunity to have face-to-face communications with the local people and to take part in activities such as the development of the Green Growth Pioneer Community in China.

THE HONG KONG POLYTECHNIC UNIVERSITY

Appointment of academic staff

WISE is seeking to establish research collaborations including joint supervision of PhD students, staff recruitment and substantial leave visits with The Hong Kong Polytechnic University. This agreement is currently in the discussion phase.

COLLABORATE

research spotlights

ENERGY HARVESTING LAB

Dr. Armaghan Salehian

Dr. Armaghan Salehian and her team seek to design and fabricate sensing devices to measure electric current for smart grid applications. Other areas of research include the use of smart material in bioengineering applications, flatness control of kapton membranes for space antenna membranes, dynamic modelling of complex cable-harnessed systems, as well as using GNSS reflectometry through micro-satellites for climate change monitoring.

USING REAL EV DATA TO DESIGN SMART CHARGING STRATEGIES

Dr. Mauricio Restrepo

By analyzing data collected by the Drive4Data campaign, researchers from the power and energy systems and the information systems and science for energy groups seek to identify patterns in the battery charging behaviors of electric vehicle owners. As EV ownership rises they seek to determine realistic charging algorithms and design strategies for minimizing EV impact on electricity delivery systems.

SETTING GOALS FOR ENERGY CONSERVATION

Dr. Ian Rowlands, Dr. Claudio Cañizares, Dr. Kankar Bhattacharya, Dr. Paul Parker

The Energy Hub Management System (EHMS), the brain child of a group of UWaterloo environment and engineering researchers, seeks to help home owners set specific energy goals by monitoring their conservation process. The result is a household smart-grid accessible by smart phone that helps home owners see how their behavior affects their hydro bill.

E-BIKE INSIGHTS

Dr. Srinivasan Keshav, Dr. Lukasz Golab

Dr. Srinivasan Keshav and Dr. Lukasz Golab launched WeBike: a three-year study that probes what Canadians think about electric bicycles and how we use them, in 2014. Now, in phase two, they have deployed 31 e-bikes equipped with sensors and a smartphone to study riders' behaviours.

Voltage and current sensors on the bikes gather data about the electric charge. Meanwhile, the smartphone uses GPS and accelerometers to track distances, terrain, speed, the number of trips each day and other pertinent details. Whether it's determining where to install charging stations or how temperatures affect battery life, the WeBike team are helping electrify transportation in Canada.

TAKING THE GUESSWORK OUT OF WIND POWER PREDICTIONS

Dr. Fue-Sang Lien

When it comes to forecasting the weather, Waterloo's Dr. Fue-Sang Lien believes that two crystal balls (or three or four or five) are better than one. By linking a number of systems, Dr. Lien and his team of researchers have pioneered a new way to more accurately anticipate wind speeds and power. On a wind farm in Northern China, he and his colleagues developed a better model, feeding the best statistical and meteorological data into an interconnected framework of artificial neural networks to forecast wind speed and turbine power. The result is more accurate 72-hour forecasts.


WISE
WATERLOO INSTITUTE
FOR SUSTAINABLE ENERGY
wise.uwaterloo.ca
TAP INTO
CONSERVE
ENABLE
smart policies and planning

hosted events

AFFORDABLE ENERGY FOR HUMANITY: IF NOT NOW, WHEN? LAUNCH EVENT

Waterloo, Ontario | September 2015

On September 29, 2015 A major 'Global Change Initiative' was launched — led by the University of Waterloo and Karlsruhe Institute for Technology — and is now underway to establish a platform for research and development of innovative energy technologies to drive down the cost of clean energy for those who need it most.

RESOURCE RECOVERY PARTNERSHIP WORKSHOP

Waterloo, Ontario | June 2015

On June 24, 2015 WISE hosted the second annual Resource Recovery Partnership Workshop which brought together partners from government, industry and academia to discuss pertinent issues regarding the present and future of resource recovery in Canada.

event participation and activities

IAN ROWLANDS

In April, 2015, Ian travelled to China. Accompanied by Prof. Paul Parker, Ian visited Beijing on behalf of the Faculty of Environment and gave a lecture entitled, 'Sustainable Energy: Canadian Examples' at the China University of Geosciences (Beijing). In Dalian he participated in an international conference on behalf of WISE — the International Workshop on the Theories and Practices of Green Growth, speaking on 'Green Energy for Green Growth?: Experiences from Ontario, Canada'.

To round out the year, alongside UW's Associate Director of the Interdisciplinary Centre on Climate Change, Ian led UW's delegation to the Paris Climate Summit COP21. A panel discussion open to the community was held in early 2016 by the COP 21 Delegation.

event participation and activities
(continued)

LUKASZ GOLAB

Lukasz gave the invited key note at the fourth International workshop on energy data management.

HEATHER DOUGLAS

September saw Heather organizing the 'Science in the Developing World: Enhancing Research Capacity' at the Balsillie School of International Affairs. She is also shaping National policy as a part of the planning committee for **scienceintegrity.ca**'s national efforts.

JATIN NATHWANI

Jatin had a busy sabbatical year prior to the launch of the consortium 'Affordable Energy for Humanity (AE4H): A Global Change Initiative'. Some key invitations to speak to leading energy access researchers and practitioners included:

CHINA Dalian University of Tech, Institute for Eco-planning & Development of DUT, Shanghai; School of Business, China University of Science and Technology

GERMANY University of Stuttgart; Karlsruhe Institute of Technology, Light Tech Institute, Karlsruhe; Helmholtz Research School for Energy Related Catalysis, Winter School, Baden-Württemberg; Fraunhofer UMSICHT Institute for Enviromental Safety and Energy Technology, Oberhausen;

SWITZERLAND Paul Scherrer Institute PSI, Villigen

UAE 4th NAUN International Conference on Energy Systems, Environment, Entrepreneurship and Innovation (ICESEEI '15), Dubai

UK UK Parliamentary Committee Hearing of the Nuclear Energy Group (APPG); World Energy Council — World Energy Scenarios Workshop, London; European Energy Policy Conference, University of Cambridge; Oxford Round Table on Environment, Climate Change and Global Warming, Oxford

USA 2015 International Conference on Sustainable Development, Panelist, Columbia University, NY

member activities

DR. MAURICE DUSSEAULT, DR. GIOVANNI CASCANTE, SEYEDBIJAN MAHBAZ, SHAHIN KARIMIDORABATI

Defects in steel reinforcement are critical factors in the evaluation of the service life of Reinforced Concrete (RC) structures. Steel reinforcement (rebar) defects or deterioration may lead to crack propagation and strength decrease in RC structural members. A prototype scanning device and software developed by two PhD students and their supervisors in the Civil and Environmental Engineering Department can scan reinforcement from the surface of concrete and detect its defects (corrosion, pitting, and cracking). The InspecTerra research team believes that with the quickness and reliability of their developed method, RC structures with high failure probability can be detected sooner in order to increase safety.

From manufacturing plants and construction sites to nuclear power plants, oil refineries and shipyards, Non-Destructive Testing (NDT) is used for numerous applications across a wide range of industries. Overall, the industry is expected to grow an annualized 6.8 per cent in five years to $2.6 billion in 2015. The Non-Destructive Testing Services industry will continue to expand over the next five years, bolstered by government regulation standards for health, safety and the protection of the environment with revenue estimated to grow an annualized 4.3 per cent to $3.2 billion over a five-year period.

informing public dialogue

WATERLOO RESEARCHERS ADVANCE ELECTRIC CAR BATTERY RESEARCH

An ultra-thin nanomaterial is at the heart of a major breakthrough by waterloo scientists who are in a global race to invent a cheaper, lighter and more powerful rechargeable battery for electric vehicles. Chemistry professor Linda Nazar and her research team have discovered that a nano sheet of manganese dioxide can be used in a lithium-sulphur (Li-S) battery that can theoretically power an electric car three times further than current lithium-ion batteries for the same weight.

Professor Nazar is presenting a perspective on the promise and reality of lithium-sulphur and lithium-air batteries at the American Association for the Advancement of Science (AAAS) annual meeting in mid-February. She will highlight recent innovations in nanomaterial strategies and new electrolytes that can help these future-generation energy storage systems realize their potential in emerging markets.

REUSING ELECTRIC CAR BATTERIES WILL CUT GREENHOUSE GASSES

Batteries no longer strong enough to drive cars can have a second life powering lights and appliances for 10+ years, Waterloo research finds. A group University of Waterloo researchers say the salvage yard need not be the end of the road for exhausted electric-vehicle (EV) batteries. They've found that refurbished EV batteries can have a second career as power sources for everything from lighting to refrigeration.

The team wants to take the research another step further — a trial, possibly in a warehouse with lighting, refrigeration and electric equipment that need power. A bank of refurbished electric-vehicle batteries could capture electricity at cheaper, off-peak times of the day and use it later to offset costs during peak periods. Re-using batteries this way formed the basis of a Master's thesis completed by Leila Ahmadi in the department of Mechanical and mechatronics engineering.

The research team is a classic Waterloo collaboration. Besides Ahmadi, it includes Steven B. Young, Associate Professor, School of Environment, Enterprise and Design, Roydon Fraser, a Professor of Mechanical and Mechatronics Engineering, Michael Fowler, a Professor of Chemical Engineering; Sean Walker, a Post-Doc in Chemical Engineering; and Arthur Yip a Waterloo undergrad. Mitsui and Co. (Canada) ltd. and Nuvation Engineering are industry partners.

Photo: Linda Nazar, Chemistry Professor in the Faculty of Science, University of Waterloo

OIL AND GAS WELLS ARE LEAKING METHANE GAS

Wells that leak methane are a bigger risk to the environment than fracking, says Waterloo researcher and Professor Maurice Dusseault. Oil and gas wells that leak methane, a potent greenhouse gas, are a bigger risk to the environment than fracking, according to a report by University of Waterloo researchers. Hydraulic fracturing, better known as fracking, is a controversial method used by the energy industry that involves injecting high-pressure water into wells to extract oil and gas from rock.

PAUL PARKER AWARDED GREEN COMMUNITIES CANADA AWARD

Faculty of Environment Professor and Associate Dean of Graduate Studies, Paul Parker has been recognized for his commitment to REEP Green Solutions and for providing exceptional stewardship to the organization with the 2015 Green Communities Canada award for outstanding board person.

“Paul is a co-founder of REEP and its longest serving board member,” said Mary Jane Patterson Executive Director at REEP Green Solutions (REEP stands for residential energy efficiency project). “He finds creative ways to weave his personal commitment to energy sustainability and community volunteerism into every aspect of his work. Paul is known for his legendary speaking style, big expansive gestures and infectious enthusiasm.”

Green Communities Canada is a national association of community organizations working with homeowners, businesses, governments and communities to reduce our impact on the environment.

public lecture series

Dr. Anthony Peirce	Professor, Department of Mathematics, The University of British Columbia	Modeling Multi-Scale Processes in Hydraulic Fracture Propogation Using the Implicit Level Set Algorithim (ILSA)
Professor Zhong Li	Deputy Director, Key Lab of Coal Science & Technology, Taiyuan University of Technology	Synthesis of Coal-Based Clean Fuels and Chemicals
Professor George Gross	Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign	A Practical Framework for the Implementation of the Vehicle-to-Grid (V2G) Concept
Tom Chapman	Markets Group, Independent Electricity System Operator	Demand Response and Capacity Auctions for Ontario
Professors Maurice B. Dusseault and Steve G. Evans	Department of Earth and Environmental Sciences. University of Waterloo	Hydraulic Fracturing: A Natural and Industrial Process
Klaus Dohring	President, Green Sun Rising Inc., Windsor ON	Electric Vehicle (EV) Charging
Dr. Doris Sáez Hueichapan	Associate Professor, Dept. of Electrical Engineering, Universidad de Chile	Design of a participatory-model/ microgrid/smart-farm system for the Mapuche Indigenous Communities
Dr. Alexandra Pehlken	Lecturer in Bioenergy for the International PPRE Program, Oldenburg University, Germany	The Impact of “Energiewende” on Renewable Energies in Germany
Dr. Anand Puppala	University of Texas at Arlington	Sustainability and Geothermal Energy Studies in Geotechnical Engineering
Dr. Bala Venkatesh	Lecturer, Dept. of Electrical and Computer Engineering and Academic Director, Center of Urban Energy, Ryerson University	Microgrid Analysis, Optimization and Implementation

member awards and honours

IAN ROWLANDS

Environment and Resource Studies

In July 2015, Professor Ian Rowlands was appointed as the faculty of Environment's first Associate Dean, Strategic Initiatives for which he will serve a three-year term.

PHILIP BEESLEY

School of Architecture

2014 Architizer A+ Jury Award, Architizer
2014 Prix ARS Electronica, ARS Electronica

TERRI MEYER BOAKE

School of Architecture

2015 Special Achievement Award,
American Institute of Steel Construction

ROYDON FRASER

Mechanical and Mechatronics Engineering

Outstanding Long-term Faculty Advisor Award,
National Science Foundation

LUKASZ GOLAB

Management Sciences

Canada Research Chair in Data Analytics
for Sustainability

KEITH HIPEL

Systems Design Engineering

President, Academy of Science, the Royal Society of Canada

Doctor Honoris Causa, Óbuda University

Honorary Diplomate, American Academy of Water Resources Engineers

Honorary Professor, Nanjing Audit University

Honorary Professor, State Key Laboratory for Environmental Criteria and Risk Assessment, Chinese Research Academy of Environmental Sciences

SUSAN TIGHE

Civil & Environmental Engineering

Award of Academic Merit,
Transportation Association of Canada

Inaugural Member of the Royal Society of Canada's College of New Scholars, Artists and Scientists

LINDA NAZAR

Chemistry, Physics and Astronomy, Electrical and Computer Engineering, Waterloo Institute for Nanotechnology

Highly Cited Researcher, Thompson Reuters

MAHESH PANDEY

Civil & Environmental Engineering

NSERC/UNENE Industrial Research Chair
in Risk-based Life Cycle Management of
Engineering Systems

AIPING YU

Chemical Engineering

Early Researcher Award,
Ontario Ministry of Research and Innovation

EHAB EL-SAADANY

Electrical and Computer Engineering

Spring 2015 Engineering Society Teaching Excellence Award

JAMES CRAIG

Civil and Environmental Engineering

Sanford Fleming – Engineering Teaching Excellence Award 2015

SEAN PETERSON

Mechanical and Mechatronics Engineering

Sanford Fleming – Engineering Teaching Excellence Award 2015

As a member of the Ontario Smart Grid Forum (Chaired by the IESO), WISE provides advice to government, regulators, agencies, and industry to advance the effective implementation of a smart grid in Ontario, to maintain a collective understanding of relevant developments in other jurisdictions and influence global developments in the interests of Ontario.

The WISE Executive Director serves as the lead Scientific Advisor to the Waterloo Global Science Initiative (WGSI) established by the Perimeter Institute and the University of Waterloo.

Upon request, members may provide expert testimony and give presentations to policy makers and legislators. As an example this year, WISE was invited to the UK House of Commons Committee Meeting of the All Party Parliamentary Group for Nuclear Energy to discuss 'Coping with a Large Nuclear Accident' with the Parliamentary Office of Science and Technology, London, March 2015.

The Council for Clean and Reliable Electricity provides a platform for open public dialogue and a solution-oriented approach to the challenges of the energy sector. It is a forum where representatives from universities, public and private sector business leaders, labour unions and strategic planning professionals collaborate to broaden public debate. As a member of the CCRE WISE has helped to develop a following among professionals within the energy sector through its highly regarded conference program and publications

The 'Global Change Initiative — Affordable Energy for Humanity' will advance the scientific and technological capacity for innovations required to meet the challenge of global energy access and energy poverty. The initiative will establish a platform for large-scale adoption of low cost energy technologies and solutions intended to reach every global citizen.

member publications

SELECTED

Invited Presentations

» **Affordable Energy for Humanity**, Ontario Smart Grid Forum, IESO, 120 Adelaide St, Toronto, October, 26, 2015

» **'Grid Storage to Grid Resiliency: How?'** Canadian German Smart Grids and Storage Series. Breakfast Seminar, Storage of Renewable Energies, Ontario Investment and Trade Centre (OTIC), 250 Yonge Street, Toronto, October 10, 2015

» **Science for Affordable Energy**, Science in the Developing World workshop, Balsillie School of International Affairs, Waterloo, ON, September, 17-18, 2015

» **'Affordable Energy for Humanity: If Not Now, When'**, The Oxford Round Table on Environment, Climate Change and Global Warming, Harris Manchester College, Oxford, England, July 22-25, 2015

» **'Global Energy Transitions: responding to the threat of Climate Change,'** China Lectures Series, Presented at the School of Business, China University of Science and Technology Shanghai, China, April 15, 2015

» **Enabling A Green ('Sustainable') Economy:** Critical Role of ICT, Dalian University of Technology, China, April 9-11, 2015

» **'Global Energy Transitions: Delivering Affordable Energy Access'**, Paul Scherrer Institute PSI, Villigen, Switzerland, March 5, 2015

» **'Innovation Pathways to Delivering Affordable Energy'**, 4th NAUN International Conference on Energy Systems, Environment, Entrepreneurship and Innovation (ICESEEI '15), Dubai, United Arab Emirates, February 22-24, 2015

» **'Energy Transitions for Affordable Energy'**, KIT, Light Tech Institute, Karlsruhe, Germany, CS 30.34, February 10, 2015

» **'Global Energy Transitions: responding to the threat of Climate Change'**, China Lectures Series, Presented at the School of Business, China University of Science and Technology Shanghai, China, April 15, 2015

MEMBER PUBLICATIONS

publications and conference papers

» Thompson, T., Rausch, S., **Saari, R.**, & Selin, N. (2014). A systems approach to evaluating the air quality co-benefits of US carbon policies. Nature Climate Change, 4, 917 – 923.

» Mirhosseini, S., Polak, M., & **Pandey, M.** (2014). Nuclear radiation effect on the behavior of reinforced concrete elements. Nuclear Engineering and Design, 269, 57 – 65.

» Arriaga, M., **Canizares, C.**, & **Kazerani, M.** (2014). Northern Lights: Access to electricity in Canada's northern and remote communities. IEEE Power and Energy Magazine, 12(4), 50 – 59.

» Wang, M., Liang, H., Zhang, R., Deng, R., & **Shen, X.** (2014). Mobility-Aware coordinated charging for electric vehicles in VANET-Enhanced smart grid. IEEE Journal on Selected Areas in Communications, 32(7), 1344 – 1360.

» Sanscartier, D., **Dias, G.**, Deen, B., Dadfar, H., McDonald, I., & Maclean, H. (2014). Life cycle greenhouse gas emissions of electricity generation from corn cobs in Ontario, Canada. Biofuels Bioproduction and Biorefining, 8(4), 568 – 578.

» Mohanto, S., Singh, K., Chakraborty, T., & **Basu, D.** (2014). Cyclic thermo-mechanical analysis of wellbore in underground compressed air energy storage cavern. Geotechnical and Geological Engineering, 32(3), 601 – 616.

» **Basu, D.**, Misra, A., & Puppala, A. (2014). Sustainability and geotechnical engineering: Perspectives and review. Canadian Geotechnical Journal, 52(1), 96 – 113.

» Ibrahim, M., & **Salehian, A.** (2014). Modeling, fabrication, and experimental validation of hybrid piezo-magnetostrictive and piezomagnetic energy harvesting units. Journal of Intelligent Material Systems and Structures, 26(10), 1259 – 1271.

» Men, Z., Yee, E., **Lien, F.**, Ji, H., & Liu, Y. (2014). Bootstrapped Multi-Model Neural-Network Super-Ensembles for Wind Speed and Power Forecasting. Energy and Power Engineering, 6, 340 – 348.

» Xia, C., Black, R., Fernandes, R., Adams, B., & **Nazar, L.** (2015). The critical role of phase-transfer catalysis in aprotic sodium oxygen batteries. Nature Chemistry, 7, 496 – 501.

» Ladubec, C., **Gracie, R.**, & **Craig, J.** (2015). An extended finite element method model for carbon sequestration. International Journal for Numerical Methods in Engineering, 102(3 – 4), 316 – 331.

» **Bhattacharya, K.**, Sharma, I., & **Cañizares, C.** (2015). Smart distribution system operations with price-responsive and controllable loads. IEEE Transactions on Smart Grid, 6(2), 795 – 807.

» Farrokhabadi, M., **Cañizares, C.**, & **Bhattacharya, K.** (2015). Frequency control in isolated/islanded microgrids through voltage regulation. IEEE Transactions on Smart Grid, 99, 1 – 10.

» Arriaga, M., **Cañizares, C.**, & **Kazerani, M.** (2015). Long-Term renewable energy planning model for remote communities. IEEE Transactions on Sustainable Energy, 7(1), 221 – 231.

» Olivares, D., Lara, J., **Cañizares, C.**, & **Kazerani, M.** Stochastic-Predictive energy management system for isolated microgrids. (2015). IEEE Transactions on Smart Grid, 6(6), 2681 – 2693.

» Shi, Z., Sun, R., Lu, R., Chen, L., Chen, J., & **Shen, X.** (2015). Diverse grouping based aggregation protocol with error detection for smart grid communications. IEEE Transactions on Smart Grid, 6(6), 2856 – 2868.

» Eajal, A., Shaaban, M., **Ponnambalam, K.**, & **El-Saadany, E.** (2015). Stochastic centralized dispatch scheme for AC/DC hybrid smart distribution systems. IEEE Transactions on Sustainable Energy, 99, 1 – 14.

MEMBER PUBLICATIONS

publications and conference papers
(continued)

» Ghiassi-Farrokhfal, Y., Kazhamiaka, F., **Rosenberg, C.**, & **Keshav, S.**, & Adjaho, M. (2015). Optimal design of solar PV farms with storage. IEEE Transactions on Sustainable Energy, 6(4), 1586 – 1593.

» Sadeghimakki, B., Zheng, Y., Jahed, N., Pham, P., Babujee, A., Bols, N., & **Sivoththaman, S.** (2015). Toxicity and safety aspects of nanoparticle spread in third generation photovoltaic device processing environments. Photovoltaic Specialist Conference (PVSC), 2015 IEEE 42nd, New Orleans, Louisiana, USA, June 14 – 19.

» Bilh, A., Naik, K., & **El-Shatshat, R.** (2015). An Adaptive Charging Algorithm for Electric Vehicles in Smart Grids. 2015 IEEE 81st Vehicular Technology Conference (VTC Spring), Glasgow, Scotland, United Kingdom (pp. 1 – 7), May 11–14.

» Malek, K., & **Nathwani, J.** (2015). Technology Management Tools for Assessing Emerging Technologies: The Case of Grid-scale Storage. 2015 Portland International Conference on Management of Engineering and Technology (PICMET), Portland, Oregon, USA (pp. 2346 – 2354), August 2–6.

» Wang, X., Wu, C., & **Nathwani, J.** (2015). Dynamic response forecasting and optimising paths of energy efficiency. International Journal of Computational Science and Engineering, 12(1), 86 – 93.

» Alhazmi, Y., & **Salama, M.** (2015). A Statistical Approach to Estimate the Correlation between Charging Station Availability and Plug — In Electric Vehicle Sales in Canada. Proceedings of the 2015 International Conference on Operations Excellence and Service Engineering, Orlando, Florida, USA, September 10-11.

» Ordouei, M. H., **Elkamel, A.**, **Dusseault, M. B.**, & Alhajri, I. (2015). New sustainability indices for product design employing environmental impact and risk reduction: case study on gasoline blends. Journal of Cleaner Production, 108, 312-320.

» Alavikia, B., Almoneef, T., & **Ramahi, O.** (2015). Wideband resonator arrays for electromagnetic energy harvesting and wireless power transfer. Applied Physics Letters, 107(24), 1 – 5.

» Gharali, K., **Johnson, D.**, Lam, V., & Gu, M. (2015). A 2D Blade Element Study of a Wind Turbine Rotor Under Yaw Loads. Wind Engineering, 39(5), 557 – 568.

» Koksal, M., **Rowlands, I.**, **Parker, P.** (2015). Energy, cost, and emission end-use profiles of homes: An Ontario (Canada) case study. Applied Energy, 142, 303 – 316.

» Herdem, M., Farhad, S., & **Hamdullahpur, F.** (2015). Modeling and parametric study of a methanol reformate gas-fueled HT-PEMFC system for portable power generation applications. Energy Conversion and Management, 101, 19 – 29.

» Oyegunie, A., & **Weber, O.** (2015). Development of sustainability and green banking regulations — Existing codes and practices. Centre for International Governance Innovation (CIGI) Papers, No. 65, pp. 24.

» Ahmadi, L, **Young, S.**, **Fowler, M.**, **Fraser, R.** Achachlouei, M. (2015). A cascaded life cycle: Reuse of electric vehicle lithium-ion battery packs in energy storage systems. International Journal of Life Cycle Assessment, 1 – 14.

» **Craik, N.** (2015). International EIA law and geoengineering: Do emerging technologies require special rules? Climate Law, 5(2 – 4), 111 – 141.

» Liu, X., **Golab, L.**, & **Ilyas, I.** (2015). SMAS: A smart meter data analytics system. IEEE International Conference on Data Engineering, ICDE 2015, Seoul, South Korea, pp. 1476 – 1479. May 26.

» Vajedi, M., & **Azad, N.** (2016). Ecological adaptive cruise controller for plug-in hybrid electric vehicles using nonlinear model predictive control. IEEE Transactions on Intelligent Transportation Systems, 17(1), 113 – 122.

» Ghiassi-Farrokhfal, Y., **Rosenberg, C.**, & **Keshav, S.**, & Adjaho, M. (2016). Joint optimal design and operation of hybrid energy storage systems. IEEE Journal on Selected Areas in Communications, 34(3), 639 – 650.

» Xua, N., Zhua, T., Qiaoa, J., Zhang, F., **Chen, Z.** (2016). Nitrogen and sulfur co-doped mesoporous carbon as cathode catalyst for H2/O2 alkaline membrane fuel cell — effect of catalyst/bonding layer loading. International Journal of Hydrogen Energy, In Press.

» Garcia, A., **Obeidi, A.**, & **Hipel, K.W.** (2016). Two methodological perspectives on the energy east pipeline conflict. Energy Policy, 91, 397 – 409.

» Said, S., **Simakov, D.**, Waseeuddin, M., & Roman-Leshkov, Y. (2016). Solar molten salt heated membrane reformer for natural gas upgrading and hydrogen generation: A CFD model. Solar Energy, 124, 163 – 176.

» An, J., Sim, J., Feng, Y., & **Lee, H.-S.** (2016). Understanding energy loss in parallel connected microbial fuel cells: Non-Faradaic current. Bioresource Technology, 203, 280 – 286.

» Ellsworth, P., **Fraser, R.**, **Fowler, M.**, VanLanen, D., Gaffney, B., Wang, C., Shen, T., Wu, W., McInnis, P. (2016). Control Analysis for Efficiency Optimization of a High Performance Hybrid Electric Vehicle with Both Pre and Post Transmission Motors. SAE International, 1253, pp. 14.

OUR PEOPLE

Industrial Research Chair ●
Canada Research Chair ●
Ontario Research Chair ●
University Research Chair ●

WISE MEMBERS

» William Anderson
» Miguel Anjos
» Dipanjan Basu
» Phillip Beesley
» Kankar Bhattacharya
» Phillip Bigelow
» Terri Meyer Boake
» Paul Calamai
» Claudio Cañizares
» Giovani Cascante
» Trevor Charles
» Pu Chen ●
» Zhewen Chen
» Zhongwei Chen ●
» Chih Hsuing (Perry) Chou ●
» Michael Collins
» James Craig
» Eric Croiset
» Richard Culham ●
» Cecile Devaud
» Goretty Dias
» Paul Doherty
» Heather E. Douglas
» Peter Douglas
» Tom Duever
» Maurice Dusseault
» Ali Elkamel
» Ehab El-Saadany ●
» Ramadan El-Shatshat
» Robert Feick
» Xianshe Feng
» Michael Fowler
» Roydon Fraser
» David Fuller
» Lukasz Golab ●
» Wojciech Golab
» Irene Goldthorpe
» Robert Gracie
» Feridun Hamdullahpur
» Keith Hipel
» Anming Hu
» Robert Hudgins
» Ihab Ilyas
» Shesha Jayaram ●
» Eric Jervis
» Beth Jewkes
» David Johnson
» Mehrdad Kazerani
» Srinivasan Keshav
» Behrad Khamesee
» Holger Kleinke
» Mark Knight
» Steve Lambert ●
» Nasser Lashgarian Azad
» Hyung-Sool Lee
» Ray Legge
» Yuri Leonenko
» Geoffrey Lewis
» Xianguo Li ●
» Yuning Li
» Yuying Li
» Fue-Sang Lien
» Qing-Bin Lu ●
» Jennifer Lynes
» David Mather
» Christine Moresoli
» Sriram Narasimhan ●
» Jatin Nathwani ●
» Linda Nazar ●
» Artie Ng
» Flora Ng
» Amer Obeidi
» Qinmin Pan
» Mahesh Pandey ● ●
» Paul Parker
» Wayne Parker
» Sean Peterson
» Kumaraswamy Ponnambalam
» Mark Pritzker
» Eric Prouzet
» Pavle Radovanovic ●
» Omar Ramahi
» Sankaran Ramalingam
» Gary Remple
» Luis Ricardez-Sandoval
» Catherine Rosenberg ●
» Leo Rothenburg
» Ian Rowlands
» Rebecca Saari
» Magdy Salama
» Armaghan Salehian
» Andrei Sazonov
» Gerry Schneider
» Anindya Sen
» Xuemin (Sherman) Shen
» David Simakov
» Siva Sivoththaman ●
» John Straube
» Zhongchao Tan
» Susan Tighe
» Robert Varin
» Xiaoling Wang
» Olaf Weber
» Lan Wei
» John Wen
» John Wright
» Serhiy Yarsevych
» Steven Young
» Aiping Yu
» Jian Zhang

ADVISORY COUNCIL

Steve Dorey
Chair, Energy Council of Canada Studies Committee

George Green
Chair, Stratos Inc.

Don MacKinnon
President, Power Workers' Union

Carmin Marcello
President & CEO, Hydro One Inc. (former)

David McFadden
Chair, Gowling LaFleur Henderson LLP

Paul Murphy
Chair, Advisory Board, MaRS Discovery District

Andrew Pride
Vice President, Ontario Power Authority (former)

William Smith
Senior Vice President, Energy Sector Siemens (Can) Ltd.

Andy Teichman
Executive Director of Investments, OPG Ventures Inc.

John Wilkinson
President & CEO, Wilkinson Insight Incorporated

Menelaos Ydreos
Executive Director, EnergyVantage

LEADERSHIP

Kankar Bhattacharya
Associate Director, Advanced Training

Claudio Canizares
Acting Executive Director, January-August 2015

Jatin Nathwani
Executive Director

Ian Rowlands
Acting Executive Director, September-December 2014

Erik Prouzet
Associate Director, Global Initiatives

STAFF

» **Armughan Al-Haq** | Manager, Program Development and Partnerships

» **Nigel Moore** | Manager, Global Programs and Initiatives

» **Iris Strickler** | Administrative Assistant

» **Amanda Myers** | Communications Specialist (co-op)

» **Neelima Chembil-Palat** | Communications Specialist (co-op)

WISE by the numbers

OUR PEOPLE

110 Members

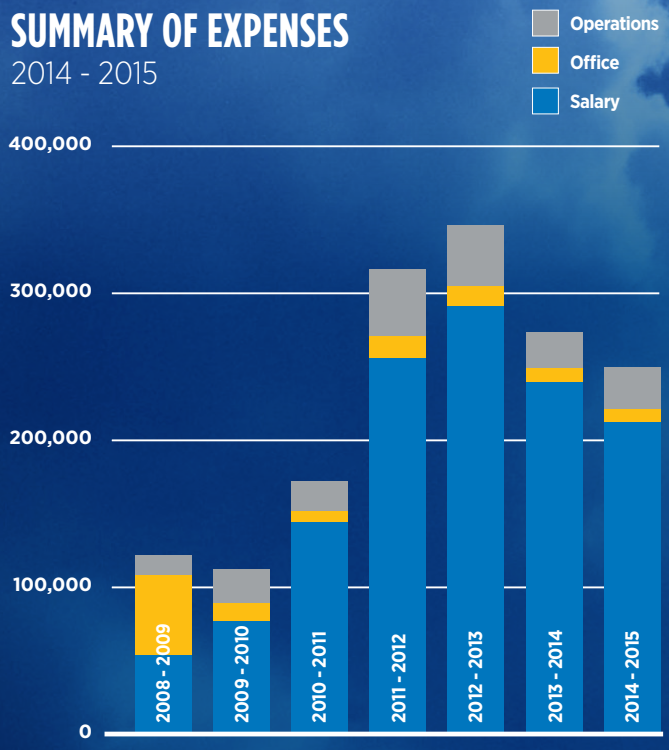
28 Labs

14 Research Chairholders

20 Areas of Expertise

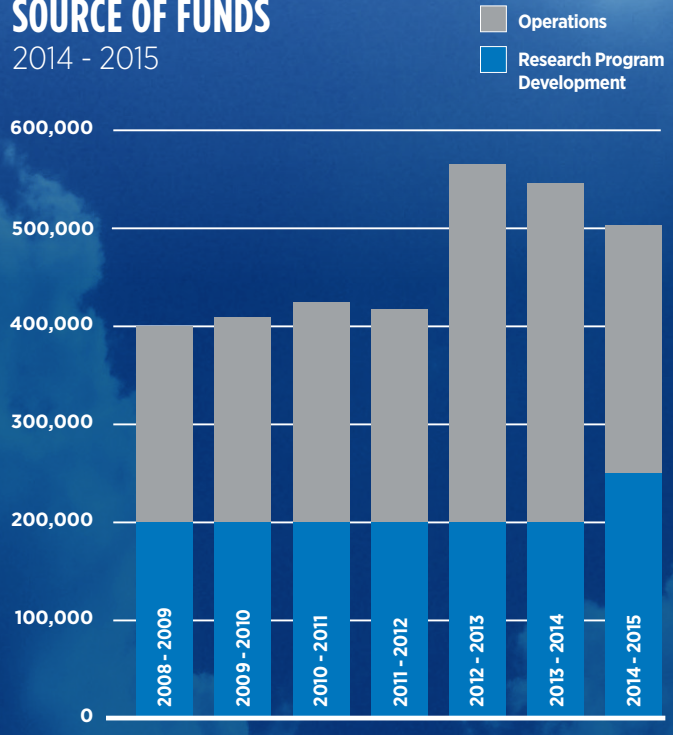
SUMMARY OF EXPENSES

2014 - 2015



SOURCE OF FUNDS

2014 - 2015



SCHOLARLY TALKS

16 industry & scientific visitors

SCHOLARLY OUTPUT

540+ member publications *(2014-2015)*

AWARDS

5 CISCO System Smart Grid Research Awards

$120,000 awarded *(2013-2015)*

8 Energy Council of Canada Fellows

31 Hydro One Undergraduate Scholarships

FOR MORE INFORMATION…

or to request additional copies of this report,
please contact us at: **info@wise.uwaterloo.ca**

UNIVERSITY OF WATERLOO | WISE WATERLOO INSTITUTE FOR SUSTAINABLE ENERGY

C0/0754