Paper 09GM0113

Distributed Generation: Operation and Control Problems – Asian and Australian Experience

Nikolai Voropai and Tom Hammons

Working Group Asian and Australian Electricity Infrastructure

2009 IEEE PES General Meeting, July 26-30 2009, Calgary, Alberta, Canada

Sponsored by: International Practices for Energy Development and Power Generation

Chairs: Tom Hammons, University of Glasgow, Scotland, UK
Nikolai Voropai, Energy Systems Institute Irkutsk, Russia

Track 5: Integrating Distributed Generation

INTRODUCTION

At present, distributed generation is gaining progressive acceptance virtually in all countries of the world. The key advantages of distributed generation are believed to be reduction of CO_2 emissions, enhancement of efficiency and rational energy use, diversification of energy resources, improvement of power supply reliability for consumers, and others. At the same time many types of distributed generation, in particular those of renewable energy sources, are very expensive so far. The operation of distributed generators jointly with electric power systems can cause some engineering problems; the issues of dispatching and control of distributed generation have been studied insufficiently as yet, etc.

Many countries have already accumulated wealth of experience in using distributed generation. The main economic and legislative problems are successfully solved in terms of the national specific features. However, many technical characteristic properties of integrating distributed generation into electric power systems, control of distributed generators in normal and fault conditions remain topical. These problems are as follows:

- Communications and control infrastructure for distributed power grid control,
- Demand side management and customer choice in distributed power grids,
- Information technologies for distribution generation automation,
- Internet tools for improved controls and operation of distributed power systems,
- Protection algorithms for islanding and security.

The task of the Panel Session is to discuss the experience of Asian countries and Australia in solving the mentioned problems of using distributed generation.

The Panelists and Titles of their Presentations are:

1. *Nikolai I. Voropai, Dmitry N. Efimov D.N. (Energy Systems Institute, Irkutsk, Russia*). Operation and Control Problems of Power Systems with Distributed Generation (Invited Panel Presentation Summary 09GM1097).
2. *Minnan Wang and Jin Zhong (The University of Hong Kong, Hong Kong, China)*. Development of Distributed Generation in China (Invited Panel Presentation Summary 09GM0698).
3. *Michael Negnevitsky (School of Engineering, University of Tasmania, Tasmania, Australia)*. Distributed Generation: Australian Experience (Invited Panel Discussion).
4. *Takao Shinji (Tokyo Gas Co., Ltd., Kanagawa-ken, Japan), Akihiko Yokoyama (Graduate School of Frontier Sciences, The University of Tokyo, Chiba, Japan), and Yasuhiro Hayashi (Graduate School of Electrical and Electronics Engineering University of Fukui, Fukui-shi, Japan),* Distributed Generation in Japan (Invited Panel Presentation Summary 09GM1404).
5. *Xuehao Hu (China Electric Power Research Institute (CEPRI), Beijing, China)*. Current Status, main Barriers and Future Prospect of Distributed Generation in China (Invited Panel Discussion).
6. *Chengshan Wang, Li Guo, Shouxiang Wang (School of Electrical Engineering and Automation, Tianjin*

University, Tianjin, China), Bing Wang, Xiaochen Wu and Yufeng Hu (China Southern Power Grid, Technology and Research Center, Guangzhou, China). The Design Experience of a CCHP Microgrid in China (Invited Panel Presentation Summary 09GM0660).

7. *Ming Ding (School of Electric Engineering and Automation, Hefei University of Technology, Hefei, China) and Yusheng Xue (Nanjing Automation Research Institute, Nanjing, China)*. The Researches and Developments of Distributed Generation in China (Invited Panel Presentation Summary 09GM1014).
8. *Junichi Arai, Shuichiro Yamazaki, and Motohisa Ishikawa (Department of Electrical Engineering, Kogakuin University, Tokyo, Japan), and Toshiyuki Ito (Solution Technology Department, Tokyo Gas Co., Ltd., Tokyo, Japan*). Study on a New Power Control of Distributed Generation in an Isolated Microgrid (Invited Panel Presentation Summary 09GM0560).
9. *Hiromu Kobayashi and Ikuo Kurihara (Central Research Institute of Electric Power Industry, Tokyo, Japan)*. Research and Development of Grid Integration of Distributed Generation in Japan (Invited Panel Presentation Summary 09GM1321).
10. *Seung-Ill Moon (School of Electrical Engineering and Computer Science, Seoul National University, Seoul, Korea)*. Experience and Prospect of Wind Power Generation in Korea: Jeju Island Case (Invited Panel Presentation Summary 09GM1288).
11. *Subrata Mukhopadhyay (IEEE PES GovBrd Member) and Bhim Singh (Indian Institute of Technology Delhi, India)*. Distributed Generation - Basic Policy, Perspective Planning, and Achievement so far in India (Invited Panel Presentation Summary 09GM0661).

Each Panelist will speak for approximately 20 minutes. Each presentation will be discussed immediately following the respective presentation. There will be a further opportunity for discussion of the presentations following the final presentation.

The Panel Session has been organized by Nikolai Voropai (Director, Energy Systems Institute, Irkutsk, Russia) and Tom Hammons (Chair of International Practices for Energy Development and Power Generation IEEE, University of Glasgow, UK).

Tom Hammons and Nikolai Voropai will moderate the Panel Session.

INVITED PANEL DISCUSSIONS

Michael Negnevitsky (School of Engineering, University of Tasmania, Tasmania, Australia). Distributed Generation: Optimal Placement and Protection Issues.

Abstract—This panel discussion discusses issues associated with distributed generation (DG) such as optimal placement and protection. It also presents results of a study based on the Tasmanian distribution system conducted by the University of Tasmania, Queensland University of Technology and Aurora Energy, Australia. Sizing and placement of the DG are optimized for improving voltage support in distribution networks. The presentation also discusses some practical considerations limiting the wide spread DG introduction. It identifies problems faced by existing protection systems. These include coordination issues associated with the protection operation due to a fault on adjacent circuit (the reversed power flow of the DG may cause protection of a non-faulted feeder to trip before the faulted feeder is isolated), coordination issues associated with the reduction of fault sensitivity (the DG installation reduces fault current contributed by the major source, and thus results in the reduction of fault current seen by upstream protective devices), etc.

Michael Negnevitsky (M'95-SM'07) received the B.S.E.E. (Hons.) and Ph.D. degrees from the Byelorussian University of Technology, Minsk, Belarus, in 1978 and 1983, respectively. Currently, he is Chair Professor in Power Engineering and Computational Intelligence and Director of the Centre for Renewable Energy and Power Systems at the University of Tasmania, Hobart, Australia. From 1984 to 1991, he was a Senior Research Fellow and Senior Lecturer in the Department of Electrical Engineering, Byelorussian University of Technology. After arriving in Australia, he was with Monash University, Melbourne, Australia. His interests are power system analysis, power quality, and intelligent systems applications in power systems. Dr. Negnevitsky is a Chartered Professional Engineer, Fellow of the Institution of Engineers Australia, and a Member of CIGRE AP C4 (System Technical Performance) and AP C6 (Distribution Systems and Dispersed Generation), Australian Technical Committees, and the CIGRE International Working Group WG C1/C2/C6.18 "Coping with limits for very high penetrations of renewable energy".

Xuehao Hu (China Electric Power Research Institute, Beijing 100192, China}. Current Status, Main Barriers and Future Prospect of Distributed Generation in China*)*.

Abstract: Recently, decentralized generation as Distributed Generation (DG) or Distributed Energy Resources (DER), usually adopting Combined Cooling, Heat and Power (CCHP) mode, is growing fast in some countries in the world, especially in the United States, Japan and some European countries. DG (or DER) has aroused more and more concern in China. In this presentation, the current status of DG development in China is introduced, focusing on the CCHP projects with gas turbine, internal combustion engine and micro-turbine using natural gas, biomass energy generation

using marsh gas (or methane) and solar energy photovoltaic generation. Then, the main barriers in the application of DG are described, including economic and high efficient utilization of energy resources, fuel supply, energy policy, grid integration, environment protection issues, power market and technical supporting tools. Finally, the future development prospect of DG in China is analyzed.

Prof. Xuehao Hu was born in Shanghai, China, on June 1, 1946. He graduated from the Electrical Engineering Department of Tsinghua University in 1968 and the Graduate School of China Electric Power Research Institute (China EPRI), Beijing, China with M.S. degree in 1982. From 1982, he joined the China EPRI as an engineer, senior engineer and professor of Graduate School of China EPRI. He was a visiting scholar in the Energy Systems Research Center, University of Texas at Arlington, U.S.A, from 1986 to 1988. He is now the Deputy Chief Engineer of China EPRI and a tutor of doctor candidate. He is the chair of IEEE PES Beijing Chapter. His special research field includes power system planning, operation and automation, nuclear power station modeling and system simulation, demand side management and energy conservation, FACTS technology and its application in power system, power grids interconnection, distributed generation, micro-grid, renewable energy power generation and its integration into power network etc. His publication includes about 30 papers and several books. He got the First Prize Award of the State Science and Technology Advance in 1985. He is an expert entitled to Government Special Allowance (GSA) since 1993. He is also an Expert with Outstanding Contribution nominated by the State Ministry of Personnel in 1999.

CONTACT DETAILS

PANELISTS:

1. **Nikolai I. Voropai**
   Professor, Corresponding Member of RAS
   Director of Energy Systems Institute
   130 Lermontov Str.,
   Irkutsk, 664033, Russia
   E-mail: voropai@isem.sei.irk.ru
   voropai@ieee.org
   Tel: +7 3952 424700
   Fax: +7 3952 424444

   Dmitry N. Efimov
   Doctor, Senior Researcher
   Energy Systems Institute
   130 Lermontov Str.
   Irkutsk 664033, Russia
   E-mail: efimov@isem.sei.irk.ru
   Tel: +7 3952 426495
   Fax: +7 3952 426796

2. **Jin Zhong**
   Doctor, Assistant Professor
   Department of Electrical and Electronic Engineering
   The University of Hong Kong
   Pokfulam Road, Hong Kong
   E-mail: jzhong@eee.hku.hk
   Tel.: +852 2857 8487
   Fax: +852 2559 8738

   Minnan Wang
   MPhil Student
   Department of Electrical and Electronic Engineering
   The University of Hong Kong
   Pokfulam Road, Hong Kong
   E-mail: mnwang@eee.hku.hk

3. **Michael Negnevitsky**
   Professor, Chair in Power Engineering and Computational Intelligence
   Director of the Center for Renewable Energy and Power Systems
   School of Engineering
   University of Tasmania
   Private Bag 65 Hobart
   Tasmania, 7001 Australia
   E-mail: Michael.Negnevitsky@utas.edu.au
   Tel. +61 3 62 267613
   Fax. +61 3 62 267247

4. **Takao Shinji**
   Deputy General Manager
   Holonic Energy Section
   Fundamental Technology Department
   Technology Development Division
   Tokyo Gas Co., Ltd.
   1-7-7 Suehiro-Cho, Tsurumi-ku, Yokohama-shi,
   Kanagawa-ken 230-0045 JAPAN
   E-mail: tshinji@tokyo-gas.co.jp
   Tel: +81-45-500-8711
   Fax: +81-45-505-8821

   Akihiko Yokoyama
   Dr., Professor
   Department of Advanced Energy
   Graduate School of Frontier Sciences
   The University of Tokyo
   5-1-5 Kashiwanoha, Kashiwa-shi,
   Chiba 277-8562 JAPAN
   E-mail: hayashi@fuee.fukui-u.ac.jp
   Tel: +81-3-5841-6665
   Fax: +81-3-5841-6065

   Yasuhiro Hayashi
   Dr., Associate Professor
   Graduate School of Electrical and Electronics Engineering,
   University of Fukui
   3-9-1 Bunkyo, Fukui-shi, 910-8507
   Japan

E-mail hayashi@fuee.fukui-u.ac.jp
Tel: +81-776-27-8035
Fax: +81-776-27-8035

5. **Xuehao Hu**
Professor, Deputy Chief Engineer
China Electric Power Research Institute
Beijing 100192, China
E-mail: xhhu@epri.ac.cn
Tel/Fax: +86 10 62916915

6. **Chengshan Wang**
Professor
Tianjin University
School of Electrical Engineering and Automation
Tianjin 300073
China
E-mail: cswang@tju.edu.cn
Tel: +86-22-27405145
Fax: +86-22-27409881

Li Guo
Post Doctor
Tianjin University,
School of Electrical Engineering
and Automation
No.92, Weijin Road,
Tianjin, P.R.China 300072
E-mail: liguo@tju.edu.cn
Tel: +86 22-27404221, 13820205469

Shouxiang Wang
Professor
Tianjin University,
School of Electrical Engineering
and Automation
No.92, Weijin Road,
Tianjin, P.R.China 300072
E-mail: sxwang@tju.edu.cn
Tel: +86 22-27404221, 13820205469

Wang Bing
Vice Director
China Southern Power Grid,
Technology and Research Center,
Power System Research Dept.
No.12 NHuajiu Road,
Zhujiang Xincheng,
Guangzhou, P.R China 510623
E-mail: wangning@csg.cn
Tel: +86 20-38120782, 13822166663
Fax: +86 20-38120853

Xiaochen Wu
Division Chief
China Southern Power Grid,
Technology and Research Center,
Power System Research Dept.
No.12 NHuajiu Road,
Zhujiang Xincheng,
Guangzhou, P.R China 510623
E-mail: wuxc@csg.cn
Tel: +86 20-38120768, 13822166914
Fax: +86 20-38120853

Yufeng Hu
Senior engineer
China Southern Power Grid,
Technology and Research Center,
Power System Research Dept.
No.12 NHuajiu Road,
Zhujiang Xincheng,
Guangzhou, P.R China 510623
E-mail: huyf@csg.cn
Tel: +86 20-38120783, 13809817851
Fax: +86 20-38120853

7 **Ming Ding**
Professor,
Chair of School of Electric Engineering and Automation
Hefei University of Technology
Hefei 230009, China
E-mail: mingding56@126.com

Yusheng Xue
Professor, Chief Engineer
Nanjing Automation Research Institute
Caijia Xiang, Najing, P.O.Box 323
210003 China
E-mail: china.yxue@nari-china.com
Tel.: +86 25 3429900
Fax: + 86 25 3427142

8. **Junichi Arai**
Professor
Kogakuin University,
1-24-2 Nishi-shinjuku, Shinjuku-ku,
Tokyo, 163-8677, Japan
E-mail: aria@cc.kogakuin.ac.jp
Tel: +81-3-3340-2996
Fax: +81-3-3348-3486

Shuichiro Yamazaki
Student of Master Course
Kogakuin University,
1-24-2 Nishi-shinjuku, Shinjuku-ku,
Tokyo, 163-8677, Japan
E-mail: cm07048@ns.kogakuin.ac.jp

Motohisa Ishikawa
Kogakuin University,
1-24-2 Nishi-shinjuku, Shinjuku-ku,
Tokyo, 163-8677, Japan
E-mail: cm07006@ns.kogakuin.ac.jp

Toshiyuki Ito
Solution Technology Department
Tokyo Gas Co., Ltd.

1-5-20, Kaigan, Minato-ku
Tokyo, 105-8527 Japan
E-mail: toshito@tokyo-gas.co.jp
Tel: +81-5400-7596
Fax: +81-5400-7681

9. **Hiromu Kobayashi**
Doctor, Senior Researcher Scientist
System Engineering Research Laboratory
Central Research Institute of
Electric Power Industry (CRIEPI)
2-11-1 Iwato-kita Komae Tokyo,
Tokyo, 201-8511, Japan
E-mail: hiromu@criepi.denken.or.jp
Tel: +81-3-3480-2111
Fax: +81-3-5497-0318

Ikuo Kurihara
Director
System Engineering Research Laboratory
Central Research Institute of
Electric Power Industry (CRIEPI)
2-11-1 Iwato-kita Komae Tokyo,
Tokyo, 201-8511, Japan
E-mail: kurihara@criepi.denken.or.jp
Tel: +81-3-3480-2111
Fax: +81-3-5497-0318

10. **Seung-Ill Moon**
Professor
School of Electrical Engineering & Computer Science
Seoul National University
Seoul, KOREA
E-mail: moonsi@plaza.snu.ac.kr
Tel: +82-2-880-1821
Fax: +82-2-878-1452

11. **Subrata Mukhopadhyay**
Member, Society Review Committee of IEEE TAB
IEEE PES GovBrd Member (PES Reg Rep Asia Pacific)
Chair STDCOM on 'History' & ECC of IEEE Delhi Section
Chair Consultants Network Affinity Group
17/403 East End Apartments
Mayur Vihar I Extension
Delhi - 110 096
INDIA
E-mail: pesdelhi@ieee.org
Tel: +91-11-43098372

Bhim Singh
Professor
Department of Electrical Engineering
Indian Institute of Technology Delhi
Hauz Khas
New Delhi
110016 India
E-mail: bsingh@ee.iitd.ac.in
Tel: +91 11 2659 1045
Fax: +91 11 2658 1606

PANEL SESSION CHAIRS

Nikolai I. Voropai
Professor,
Director of Energy Systems Institute
130 Lermontov Str.,
Irkutsk, 664033, Russia
E-mail: voropai@isem.sei.irk.ru
Tel: +7 3952 424700
Fax: +7 3952 424444

Tom Hammons
Chair International Practices for Energy Development and Power Generation
University of Glasgow
11C Winton Drive
Glasgow G12 0PZ, UK
E-mail: T.Hammons@ieee.org
Tel: +44 141 339 7770

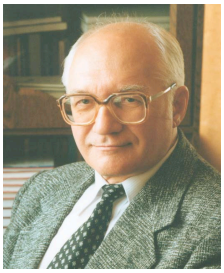
BIOGRAPHIES

Thomas James Hammons (F'96) received the degree of ACGI from City and Guilds College, London, U.K. and the B.Sc. degree in Engineering (1st Class Honors), and the DIC, and Ph.D. degrees from Imperial College, London University.

He is a member of the teaching faculty of the Faculty of Engineering, University of Glasgow, Scotland, U.K. Prior to this he was employed as an Engineer in the Systems Engineering Department of Associated Electrical Industries, Manchester, UK. He was Professor of Electrical and Computer Engineering at McMaster University, Hamilton, Ontario, Canada in 1978-1979. He was a Visiting Professor at the Silesian Polytechnic University, Poland in 1978, a Visiting Professor at the Czechoslovakian Academy of Sciences, Prague in 1982, 1985 and 1988, and a Visiting Professor at the Polytechnic University of Grenoble, France in 1984. He is the author/co-author of over 400 scientific articles and papers on electrical power engineering. He has lectured extensively in North America, Africa, Asia, and both in Eastern and Western Europe.

Dr Hammons is Chair of International Practices for Energy Development and Power Generation of IEEE, and Past Chair of United Kingdom and Republic of Ireland (UKRI) Section IEEE. He received the IEEE Power Engineering Society 2003 Outstanding Large Chapter Award as Chair of the United Kingdom and Republic of Ireland Section Power Engineering Chapter (1994~2003) in 2004; and the IEEE Power Engineering Society Energy Development and Power Generation Award in Recognition of Distinguished Service to the

Committee in 1996. He also received two higher honorary Doctorates in Engineering. He is a Founder Member of the International Universities Power Engineering Conference (UPEC) (Convener 1967). He is currently Permanent Secretary of UPEC. He is a registered European Engineer in the Federation of National Engineering Associations in Europe.



Nikolai I. Voropai (F'09) was born in Belarus in 1943. He graduated from the Leningrad (St. Petersburg) Polytechnic Institute in 1966. N.I. Voropai received his PhD degree from the Leningrad Polytechnic Institute in 1974 and the Doctor of Technical Sciences degree from the Siberian Energy Institute in 1990.

His research interests include: modeling of power systems, operation and dynamics performance of large power grids; development of national, international and intercontinental power grids; reliability and security of energy systems, power industry restructuring. Prof. N.I. Voropai is Director of the Energy Systems Institute of the Russian Academy of Sciences, Irkutsk, Russia. He is also Head of Department at the Irkutsk Technical University, Corresponding Member of the Russian Academy of Sciences, IEEE R8 East Zone Representative, and Chairman of IEEE PES International Practice Subcommittee WG on Asian and Australian Electricity Infrastructure