

Proceedings of the Symposium on Alternate Energy and Global Synergy

July 15th, 2008

George Vari Engineering and Computing Center
Electrical and Computer Engineering Department, Ryerson University
245 Church Street, Toronto, ON, M5B 1Z2



Organizing Committee

SS Murthy (Ryerson U), Chair
Sri Krishnan (Ryerson U)
Bin Wu (Ryerson U)

Richard Cheung (Ryerson U)
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**Alexei Botchkarev (Chair, IEEE
Toronto Section)**
Ravi Seethapathi (Hydro One)

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visit <http://www.ee.ryerson.ca/~venkatesh>

Annexure-C List of delegates

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I Program

8:30am: **Registration**

9:00am: **Welcome and Plenary Session**

- Prof. Sridhar Krishnan, Chair, ELCE Dept, Ryerson U, *Welcome Remarks*
- Prof. Stalin Boctor, Dean of Engineering, Ryerson U, *Inauguration*
- Presentation of Working Paper: Prof. S(Sreenivasa) Murthy, Symposium Chair, *Objective of the Symposium and expected outcome*

10:00am: **Session-I**

Theme: R&D in Alternate Energy - Role of Govt., Industry and Utilities

Chair: Dr. Sri Krishnan, Chair, ELCE, Ryerson U.

- Mr. Robert Arnot, Deputy Director, Energy Technology Policy, Natural Resources Canada, *Alternate Energy Policy in Canada and scope for research support*
- Mr. Bob Singh, Manager Asset Strategies and Standards, Hydro One, *Integrating Renewable Generation in Ontario - Opportunities and Challenges*
- Mr. Surinder Sharma (President, Power Saving Systems Inc.), *Energy Conservation and Efficiency- an Experience*

10:50am: **Tea/Coffee Break & Networking**

11:00am: **Session-II**

Theme: Role of Universities, Research on Alternate Energy in Universities

Chair: Prof. Bin Wu, ELCE Dept, Ryerson U.

- Prof. Bin Wu, Ryerson U
- Prof. Narayan Kar, U of Windsor
- Prof. Vijay Sood, UOIT
- Prof. Jatin Nathwani, U of Waterloo
- Prof. Rajeev Varma, U of Western Ontario
- Prof. David Jackson, McMaster University
- Prof. Hitesh Doshi, Ryerson U

12:45pm: **Working Lunch**

1:30pm: **Session-III**

Theme: Support from Funding agencies: (15 mins each)

Chair: Dr. Richard Cheung, ELCE Dept, Ryerson U.

- Mr. Robert Stasko, Director, Business Development, Ontario Centres of Excellence, (OCE) Centre for Energy

- Mr Bharat Rudra, Country Manager International science and Technology Partnerships (ISTP) Canada Inc
- Dr. William Dobson, Director, Ontario Region, Industrial Research Assistance Program (IRAP)

2:15pm: **Session-IV**

Theme: General discussion on technology gaps and identification of R&D efforts.

Chair: Prof Sreenivasa Murthy, RU

Moderator: Prof. S Murthy, Prof. Richard Cheung

3:30pm: **Session-V**

Theme: Identification of possible projects and teams, Modes of implementation and Global Synergy, Networking of Stake holders

Track #1: Energy Generation

Moderator: Prof. S S Murthy, Mr Bob Singh

Track #2: Energy Utilization

Moderator: Prof. Jatin Nathwani, Mr Surinder Sharma

4:30pm: **Tea/Coffee Break**

4:45pm: **Concluding Session**

Chair: Mr. Ravi Seethapathi, Hydro One

Presentations of Conclusions of Tracks1,2: Profs. S S Murthy and Prof. Jatin Nathwani

Presentation of Outcome of Technical Sessions

Major Recommendation of the Symposium

5:15 pm: **Vote of Thanks, Presentation of Mementoes and Closure**

II Background

Climate Change and Global warming caused by excessive Greenhouse gases (GHG) are considered the biggest threat to our planet. Kyoto Protocol is a mandate for countries to reduce GHG emission globally although few are subscribing to it aggressively. Electricity generation resulting from burning of fossil fuels is considered one of the three prime sources of GHG emission. Therefore alternate energy systems to reduce burning of fossil fuels have come to centre stage of development globally. Wind, Hydro and Biofuels have to be considered as viable sources for power generation so as to reduce the need for additional coal and oil based plants. About 20% generation from such renewables is anticipated in the next decade. In addition Solar, Ocean / Tidal and Hydrogen Energy are also in development stage.

Energy Conservation and Efficiency are the new Mantra in this endeavor wherein saving energy is assuming prime importance in all sectors. Converting Urban and Rural waste to energy called “Waste to Watts” is another promising area. Both Micro and Macro level solutions should be attempted. Unlike centralized power generation of yore, emphasis will be on distributed (or decentralized generation) using locally available resources. ‘Roof top’, ‘back yard’ or ‘basement’ power plants may become the order of the day both to feed local loads and to the grid. Many technological, economic and social challenges lie ahead as we attempt to seek ‘out of box’ solutions.

The Kyoto protocol thrust may indeed become the vehicle for industrialized countries to not only reduce their emissions but help developing countries to effect the same through development of appropriate technologies. An appropriate “Carbon Credit” scheme could also support developing countries to reduce emissions through technology intervention and implementation in the latter. Thus “global synergy” will become a requirement and global R&D a necessity in tackling this energy crisis and climate change is a requirement of the day. We need to identify suitable R&D projects to be undertaken by Universities and Research organizations to augment the above efforts leading to viable “green technologies” centered on “Alternate Energy Systems”.

A one day symposium was organized by the ELCE Department of Ryerson University jointly with IEEE Toronto Section on 15th July 2008 to brain storm and to deliberate on all relevant issues aimed at identifying R&D projects, possible international collaborations, working teams and role of stake holders. Academic institutions can play a crucial role in research and knowledge dissemination in relevant areas. It is also necessary to focus on workable demonstration units/systems for transferring to field. Symposium will be attended by Academia, Industry, Utilities, Govt. agencies and user energy agencies drawn from the region to provide appropriate inputs. In recognition of the need for global efforts and to have international presence, a sample representation from EU (a strong supporter of Kyoto), and fast developing economies like India and China - would be attempted.

The symposium was to focus on specific issues and aim for realistic goals. Appropriate applications for urban, rural, developed and developing countries were deliberated to seek

localized implementable solutions under the concept “Think global and act local”. Economic and social factors would interweave with the above technical solutions and will be discussed as well.

Funding and resource mobilization for R&D are crucial. Since the issue is critical to mankind there are several regional and international programs to support promising research. Most of the affected countries are investing considerable funds for new technologies and implementation.

Symposium was expected to deliberate on the above issues to arrive at suitable conclusions and recommendations for follow up.

III Vision and Objectives

1. Brainstorm on viable / implementable technologies to be developed through R&D efforts on “Alternate Energy” in view of climate change, global warming, international commitments and depleting fossil fuels.
2. Identify technologies for local and global applications.
3. Identify the role of stake holders- Universities, Industry, Govt./Funding Agencies (National and international) and Utilities/ User Agencies- in this effort.
4. Identify possible teams comprising individuals and organizations for specific projects.
5. Prepare a roadmap to implement the above ideas for follow up.
6. Discuss workable mechanism to carry out R&D efforts for the desired goal – develop transferable technologies leading to demonstration projects in the field.
7. Discuss mechanism of international cooperation in these efforts to effect ‘Global Synergy’.

IV Deliberations of the Symposium

Symposium with nearly 150 delegates (Annexure-C) drawn from academia, industry, utilities, government and profession started with the Inaugural Session. Dr. Sri Krishnan, Chair of Electrical and Computer Engineering department of Ryerson University (RU) in his welcome address gave the policy background in organizing this symposium and hoped that this being the first of its kind could be a trend setter. He briefed about the symposium program, the sessions planned and expected outcome. He introduced the chair person of this symposium Prof. S. Sreenivasa Murthy, a visiting professor to Ryerson University from Indian Institute of Technology, Delhi. He also complemented Dr. Murthy for his enormous efforts in fructifying this event. Prof. Stalin Boctor, Dean of Engineering, RU in his inaugural speech complemented the organizers of the symposium and promised all support for such academic efforts. He emphasized the importance of Alternate Energy and urged Universities to boost research efforts in this area jointly with Industry and Utilities.

Dr. Sreenivasa Murthy, Symposium Chair, presented the working paper (Annexure-B1). He explained the vision and objectives of the symposium. He stated that alternate energy technologies have to be developed and implemented to tackle climate change and global warming caused by green house gas (GHG) emissions. He discussed the Kyoto protocol that created an international commitment on emission control. He highlighted the need to develop new technologies taking into account depleting fossil fuels for the sake of future generations. He presented an overview of the energy scenario highlighting the current state of utilization of fossil fuels and renewable energy options. He insisted that development of new technologies not only should be suitable for locally available alternate energy sources but help global needs. He explained how the stake holders like universities, industries, utilities, governments and various funding agencies can act in resolving the crisis. He requested these stake holders to identify possible teams for specific field related Research and development projects and develop transferable technologies through international cooperation or global synergy.

Session 1 started with presentation by Mr. Robert Arnot, Deputy Director, Natural Resources (NR) Canada on the overview of Canadian Energy Sector (Annexure-B2) and identified priorities for funding of science and technology projects by Canadian Federal government. He described why a country like Canada requires more energy for normal living due to its weather conditions. He discussed the level of GHG emissions by Canada and steps taken by NR Canada in bringing down the same. He explained how NR Canada is contributing to proper development of local natural resources through appropriate policies and programs so as to improve the quality of life for all Canadians by creating a sustainable resource advantage with special reference to renewable energy sources such as wind solar, hydro and Bioenergy without undermining the role of locally available vast conventional fuels such as oil, coal and uranium.

Mr. Bob Singh Manager for Asset Strategies, Hydro One presented (Annexure-B3) the opportunities and challenges faced by Hydro One in Integrating Renewable Generation in

Ontario. He presented an overview of the company's Transmission, distribution and generation capabilities. He discussed the Hydro One's initiatives in introducing alternate energy sources by effectively utilizing the available opportunities for Wind energy. He explained the challenges in this process as the existing power system is not designed to accept distributed generation. However efforts are being made jointly by IESO and Hydro One in speeding up the process of utilizing alternate energy by conducting a large number of system studies and developing codes and standards in consultation with appropriate organizations and wind turbine manufacturers towards regulating the power system to accept these new energy sources.

The Session ended with a presentation by Mr. Surinder Sharma, President Power Saving Systems Inc. (Annexure- B4) on his company's vision and mission on energy efficiency with the slogan-"Save Energy, Save Money, Save Environment". He shared his experience in incorporating energy efficient programs that resulted in cost benefits. He described about various energy management methods using energy efficient equipment and accessories. He described on implementing the energy efficiency awareness programs at all levels in any organization- commercial, industrial or domestic- that results in energy saving.

Session II was on the role of Universities on Alternate Energy Research, through presentation by well known academics from different universities of Ontario. Prof Bin Wu of Ryerson University(RU) briefed (Annexure- B5) on various wind power projects in Canada with a comparative overview on wind turbine technologies, their design, speed control, rating, control system, converter systems and the evolution. He detailed the efforts on various Wind energy research areas in RU by faculty members and research students and the facilities in the university to undertake such projects He also listed the ongoing research programs in these areas at the university.

Dr. Narayan Kar from University of Windsor made a presentation (Annexure-B6) on Hybrid Vehicle Technology its current status, key challenges and future prospects. He described about the types of hybrid vehicles and pointed out on the energy saving on each type. He briefed about the challenges being faced in designing various components of the hybrid vehicles and thereby saving energy. He listed the research pursued by his group at the university.

Prof. Vijay Sood from University of Ontario Institute of Technology made a presentation (Annexure-B7) on Modeling Issues of Windmill Integration. He made an overview of Wind power Integration and it's relating issues such as data, modeling tools and validation. He described about a windmill farm and stating their problems. He explained the various types of converter model like Multi-level converter, current source converter, voltage source converter. He talked about Synchronous and Induction Machines on their electrical, mechanical data and its machine rating. He also talked about the simulation labs at Ryerson University. He described the various components of Load models including active & reactive power measurements. He highlighted the problems faced by researchers in modeling in the absence of reliable data and information from the manufac-

turers of wind equipment and systems. He felt the need to develop workable and reliable models.

Prof. Jatin Nathwani from university of Waterloo who is also the Ontario research chair in public policy and sustainable energy management made a presentation (Annexure-B8) on energy and environmental sustainability. He detailed about the policies, programs and directions of Waterloo Institute of Sustainable Energy (WISE). He expressed how energy poverty affects the quality of life and human development. He detailed that the Ontario electricity system would become greener and the Ontario GHG emission problem will be essentially resolved during the near future.

Dr. Rajiv Varma from University of Western Ontario (UWO) made a presentation (Annexure-B9) on Grid Integration of Wind and PV-Solar Power Plants. He described the impacts and influences to Hydro One Networks Inc. such as Impact of Wind Power Distribution on Transformers, Voltage Regulation in Hydro One Feeder Systems, Modeling of Multiple Distributed Generators, Ferro resonance Studies in Wind farms - a research study project and Model Validation of Wind Turbine Generators. He described the main FACTS devices and controllers like the Static Var Compensator (SVC) and the Static Synchronous Compensators (STATCOM). He talked about the upcoming projects at UWO funded by the Ontario Centre of Excellence on Large-Scale Photovoltaic Solar Power in Transmission and Distribution Network. He mentioned their Industrial Partners and International Collaborations such as: SICI, IIT, Central Power Research Institute and Wind-Turbine Generator Manufacturers.

Prof. David Jackson of McMaster University highlighted (Annexure-B10) their work on Energy such as Vertical Axis Wind Turbines, Improved PV cells, Fuel Cells, Supercapacitors, Conservation, Modeling and Air Pollution from Vehicles. He talked about McMaster receiving support from different Government and Industry. He informed on various studies to enrich educational programs and to expand further into transportation.

Prof. Hitesh Doshi from Ryerson University made a presentation on Sustainability and Green Roots highlighting enormous opportunities for Solar architecture in Building Industry for energy conservation and to have 'green' buildings. He touched upon, cost benefits, sensors/instruments, use of Solar Panels with emphasis on International Collaboration for Green Roots.

Session-III with theme on 'support from funding agencies' had three presentations, Mr. Bharat Rudra, Country Manager (India), International Science and Technology Partnership (ISTP) Canada Inc. presented(Annexure-B11) the opportunity for Industry inspired international R&D projects under ISTP so long as active partnership can be established between Industry and Academia in Canada and partner countries. He cited 8 projects (totalling \$17M) recently funded under Canada- India arrangement giving a brief outline of current R & D projects. He talked about the funding agreements with Canadian contributions and Partnership Development Activities (PDA) with India and China.

Mr. Robert Stasko, Director, Ontario Center of Excellence (OCE) presented (Annexure-B12) schemes of OCE to support Ontario universities and industry for R&D projects with promising marketable technologies. He emphasized that Alternate Energy is a priority area for support and researchers should take advantage of the same. He described about various Energy Markets, Energy Systems, Emerging Energy Technologies, Skill Development and Technology Convergence. He mentioned their current researches as on 2008 with Ontario Government's budget of \$50 million on Transformation Energy Innovations. Dr. William Dobson, Director, Industrial research Assistance Program (IRAP), presented (Annexure-B13) schemes to financially support local industry to develop appropriate technologies so long as matching funds are earmarked by them. . He gave a brief overview on SMEs and programs at National Research Council. He talked about the innovation strategies, impact on their clients, their research development expenditure and about Business Enterprise Sector. He concluded by highlighting some facts on Private Sector R&D on Alternate Energy.

Sessions IV and V were of 'brainstorming' nature with open discussion among delegates on technology gaps, identification of R&D efforts , possible projects, modes of implementation, global synergy and networking of stake holders. Deliberations of these sessions with relevant conclusions and recommendations are given in the following section along with list of possible projects (Annexure-A).

During the concluding session, Prof Murthy (Symposium Chair) summarized the deliberation. Mr. Ravi Seethapathi, Hydro One, who chaired the sessions emphasized that emerging down town areas and commercial complexes will become complex with problems of right of way. Solar energized buildings need to be developed with emphasis on energy saving through smart controls, smart meters, smart appliances and retrofitting of equipment and devices. In the end Prof Murthy thanked all those who contributed to the success of the symposium, significantly the band of volunteers of RU and IEEE.

V Major Conclusions and Recommendations

1. Energy Crisis caused by depleting fossil fuel, Green House Gas (GHG) emissions, global warming and climate change needs development of viable Alternate Energy (AE) Technologies in which Universities and Academia can play an active role through R&D.
2. In the above effort synergy among academia, industry, utilities, government/ funding agencies and society at large is essential.
3. While Kyoto protocol aims at global reduction of GHG emissions, developed and developing countries have differing mandates and actions needing appropriate technologies for each.
4. Therefore global synergy in developing suitable technologies for each country and region considering local needs and resources is imperative.
5. Alternate Energy Systems (AES) mainly deal with Energy generation and Energy Utilization, although energy transmission/transportation will have a role.
6. It is noted that there is a quantum jump in energy related research in Canadian Universities and synergy among them would be beneficial. Presentations by different universities in the symposium reflect this new paradigm.
7. AE systems are highly inter-disciplinary in nature encompassing almost all branches of Engineering and Science. Hence R&D projects must involve all and universities provide the most suitable ambience for the same.
8. Many Electric utilities in Canada are preparing for increased penetration of renewable energy based generation in their system recognizing many technical problems.
9. Local funding agencies such as NSERC, IRAP, OCE can be tapped to support research.
10. Canadian industry may have to play an increasing role in this Endeavour.
11. Canadian entities can interact effectively with other regions and countries such as EU, USA, China, India, Asia Pacific on technology development efforts.
12. International funding agencies such as ISTEP Canada, UNDP, GEF can be tapped to support joint international projects with matching support from other partners.
13. Canadian Federal agencies such as Natural Resources, Canada have policies in place to support alternate energy.
14. It is noted with concern that cumbersome procedures of many funding agencies and enormous delay in processing proposals have dampened the interest of researchers. In

reality actual R&D fund made available and actually allotted for Alternate Energy research is insignificant globally considering its importance. This aberration needs to be urgently rectified. It is hoped that a quantum jump in funding for AE research will be forthcoming globally with most of the country leaders and law makers openly declaring commitment for AE to save the planet. Procedure for R&D funding needs to be streamlined and made efficient. Industry has to chip in significantly in this effort with support in cash and kind.

15. Grid integration of AES is of paramount importance with many problems (technical, social, political, economic) to be solved.

16. Since many Power conversion equipment of AE are remotely located, environmental effects on these need to be studied as snow, dust, wind and water may affect their performance.

17. AE sources are highly decentralized and varying in nature needing the technologies to address the same. Therefore distributed decentralized generation (DDG) comes to central stage and Energy storage assumes greater importance. Off grid systems with micro grids will be as important as grid fed systems.

18. Environment and economic issues of AE can not be wished away. Noise, Public safety, cost, pollution, ecological impacts and social concerns of wind, hydro, bio and solar systems need to be addressed through relevant R&D.

19. Nano-technology can play a major role in material development for devices / equipment of AE systems such as Wind, Solar, Hydro and Bio. Combining research in Nano technology and Energy may be beneficial.

20. It is suggested to form a consortium of willing entities comprising universities, industry and utilities to undertake R&D projects on alternate energy. Such a consortium may be of local or global pattern with focused goals and deliverables.

21. Based on the interests of Symposium participants, a typical consortium may consist of- Universities of Waterloo, Ryerson, Western Ontario, Windsor, UOIT and ETS along with willing utilities such as Hydro One and Industry.

22. In an international plane multinational companies (such as GE, ABB) and Academia outside Canada may be included. Potential institutions from India and China could be preferred partners due to global concern of high emissions of these fast developing economies.

23. The members of the consortium should evolve suitable projects to bid for funding. It must be noted that such a venture will succeed only when all entities bring something tangible to the table and promise specific deliverables.

24. A formal arrangement may be made to network the members of the consortium.

25. Interested entities willing to be part of this consortium may send e mail to: smurthy@ee.ryerson.ca, venkat@ee.ryerson.ca, nathwani@uwaterloo.ca

26. Based on the discussions during the symposium Wind, Small Hydro, Solar and Bio Energy were considered appropriate to generate electricity needing prioritized R&D on the same.

27. Technologies for 'Grid connected' and 'Off grid' systems suitable for developed and developing countries need to be developed exploiting the above renewable energy sources.

28. Research areas on AE as identified during the symposium are listed in Annexure-A

Annexure-A

Research Areas in Alternate Energy

1 Energy Generation

1.1 Grid connected Systems

1.1.1 Wind

- Wind prediction, mapping and modeling- identify favorable locations and power potential globally.
- Modeling and analysis of Grid interphase and related problems.
- Comparison of Fixed and variable speed systems with and without gears.
- Design and Performance analysis of different generators and associated systems- Induction, synchronous, dual winding, doubly fed, permanent magnet etc.
- Converter technology for the above.
- Standardization of Wind Equipment for different ranges: Above 10MW, 1-10 MW, 10kW – 1 MW, less than 10 kW. Development of appropriate systems for each.
- Low capacity (1-100kW) domestic and commercial wind systems- turbine, generator and controller development.
- Protection, operation, maintenance and condition monitoring
- Energy instrumentation, data acquisition.
- Noise and environmental issues

1.1.2 Solar

- Grid interphase issues.
- Converter technology
- Studies on Techno- economics and conversion efficiency of PV panels. Life cycle costs
- Power quality
- Solar architecture for buildings

1.1.3 Bio Energy

- Bio conversion to gas and steam
- Use of Bio solids, Liquids, gas
- Appropriateness of Prime movers with Bio fuels- Engines, Turbines, Micro-turbines
- Variable speed generators and controllers.
- Active and reactive power control, Power quality
- Social forestry, renewable plants and “Tree to Electricity”
- Economic and environment issues of Bio Energy.

1.1.4 Small Hydro

- Turbine design- uncontrolled systems
- Constant power operation.
- Generator and controllers- Synchronous and Induction generators
- Condition monitoring, operation and maintenance issues.
- Instrumentation and remote controls

1.1.5 Energy Storage, Smart grids and Hybrid systems

A combination of sources feeding converting electricity to grid. Load balancing, Micro grid, Distributed generation

1.2 Off Grid Systems (Decentralized generation):

1.2.1 Wind

- Wind diesel
- Wind Battery
- Development of Turbine, Generator and control system

1.2.2 Solar

- Techno economic issues of Solar PV
- Load management
- Converter development
- Power quality

1.2.3 Bio

- Bio conversion
- Performance with different fuels and comparison
- Prime movers- Dual fuel and dedicated engines
- Generator and controller
- Standardization of power rating.
- Vendor development

1.2.4 Small Hydro

- Prime mover- Turbine, Pump as turbine- comparison
- Generator
- Electronic load controller for constant power
- Micro, Pico Hydro systems
- System integration, economics, O&M, vendor development
- Standardization, Modularization, Product development

1.2.5 Hybrid systems encompassing the above based on local conditions

2 Energy Utilization (Conservation & Efficiency)

Main Objective - save oil and electricity

2.1 Energy efficient buildings/architecture, Solar powered, intelligent buildings

2.2 Energy Efficient motors and Variable Frequency Drives

2.3 Transportation: Plug in Hybrid vehicles- Motors, drives and control

2.4 Energy saving in HVAC- Development of subsystems.

2.5 Efficiency labeling and standardization.

2.6 Sensor technology, Smart appliances, Smart meters, smart controls.

Annexure-B

Presentation Slides during Symposium

ANNEXURE-B1

Presentation by Prof Sreenivasa Murthy

ANNEXURE-B2

Presentation by Mr. Robert Arnot

ANNEXURE-B3

Presentation by Mr. Bob Singh

ANNEXURE-B4

Presentation by Mr. Surinder Sharma

ANNEXURE-B5

Presentation by Prof. Bin Wu, Ryerson U

ANNEXURE-B6

Presentation by Prof. Narayan Kar, U of Windsor

ANNEXURE-B7

Presentation by Prof. Vijay Sood, UOIT

ANNEXURE-B8

Presentation by Prof. Jatin Nathwani, U of Waterloo

ANNEXURE-B9

Presentation by Prof. Rajeev Varma, U of Western Ontario

ANNEXURE-B10

Presentation by Prof. David Jackson, McMaster University

ANNEXURE-B11

Presentation by Mr. Bharat Rudra,

ANNEXURE-B12

Presentation by Mr. Robert Stasko

ANNEXURE-B13

Presentation by Dr. William Dobson

Annexure-C List of Delegates

Michael Casciano	<i>Bell Canada</i>
Shiva Amiri	<i>British Consulate General Toronto</i>
William K. G. Palmer	<i>Bruce Telecom</i>
Jonathan Wheatle	<i>Durham Strategic Energy Alliance</i>
Sankar DasGupta	<i>Electrovaya</i>
James Britnell	<i>Engauge Controls Inc.</i>
Raj Murthy	<i>Environment Canada</i>
Ben Kennedy	<i>General Electric</i>
Ravi Seethapathy	<i>Hydro One</i>
Bob Singh	<i>Hydro One</i>
Ry Smith	<i>Hydrogen Village Program</i>
Visda Vokhshoori	<i>IEEE</i>
Frank O. Dixon	<i>Independent Energy Consultant</i>
William Dobson	<i>Industrial Research Assistance Program</i>
Bharat Rudra	<i>ISTPCanada</i>
David Jackson	<i>McMaster Institute for Energy Studies</i>
Melena Sejnoha	<i>Natural Resources Canada</i>
Na`al Nayef	<i>New World Generation Inc.</i>
Xiaohui Dai	<i>NORR Limited</i>
Vijay Kris Narasimhan	<i>NRCan</i>
Bob Middlemiss	<i>N-Vision</i>
Robert Stasko	<i>oce-ontario</i>
Nathan Fahey	<i>Ontario Centres of Excellence Inc.</i>
Dorothy Chao	<i>Ontario Ministry of Economic Development and Trade</i>
George Mandrapilias	<i>Ontario Ministry of Economic Development and Trade</i>
Chris Quirke	<i>Ontario Ministry of Economic Development and Trade</i>
Surinder (Sam) Sharma	<i>Power Saving Systems Inc.</i>
Ning Zhu	<i>Ryerson University</i>
Vera Straka	<i>Ryerson University</i>
George Daniel	<i>Ryerson University</i>

Daolun Chen	<i>Ryerson University</i>
Vincent WS Lee	<i>Ryerson University</i>
M.Ebrahim Poulad	<i>Ryerson University</i>
Rabindranath Tagore	<i>Ryerson University</i>
David Naylor	<i>Ryerson University</i>
Anwar Hossain	<i>Ryerson University</i>
Ahmad Jouni	<i>Ryerson University</i>
Rubaid Khan	<i>Ryerson University</i>
Niaz Ahmad	<i>Ryerson University</i>
Nimish Bhatnagar	<i>Ryerson University</i>
Maninder Kamboj	<i>Ryerson University</i>
Todd Mander	<i>Ryerson University</i>
Yucheng Wang	<i>Ryerson University</i>
Peter Bradley	<i>Ryerson University</i>
S. Karim	<i>Ryerson University</i>
Ehsanul Karim	<i>Ryerson University</i>
Ankur Shah	<i>Ryerson University</i>
Alan S. Fung	<i>Ryerson University</i>
Andu Dukpa	<i>Ryerson University</i>
Dechen Choling	<i>Ryerson University</i>
Peng Yu	<i>Ryerson University</i>
Mohd. Hasan Ali	<i>Ryerson University</i>
B. Venkatesh	<i>Ryerson University</i>
Behnaz	<i>Ryerson University</i>
Salman Farooq	<i>Ryerson University</i>
Sanam Sadr	<i>Ryerson University</i>
John Cheng	<i>Ryerson University</i>
Inderpreet	<i>Ryerson University</i>
Ahmad Yafaoui	<i>Ryerson University</i>
Lin Wang	<i>Ryerson University</i>
Jiacheng Wang	<i>Ryerson University</i>
Zhenhan Luo	<i>Ryerson University</i>
Nima Haghighi	<i>Ryerson University</i>

Helen Cheung	<i>Ryerson University</i>
Alex Hamlyn	<i>Ryerson University</i>
Jim Koch	<i>Ryerson University</i>
Bin Wu	<i>Ryerson University</i>
Richard Cheung	<i>Ryerson University</i>
David Xu	<i>Ryerson University</i>
S. S. Murthy	<i>Ryerson University</i>
Stalin Boctor	<i>Ryerson University</i>
Sridhar Krishnan	<i>Ryerson University</i>
Hitesh Doshi	<i>Ryerson University</i>
Hamideh Parizi	<i>Simulent Inc.</i>
Kashif Jahangir	<i>SNC Lavalin</i>
Jayesh Shah	<i>SNC Lavalin ATP Inc.</i>
Vijay Aivalli	<i>Sutton Group Realty Systems Inc.</i>
Janaki Balakrishnan	<i>Toronto Hydro</i>
Philip Wood	<i>Toronto Transit Commission</i>
William Dong	<i>TTC</i>
Lakshman Pillai	<i>TTC</i>
Jatin Nathwani	<i>U of Waterloo</i>
Rajeev Varma	<i>U of Western Ontario</i>
Ambrish Chandra	<i>Université du Québec</i>
Mukhtiar Singh	<i>Université du Québec</i>
Aslain Ovono Zué	<i>Université du Québec</i>
Aisha Bukhari	<i>University of Toronto</i>
Kristine Alvaran	<i>University of Toronto</i>
Reza Iravani	<i>University of Toronto</i>
Peter Lehn	<i>University of Toronto</i>
Ahmed Huzayyin	<i>University of Toronto</i>
Mahmoud Bayoumi	<i>University of Toronto</i>
Jonathan Berge	<i>University of Western Ontario</i>
Rashed Mazhar	<i>University of Windsor</i>
Anas Labak	<i>University of Windsor</i>
Gaurav Nanda	<i>University of Windsor</i>

KHURSHID HAFIZ	<i>University of Windsor</i>
Mariam Khan	<i>University of Windsor</i>
Narayan Kar	<i>University of Windsor</i>
Vijay Sood	<i>UOIT</i>
M.Eklund	<i>UOIT</i>
S.Sivadas	<i>UOIT</i>
B. C. S. Prabhu	
Charles E. Johnson	
Marilyn T. Welles	
Radiy Bekbudov	
Maneesh Mehta	<i>Mesa Investments</i>
Srinivasan Venkatesh	<i>Environment Canada</i>
Adeel Afzal	<i>SNC Lavalin ATP Inc.</i>
Pierre Hinse	<i>UOIT</i>
Ashutosh Bhardwaj	<i>Ryerson University</i>
Farid Katiraei	<i>Quanta Technology</i>
Ahmed Reza	<i>Ryerson University</i>
Sukrit Chaudary	<i>Ryerson University</i>
Hartej Sidhu	<i>Ryerson University</i>
Tejas Aivalli	<i>Municipal Services Office</i>
Nafia Al-Mutawaly	<i>McMaster</i>
Bak Chauhan	<i>NorEEco Corporation</i>
Ida Jagaric	
Ajmer Bal	
Lalchan Persaud	<i>University of Toronto</i>
Kal Chakraborty	<i>CSQR Inc</i>
Dale Dolan	<i>University of Toronto</i>
Harmeet Litt	<i>Nipissing Uni Environmental</i>
Abhijit Chattopadhyay	<i>CGI Toronto</i>

Annexure-D Symposium in Pictures









