

## **PROPOSAL**

This document is a two-part proposal:

**Part A:** January 1 to February 28, 2004

**Part B:** April 1, 2004 to March 31, 2005

Funding for Part B is contingent upon satisfactory performance of Part A.

A submission to the South Asia Regional Initiative, SARI/Energy Phase 2,  
through the Institute of International Education, IIE, for USAID funding

# **A CONTINUATION OF LONG-TERM ELECTRICITY POLICY ANALYSIS FOR THE ENERGY MARKETS OF SOUTH ASIA**

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## Summary

Electricity market restructuring, energy tariff policies, generation capacity expansion plans, opportunities for international trade, and the role of IPPs are among some of the major policy issues concerning energy planners in the South Asian nations of Bangladesh, Bhutan, India, Pakistan, and Sri Lanka. Still, in many parts of South Asia, there is very limited electricity market modeling analysis capability. This proposal documents how a standardized and transparent electricity marketing policy analysis capability can be established in the region which can be a strategic benefit immediately to these nations. The proposal also outlines how the process would continue to build substantial improvement in that capability. It can be achieved through transfer of proven large-scale energy network planning technology from Purdue University to regional researchers, utility planners and government regulators, and through the regional institutions becoming collaborative partners in a proposed collective planning forum, the South Asia Electricity Modeling Consortium (SAEMC).

The technology and essential foundational knowledge transfer would be conducted through a series of three training sessions; planned for February 2004 (Dhaka, Bangladesh), June 2004 (Purdue, USA) and March 2005 (New Delhi, India). The construction and use of national electricity market models, of the type proposed, will provide instant quantitative help to each of the participating countries as a decision support tool during each country's electricity planning deliberations. A further benefit is that these country models will be constructed using a common set of definitions and a common structure for all countries. This will facilitate the process of cross national comparison of projects as well as future collaboration across the South Asia region for the planners of the 21<sup>st</sup> century.

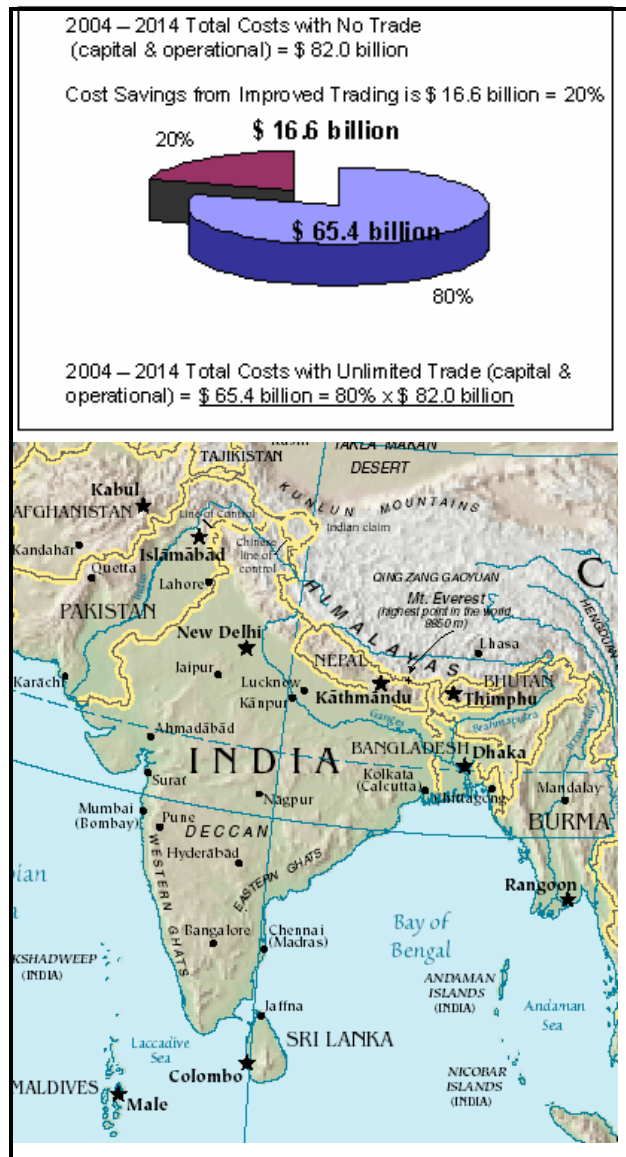
The real growth in India's gross domestic product (GDP) was 4.8% for 2002, and was also projected to rise to 5.7% in 2003. To meet growing demand in electricity the government has targeted capacity increases of 100,000MW over the next ten years. As of January 2001, total installed Indian power generating capacity was 112,000 MW [1]. The proven reserves of natural gas in Bangladesh and Pakistan [2], coal in India and future hydropower capabilities of Bhutan and Nepal represent enormous potential export earnings for each of these countries as well as supplying the high electricity demand growth rates for each country (around 10% compared with 2% in the USA). In each of these countries there are major electricity restructuring initiatives now being considered. Developing therefore the national electricity market models, to support the high level energy decision making process, by government energy advisors, is most timely.

The Purdue Energy Modeling Research Groups, PEMRG, of Purdue University (West Lafayette, Indiana, USA) have over 20 years of experience in constructing models which have been used as decision support tools both in the Mid-West USA (Indiana and the ECAR-MAIN region of NERC) and internationally with the Southern African Power Pool (SAPP) and the West African Power Pool (WAPP) [3-8]. The academic link that was established in 2003, during the Phase 1 of SARI/Energy, between Purdue and the Bangladesh University of Engineering and Technology (BUET, Dhaka, Bangladesh), is an ideal foundation for expanding the training and promoting electricity policy analysis skills that are required for providing the substantial and in-depth quantitative policy analysis to national government energy planners and utilities across the South Asia region. It is planned for BUET to be the coordinating regional institution of the proposed SAEMC.

### Rationale

Significant cost savings are to be gained from optimal planning of electricity power supply systems. This is well documented in the literature with many relevant examples [9-14 etc].

Figure 1. Optimal Cost Savings in S.Asia



The October 2003 Consultation Workshop, at Purdue, with faculty from BUET created a preliminary electricity market model for South Asia. This work, which employed the Purdue long-term cost minimizing electricity planning model, demonstrated 20% cost

savings over a 10 year horizon. This amounts to saving in excess of \$16 Billion (Figure 1). Data used in the model awaits validation and several important generalizations were made but the significance of collective planning and the implementation of the most economic and efficiently run projects is demonstrated. Structured for national policy purposes these long-term Purdue models are to be incorporated into the first year of modeling, in SARI Phase 2, 2004, with researchers, utilities and government planners of South Asia.

The cost savings, to each country of South Asia, can also be substantial with more efficient planning and infrastructure building. In trying to keep pace with India’s high economic growth the Government plans to increase electricity supplies. Significant shortages exist and current generation is well below peak demand. Although about 80% of the population has access to electricity, power outages are common, and the unreliability of electricity supplies is severe enough to constitute a constraint on the country's overall economic development. The proposal designates researchers, utility and government personnel from each of the five regions of India, who are recommended for participation in the electricity market modeling.

Electricity policy decisions, in each of the countries of South Asia, need substantial further analysis (generation investment strategies, construction options of energy by wire or pipe, shipment needs, fuel costing, water values, new transmission lines and network and distribution expansion) before major national energy decisions can be promulgated over the next few years.

Three electricity market modeling analysis, consultation, and training sessions (two workshops and one conference) are being planned for 2004/5 at which strategic energy research groups (universities) from the region, representing specific national policy concerns, are to participate (Table 1). Utility and government energy planners are also to be represented, so ensuring that the benefits of the in-depth policy discussions are gained and fully appreciated by top energy policy makers. Participants from the utilities and government departments should be from senior management, CEO, and ministerial advisory level. The dates being proposed are as follows:-

Table 1. Members of the South Asia Electricity Modeling Consortium, SAEMC

	<b>Researchers</b>	<b>Utilities</b>	<b>Government</b>
<b>Workshop #1</b> February 21-25, 2004 “ <i>Electricity Market modeling General Workshop</i> ” Venue: Dhaka, Bangladesh*	One university or research foundation is selected from each country & region of India. Its’ leading energy researcher is confirmed to join the SAEMC and will assist in directing the national electricity modeling initiative.	The senior managers & CEO reps will represent the utilities of a country and provide data and planning information as well as give guidance to the modeling.	Top policy makers, regulators, & senior energy department planners will assist to identify critical energy infrastructure needs and objectives.
<b>Workshop #2:</b> June or July 2004, “ <i>Electricity Market Modeling Technical Workshop</i> ” Venue: West Lafayette, Indiana, USA**			
<b>Conference:</b> March 2005, “ <i>South Asia Electricity Marketing Policy Conference</i> ” Venue: New Delhi, India			
Notes: * National modeling coordinators to be confirmed at February 2004 Workshop. ** National coordinators will represent the national modeling team at the June 2004 workshop, at Purdue.			

The detailed objectives and deliverables of each of these three consultation and training sessions are described in the section that follows and Appendix 5. The electricity marketing modeling, that is to be provided at Workshops 1 and 2 (February and June 2004), will be based on the materials in Purdue’s electricity modeling manuals, as outlined in the following:

General Training Manual and technical User Manual:

<https://engineering.purdue.edu/IIES/PPDG/MODEL/GenTrainMan-Oct2003.pdf>

<https://engineering.purdue.edu/IIES/PPDG/SAPP/user-manual.whhtml#Seventh>

Following the summer workshop at Purdue the SAEMC will prepare national electricity planning papers, based on the national models, which will be presented at the March 2005 Conference.

The magnitude of the India electricity power system and national grid requires that the five regions of India are individually represented at the three sessions listed above. India has in excess of 112,000MW with the next largest national utility being in Pakistan with over 19,000MW. The electricity demand growth rates across the region are high and significant capacities of new generation plants are therefore required over the next 10 years (Table 2) [15].

The preparations for the three consultation and training sessions will be provided by the Purdue BUET team and other selected regional experts (SARI/Energy Phase 1 established the institutional link between Purdue University and the Bangladesh University of Engineering and Technology, documented in Appendix 4). BUET faculty are already trained and well versed in

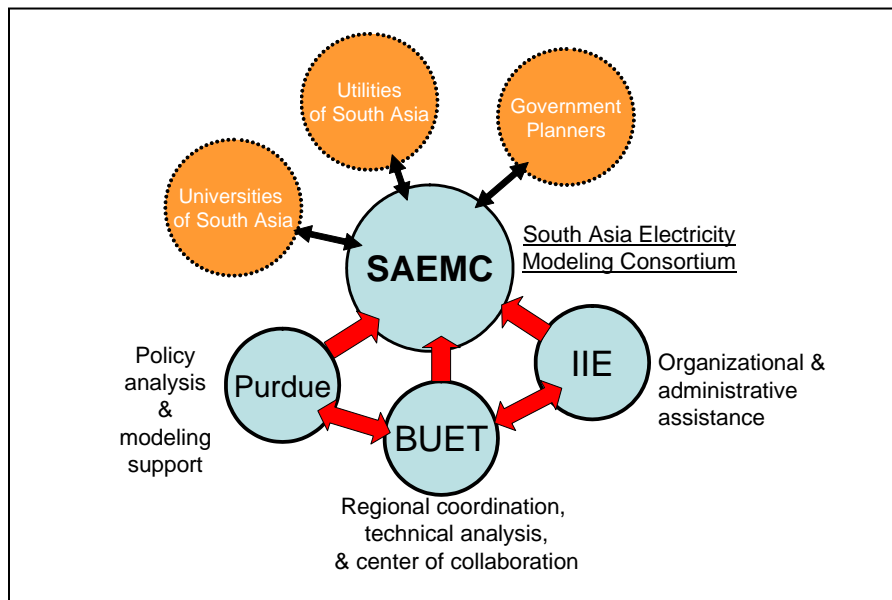
using the Purdue long-term planning models. Collaboration from members of Purdue, BUET, the SAEMC, and the IIE will mean that the best expertise may be obtained for providing three successful consultation and training sessions as well as implementing sustainable and well integrated national electricity market models into the national energy infrastructure plans. Official invitations and administration of the meetings will be provided by the Institute of International Education (IIE, Figure 2).

Table 2. South Asia Overview of Generation Capacities

	Country	Existing Capacity		Electricity Demand in 2003		
		Thermal PGO (MW)	Hydro H (MW)	Peak Load (MW)	Annual Production (GWh/yr)	Demand Growth Rate (%/yr)
1	Bangladesh	4,500	230	3,200	33,147	10
2	Bhutan	9	400	100	2,852	8
3	India	75,000	26,000	82,000	701,501	9
4	Nepal	50	576	550	4,387	8
5	Pakistan	14,000	5,000	14,000	133,152	10
6	Sri Lanka	752	1,147	1,600	13,308	10

The data collection and compilation for each country will be the major activity between meetings 1 and 2. At the Purdue meeting the priority planning needs of each South Asian nation will be discussed and draft national electricity policy planning papers will be prepared based on the national models that will have been run. These papers will be completed and vetted on returning to home institutions and will later be presented at the March 2005 Regional Conference, (South Asian National Modeling Conference, New Delhi, India). Recommended participants for the two workshops and conference are proposed in Appendices 1, 2, and 3. A tentative schedule of the February 2004 Workshop is shown in Appendix 5. Following the consultations at Purdue, in June 2004, the Purdue BUET team will prepare proposals for the further modeling of South Asia’s electricity markets for the following years of SARI/Energy Phase 2.

Figure 2. South Asia Electricity Modeling Consortium, SAEMC, & Organizations



BUET colleagues were provided with high-speed laptop computers under the Phase 1 of SARI, as well as commercial mathematical solver software that is required for running the Purdue energy trade models (freely installed). It is recommended that the researchers, attending the summer technical workshop at Purdue are supplied with similar top of the range laptop computers also already installed with the solver software.

### **Deliverables to South Asian National Energy Market Planners**

There are eight main deliverables in this first year electricity modeling proposal of the SARI/Energy Phase 2 Program.

#### **Part A (January 15, 2004 to February 28, 2004):**

1. Creation of a South Asia Electricity Modeling Consortium (SAEMC).
2. Employ the Purdue BUET link and others to provide trainers.
3. Capacity building in modeling national electricity markets: a regional workshop.
4. Nomination and appointment of national modeling coordinators.
5. Workshop preparation and tailoring the Purdue models to South Asian modeling requirements.

Between Part A and Part B there is an interval of one month for the sponsors to assess the effectiveness of the deliverables in Part A. Proceeding to Part B is based on success in Part A.

#### **Part B (April 1, 2004 to March 31, 2005)**

6. Enhancing appropriate electricity marketing analysis skills: a Purdue workshop.
7. BUET colleagues will be at Purdue for 5 weeks in summer 2004.
8. National electricity marketing policy papers preparation and presentation.
9. Assessment of preliminary national electricity market models: a regional conference.

Each of the nine deliverables are further discussed in the following sections.

1. **Creation of a South Asia Electricity Modeling Consortium (SAEMC)** consisting of colleagues from electricity policy research groups and institutions from all across the South Asia region including Bangladesh, Bhutan, India, Pakistan, Nepal, Sri Lanka (January 2004).
2. **Trainers from the Purdue BUET link and collaborating regional institutions**  
Purdue University and Bangladesh University of Engineering and Technology (BUET) and others in the region are to provide training in electricity marketing policy analysis and to coordinate three training sessions for researchers, utilities, and regulators from the nations of South Asia:
  - February 2004 Electricity Market Modeling General Workshop (Venue: Dhaka, Bangladesh, 5 working days)
  - June/July 2004 Electricity Market Modeling Technical Workshop (Venue: West Lafayette, Indiana, USA, 10 working days)
  - March 2005 South Asia Electricity Marketing Policy Conference

(Venue: New Delhi, India, 3 or 4 working days).

3. **Capacity building** and equipping the nations of South Asia for electricity marketing policy analysis, including general training in data collection, and incorporating national data into country electricity market models. Provision of an appreciation of the transparent nature of the formulated cost minimizing objective functions and market model constraints. This general training will be for researchers (SAEMC members), utility energy planners, and national regulatory bodies and will take place at a five day workshop. Each national and Indian regional modeling team will confirm the appointment of a coordinator for electricity market modeling analysis. (five working days, February 21-25, 2004, venue Dhaka, Bangladesh).
4. **Nomination and appointment** of national and Indian regional electricity market modeling coordinators will take place in 2004. Nominations can start in January 2004 and will certainly all be confirmed at the February 2004 regional Workshop.
5. **Workshop preparation and tailoring the Purdue models to South Asian modeling requirements.** The structure of the long-term models are to be modified to meet national planning needs allowing a number of stations to be located a specified number of sites in a country. Each of the five regions of India will be modeled individually while also allowing major transmission interconnections to appear with neighboring regions. These models will be prepared for installation onto participant's personal laptop computers. This will ease and facilitate objective national data input (new and old generation stations and transmission lines).
6. **Enhancing appropriate electricity marketing analysis skills** for the development of national in-depth policy analysis. The Purdue BUET partnership will prepare and present a two-week long Technical Modeling Workshop, for the researchers that constitute the SAEMC. This technical modeling workshop will take place at Purdue University. This in-depth technical training will build upon the February workshop and will conduct sensitivity tests on selected electricity market parameters (two weeks in June or July 2004 at Purdue University, USA).
7. **BUET colleagues will be at Purdue for 5 weeks**, during June and July 2004. They will arrive two weeks prior to the start of the Purdue SAEMC consultations technical workshop and prepare for the two-week technical workshop while also enhancing research work on the modeling of South Asia's electricity transmission networks. They will remain at Purdue for one week following the technical modeling workshop for assessment and planning purposes.
8. **National & regional Indian electricity marketing policy papers** will be prepared for presentation at the March 2005 South Asia Electricity Marketing Policy Conference. The main presenter and contact person responsible for the production of each national and regional Indian paper will be the electricity market modeling coordinator. The electricity market modeling coordinators will have the important responsibility of organizing the final preparation of the electricity modeling policy

paper (based on the modeling results) as a working document and also in power point presentation format for the March 2005 Conference.

9. **Assessment of preliminary national & regional Indian electricity market models.** This will take the form of a three or four day Conference at which SAEMC members, utility planners, government regulators, and other regional agencies and energy system planners and developers will attend. The results from the national electricity market models, that were developed over the previous 12 months, will be presented. Identification of top priority energy marketing concerns will be discussed and will form the basis for South Asian electricity market models in the consequent years of SARI/Energy Phase 2 (three or four days in March 2005, New Delhi, India).

### **The South Asia Electricity Modeling Consortium (SAEMC)**

To ensure successful and effective regional implementation and technology transfer of the electricity marketing models to the region it is proposed that leading research institutions and universities, from member nations of the whole South Asia region, will be engaged in the modeling and policy analysis of national electricity markets. One research institution is selected from each of the following to be members of the South Asia Electricity Modeling Consortium (SAEMC). Utilities and government planners will also be needed to provide a person to represent each of the following countries/regions of India:

- (1) Bangladesh
- (2) Bhutan
- (3) India Northern Region
- (4) India Western Region
- (5) India Southern Region
- (6) India Eastern Region
- (7) India North Eastern Region
- (8) Nepal
- (9) Pakistan
- (10) Sri Lanka

The total number of regional members, of the SAEMC, is therefore expected to be 32 (including the three BUET professors, two from Bangladesh, three from Bhutan, 15 from India, three from Nepal, three from Pakistan, and three from Sri Lanka).

The research institutions identified in Appendix 1 are expected to be nominated to act as national modeling coordinators for the national marketing models at the February 2004 workshop in Dhaka. Formal acceptance of the role of national coordinator (five coordinators for India) will take place at the February 2004 General Training Workshop. This nomination and acceptance process will be coordinated by BUET. If a strong technical participant from either the utilities or governments is present then the national modeling coordinator might come from either of these organizations.

**February 2004 Electricity Market Modeling General Workshop (5 working days)  
(Venue: Dhaka, Bangladesh)**

The South Asia electricity market modeling project will be launched at this workshop event. The supply and demand data needs and standardization of the data notation and format will be explained. Modeling background and an introduction to the formulation objectives (cost minimizing of capital and operational costs) and the various constraints (existing thermal and hydropower generation, new generating options including combined cycle, transmission capabilities) will be presented. Major electricity market policy needs will be identified and discussed with the view to the results that will be required from the national market models that are to be produced for the end of the year of Conference. National modeling coordinators are expected to be members of the SAEMC but could also be from other technical members if a country team so prefers.

**June/July 2004 Electricity Market Modeling Technical Workshop (10 working days)  
(Venue: Purdue University, West Lafayette, Indiana, USA)**

This event will look in depth at the market models and inputting of all of the national data into the models during the first week of this technical workshop will take place. During the second week of the workshop the output results are to be considered with the view to addressing immediate national planning needs and for preparing the papers to be presented at the March 2005 Conference.

**March 2005 South Asia Electricity Marketing Policy Conference (3/4 working days)  
(Venue: New Delhi, India)**

This regional conference will be the forum for presenting the national electricity market papers (based on the models created) and will assess the policy recommendations. Demonstrations of policy results from various national models will be provided by each national team. This Conference will be an excellent venue to promote the economics of efficiently run electricity markets and will show the benefits from implementing various new capacity expansion projects and alternative policies over others.

**Work Plan**

**January – February 2004: Creation of SAEMC**

Communications with the proposed SAEMC members will take place. Consultations on the content of presentations is necessary for the February 21-25 Workshop.

A tentative schedule of the February Workshop is in Appendix 5. The training and presentations at this February General Modeling Workshop will be conducted by the Purdue BUET team with selected speakers also from the participants representing each of the SAEMC countries (and the five regions of India). Preparation will take place in January, prior to departure to the February Dhaka General Modeling Workshop, on modifying the structure of the Purdue models. The February 2004 Workshop will establish the SAEMC and confirm its objectives and mission statement. The harmonization of regional electricity data and the

discussions on national electricity planning priorities will lay the foundation of the regional modeling work for the coming years of SARI/Energy Phase 2.

### **March 2004: Decision of Further National Electricity Marketing Modeling**

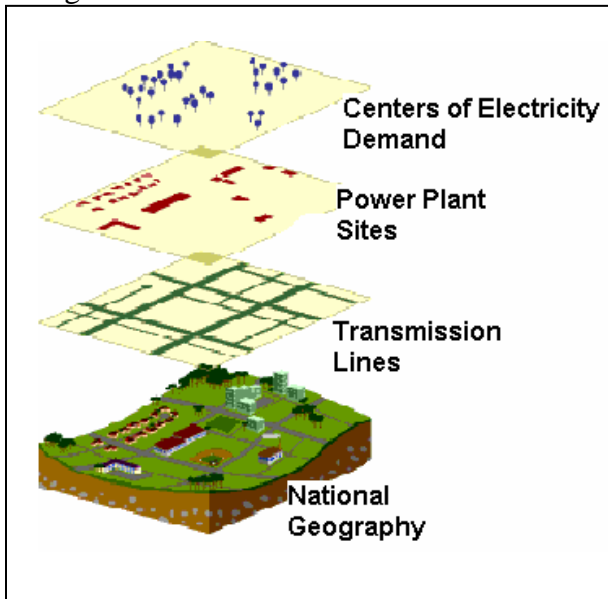
The IIE in consultation with SAEMC members, BUET and Purdue colleagues, and participants at the February Workshop will take the decision of whether or not to proceed with Part B of this proposal.

### **April – May 2004: South Asia Data Validation, National Electricity Policy Priorities & Development of the South Asia User Friendly Interface**

The SAEMC members will compile and validate their national data. The national modeling coordinator is the candidate to represent the national modeling team at Purdue in June 2004. If this person is unavailable at the final dates decided upon then the national team will decide who his representative should be. A comprehensive appraisal should take place on national electricity planning priorities prior to attendance at Purdue.

The Purdue computer programmers will develop user output screens for the individual countries of South Asia. This facility will help each national team to have a much quicker understanding of the output results from the modeling as well as providing graphical inputs of the many electricity data input sets.

Figure 3. The GIS & South Asia Data



The GIS (Geographic Information Systems) employs a method of presenting information about a place in layers (Figure 3).

It is a system of computer software, hardware, data, and personnel to help manipulate, analyze, and present information that is tied to specific special locations. It can be used to show electricity centers of demand, generation production at certain sites, location of new transmission lines and natural gas pipelines.

This facility has not been used at all in previous electricity long-term models. The Purdue team has not developed this for the USA, SAPP or WAPP projects. The benefits to SAEMC participants will be substantial in providing a quick and easy to understand spatial presentation of inputs and outputs to the national electricity market models.

This new modeling facility will require extra Purdue computing programming time in order to provide a unique development under the SARI program that will provide training and policy analysis benefits to the whole of the Phase 2 and be used by hundreds of energy modeling

participants. SAEMC members will greatly appreciate the accuracy of national geographic and utility information in a further improved professional format.

**June-July 2004: Technical Modeling at Purdue & Running the National Models**

The SAEMC national modeling coordinators (or their representative) will attend a two-week (10 working days) Technical Modeling Workshop at Purdue University. The BUET faculty will arrive at Purdue two weeks prior to the start of the Workshop to assist in the final preparations and to continue their research on the modeling of transmission networks.

The time at Purdue will also require that the SAEMC participants, of this technical workshop, will be required to run their national electricity models after inputting all of their validated data of major power stations and transmission lines and demand centers. Each national model is proposed to have a ten year planning horizon. The collection of accurate operating costs (fuel and maintenance costs) and investment costs (capital investments and borrowing costs for proposed new expansion plans in generation and transmission). It is proposed that each SAEMC national coordinator will be supplied with a top-of-the-range laptop computer. This computer will be installed with the Purdue models (free installation), by the Purdue BUET team, prior to the arrival of SAEMC participants. Commercial solver licenses will need to be purchased to run the long-term models.

The final outcome of the Purdue Workshop will be initial drafts of national electricity plans which are based on the optimization results from the long-term economic model that has been used throughout the first six months of the project.

**August 2004 – February 2005: Preparation of the National Electricity Policy Papers and Modeling Analysis Results**

The members of the SAEMC teams will continue to run their national models following the Purdue Technical Workshop in the process of preparing their national policy papers.

The Purdue BUET staff will provide support and answer questions concerning the national modeling results via emails and other communications.

Future South Asian electricity policy analysis plans and scenarios will be considered by Purdue and BUET, in collaboration with SAEMC members, for further modeling under the auspices of SARI/Energy Phase 2.

**March 2005: The South Asia Electricity Modeling Conference**

This Conference will bring together all of the participants from the February 2004 Workshop to demonstrate the results from the national modeling and to present the national electricity policy papers as well as provide a wide regional forum for discussion of long-term electricity policy across the region.

At this Conference there will also be confirmation of the next steps and modeling needs of the SAEMC.

**South Asia Electricity Market Modeling for the SARI/Energy Phase 2, 2004 to 2008**

Following the June/July technical workshop several proposals will be considered for the longer term electricity marketing work for South Asia. Proposals for further development of electricity market analysis skills, in South Asia, and the agreed upon top priority policy issues will be presented at the March 2005 Conference. It is anticipated that two further proposals, each of two years duration, will be made to ensure that a complete transfer of modeling skills as well as thorough and satisfactory future market plans for each of the nations of South Asia takes place.

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**Appendix 1**  
**SAEMC & South Asian University/Research Partners**

<p>1. <u>Bangladesh</u>          Profs Ahsan, Ahmed, Khan          BUET, Dhaka          See Resumes in Appendices 7C, D,E  <a href="mailto:qahsan@eee.buet.ac.bd">Em:qahsan@eee.buet.ac.bd</a>,  <a href="mailto:ssahmed@eee.buet.ac.bd">Em:ssahmed@eee.buet.ac.bd</a>,  <a href="mailto:rezwanm@eee.buet.ac.bd">Em: rezwanm@eee.buet.ac.bd</a></p>	<p>6. <u>India Eastern Region</u>          DR. R.B.MISRA          Reliability Engineering Department,          IIT, Kharagpur          West Bengal, India.  <a href="mailto:ravi@ee.iitkgp.ernet.in">Em: ravi@ee.iitkgp.ernet.in</a></p>
<p>2. <u>Bhutan</u>          MR. JIGME SINGYE          Engineering Officer,          Chukha Hydro Power Corporation,          Bhutan.          Ph: 975- 232-1846, Fax: 975-232-1847  <a href="mailto:chpcl@druknet.bt">Em:chpcl@druknet.bt</a> ;  <a href="mailto:Jsingye@hotmail.com">Em : Jsingye@hotmail.com</a></p>	<p>7. <u>India North Eastern Region</u>          MR. NALIN BEHARI DEV          CHOUDHURY          Lecturer, National Institute of Technology,          Silchar, Assam-788010, India          Ph: 91-3842-240834, Fax: : 91-3842-233797          Em:</p>
<p>3. <u>India Northern Region</u>          Prof. Prem Kumar Kalra          Dept of Electrical Eng          Indian Institute of Technology Kanpur          U.P. India 208019          Ph: 91 512          97810,597032(o),591462,598785(r)          Fax 91 512 590063  <a href="mailto:kalra@iitk.ac.in">Em: kalra@iitk.ac.in</a></p>	<p>8. <u>Nepal</u>          MR. NAVARAJ KARKI          MSc Program Coordinator,          Institute of Engineering, Pulchowk          Lalitpur,Nepal          Ph: 977-1-5543081  <a href="mailto:nrkarki@ioe.edu.np">Em: nrkarki@ioe.edu.np</a>;  <a href="mailto:Ksnraj25@yahoo.com">Em : Ksnraj25@yahoo.com</a></p>
<p>4. <u>India Western Region</u>          Dr. A.K.M. Kulkarni          Electrical Engineering Department          IIT, Bombay          Powai, Mumbai-400076, India          Ph: 91-22-2576-7416, 2576-8416 (Res.)  <a href="mailto:anil[AT]ee.iitb.ac.in">Em: anil[AT]ee.iitb.ac.in</a></p>	<p>9. <u>Pakistan</u>          PROF. DR. TABREZ ASLAM SHAMI,          Head, Electrical Department,          University of Engineering &amp; Technology,          Lahore, Pakistan.          Em:</p>
<p>5. <u>India Southern Region</u>          Dr. R. Sethumadhavan          Assistant Professor,          Institute for Energy Studies,          Anna University, Chennai 6000 25, India  <a href="mailto:rsm_ies@hotmail.com">Em: rsm_ies@hotmail.com</a></p>	<p>10. <u>Sri Lanka</u>          Dr. Rahula A. Attalage          Senior Lecturer, (Center for Energy Studies)          Dept of Mechanical Engineering          University of Moratuwa, Katubedda          Moratuwa, Sri Lanka          Ph: 94-1-650301, Fax: 94-1-647622  <a href="mailto:dinu@mech.mrt.ac.lk">Em: dinu@mech.mrt.ac.lk</a></p>

## Appendix 2 South Asia Participating Utilities

<p><u>1. Bangladesh</u> Mr. Md. Mizanur Rahman Executive Engineer, System Planning, BPDB, WAPDA Building Ph: 7200299 (Res) Em: <a href="mailto:mizan9948@yahoo.com">mizan9948@yahoo.com</a></p>	<p><u>6. India Eastern Region</u> Mr. Swapan Kumar Ghosh Zonal Manager, Silguri (Dist.) Zone West Bengal State Electricity Board Administrative Building Silguri, Darjeeling Ph: 91-353-2540432, Fax: 91-353-2541401 Em: <a href="mailto:slg_dchak@sancharnet.in">slg_dchak@sancharnet.in</a> Em: <a href="mailto:cped@cal3.vsnl.net.in">cped@cal3.vsnl.net.in</a></p>
<p><u>2. Bhutan</u> Mr. Saha Bahadur Chhetri Senior Manager, Central Transmission Division Bhutan Power Corporation Em: <a href="mailto:eetu@hotmail.com">eetu@hotmail.com</a></p>	<p><u>7. India North Eastern Region</u></p>
<p><u>3. India Northern Region</u> Ms. Anjali Chandra Deputy Director Central Electricity Authority New Delhi Ph: 91-11-26108999, Fax: 91-11-26102793 Em: <a href="mailto:accllok@indiatimes.com">accllok@indiatimes.com</a></p>	<p><u>8. Nepal</u> Dr. Ram Hari Aryal Joint Secretary, Water Resources and IT Division National Planning Commission Secretariat Singh Durbar Kathmandu, Nepal Em: <a href="mailto:rharyal@npnepal.gov.np">rharyal@npnepal.gov.np</a> Em : <a href="mailto:rharyal@infoclub.com.np">rharyal@infoclub.com.np</a></p>
<p><u>4. India Western Region</u> Mr. S.K.Patel Dy. General Manager BSES Ltd., Electricity House Santacruz (East) Mumbai 400 055 India Ph: 91-22-26153447, Fax: 91-22-26170994 Em: <a href="mailto:skpatel@powersurfer.net">skpatel@powersurfer.net</a></p>	<p><u>9. Pakistan</u></p>
<p><u>5. India Southern Region</u></p>	<p><u>10. Sri Lanka</u> Mr. Y.L. Farook System Development Manager Lanka Electricity Company (Pvt.) Ltd., E.H. Coorav Building 411, Galle Road Colombo-3</p>

**Appendix 3**  
**South Asia Participating Regulatory Commissions**

<p><u>1. Bangladesh</u> Mr. Alamgir Kabir, Director, Power cell, Ministry of Energy &amp; Mineral Resources, BTMC Bhaban, Kawran Bazar, Dhaka-1215 Ph: 8122441 Em: <a href="mailto:dgpcmemr@citechco.net">dgpcmemr@citechco.net</a></p>	<p><u>6. India Sothern Region</u> Mr. V. Veera Raghavan, Director-Law Andhra Pradesh Electricity Regulatory Commission, D-No. 11-4-660, 5<sup>th</sup> Floor Singareni Bhavan, Red Hills, Khairatabad Hyderabad-500 004 Ph: 91-40-3397364, Fax: 91-40-3397489 Em: <a href="mailto:venkatshikaram@rediffmail.com">venkatshikaram@rediffmail.com</a></p>
<p><u>2. Bhutan</u> Mr. Nima Tshering Project Coordinator, Department of Energy Ministry of Trade and Industry Bhutan Em: <a href="mailto:ugyer_nima@hotmail.com">ugyer_nima@hotmail.com</a></p>	<p><u>7. India Eastern Region</u></p>
<p><u>3. India NorthEastern Region</u> Mr. S.S. Gupta, Chairman Himachal Pradesh Electricity Regulatory Commission, Keonthal Commercial Complex Shimla-171 002 Ph: 91-177-227262, Fax: 91-177-227162 Em: <a href="mailto:shan_gupta2@rediffmail.com">shan_gupta2@rediffmail.com</a></p>	<p><u>8. Nepal</u> Mr. Keshari Raj Pandit Judge Appellate Court Biratnagar, Nepal Ph: 977-21-27197, Fax: 977-21-27197 Em: <a href="mailto:kesharipandit@hotmail.com">kesharipandit@hotmail.com</a></p>
<p><u>4. India Western Region</u> Mr. Dharmendra R. Parmar Deputy Director Gujarat Electricity Regulatory Commission First Floor, Neptune Tower, Opp. Nehru Bridge, Ashram Road Ahmedabad-380009 Ph: 91-79-6580350, Fax: 91-79-6584542 Em: <a href="mailto:gercin@indiatimes.com">gercin@indiatimes.com</a></p>	<p><u>9. Pakistan</u></p>
<p><u>5. India Nortern Region</u> Mr. K.J.S. Bains Director-Low Delhi Electricity Regulatory Commission New Delhi Ph: 91-11-6673615 Em: <a href="mailto:kjsbains@rediffmail.com">kjsbains@rediffmail.com</a></p>	<p><u>10. Sri Lanka</u> Ms. M.M.N. Munawwara Chief Engineer DGM office North Central Province Ceylon Electricity Board Anuradhapura Em: <a href="mailto:cebrcp@sltnet.lk">cebrcp@sltnet.lk</a> Em: <a href="mailto:munaw61@yahoo.com">munaw61@yahoo.com</a></p>

## **Appendix 4**

### **Memorandum of Understanding**

Purdue University & Bangladesh University of Engineering & Technology

*(Scanned signed document – See separate electronic file)*

## Appendix 5

### Tentative Schedule Electricity Market Modeling General Workshop

Saturday February 21 to Wednesday February 25, 2004  
Venue: Dhaka, Bangladesh

<i>Dates 2004</i>	<i>Morning Session</i>	<i>Afternoon Session</i>
Saturday February 21	(1) Welcome (BUET-IIE) (2) Electricity Demand Forecasting (Sparrow) (3) Modeling Existing Thermal Stations (Sparrow) (4) Load Market Interface onto laptops (Ahmed, Khan, Bowen) (5) Electricity Policy Priorities in N.E.India(*)	(1) Electricity Demand & the 36hour model (Ahsan) (2) Demand & Existing Thermal Data Inputs to the Market Model (Khan) (3) SAEMC Launching, Objectives & National Coordinators Nominations (Sparrow, Ahsan) (4) Electricity Policy Priorities in Bangladesh (*)
Sunday February 22	(1) Modeling Hydropower Stations (Sparrow) (2) SAEMC Coordinator Confirmations (Ahsan, Sparrow) (3) Transmission Line Modeling (Sparrow) (4) Electricity Policy Priorities in Bhutan (*)	(1) Hydropower Data Inputs (Bowen) (2) Transmission Line Data Inputs (Ahmed) (3) Electricity Policy Priorities in N.India (*) (4) Interface Outputs Demonstration (Bowen)
Monday February 23	(1) Generation Capacity Expansions & Technology and Fuel Options (Sparrow) (2) Network Modeling & Autonomy (Ahmed, Sparrow) (3) Electricity Policy Priorities in E.India (*) (4) Panel Question Time # 1 (Chair Sparrow)	(1) Country & Site Input Data (Ahsan) (2) Creating a 10 Site Model (Khan, Bowen) (3) SAEMC Data Collection & Management (Ahmed, Sparrow) (4) Electricity Policy Priorities in Pakistan (*)
Tuesday February 24	(1) Output Results from the 10 Site National Model (Ahsan, Sparrow) (2) SAEMC Planning (Khan, Bowen) (3) Electricity Policy Priorities in Nepal (*) (4) Panel Question Time # 2 (Chair Ahsan)	(1) IPPs in the National Model (Sparrow, Ahmed) (2) Summary of National Policy Priorities (Ahsan, Sparrow) (3) Electricity Policy Priorities in S.India (*) (4) Electricity Policy Priorities in W.India (*)
Wednesday February 25	(1) SAEMC at Purdue & Delhi (Sparrow, Ahsan) (2) SAEMC Universities Coordination & National Papers for 2005 (*) (3) SAEMC Collaboration & Data Harmonization (BUET) (4) SAEMC Regulatory Progress (Khan, Ahmed) (5) Electricity Policy Priorities in Sri Lanka (*)	(1) Panel Question Time #3 (Chair Bowen) (2) March 2004 Assessment (IIE) (3) Wrap Up & June 2004 (Ahsan, Sparrow)
Notes: (*) Name to be supplied, of SAEMC presenter, following December/January communications		

### Appendix 6 A

#### Summary of Activities for Budgeting Requirements

Dates	<u>Institutions</u>							
	<b>Partnerships in the South Asia Electricity Modeling Consortium, SAEMC</b>							
	<b>Purdue:</b> Purdue University, <b>Univs:</b> South Asian Universities, <b>Planners:</b> Government planners/regulators			<b>BUET:</b> Bangladesh University of Engineering & Technology <b>Utilities:</b> Representatives from utility planning <b>IIE:</b> Institute of International Education				
	2004/5	1. Purdue	2. BUET	3. Univs	4. Utilities	5. Planners	IIE	
<b>1</b>	<u>PART A</u> January 2004	Communicate with SAEMC, utilities & governments. Prepare models.	Communicate with SAEMC, utilities & governments	Communications & confirmation of interest & participation				
	February 21-25 2004  General Modeling Workshop: (5 days duration)  Dhaka Bangladesh	(1) Prepare presentations, model structures, & data needs  (2) Appoint national modeling coordinators.  (3) Confirm national policy priorities  <i>Time &amp; travel expenses</i>	(1) Propose & designate SAEMC members  (2) Prepare presentations on modeling and data needs  (3) Install user friendly interface on all laptops <i>Time &amp; travel expenses</i>	Confirm SAEMC members (9 members + 3 BUET): 5 India 1 Bhutan 1 Nepal 1 Pakistan 1 Sri Lanka  <i>Time &amp; travel expenses</i>	Confirm SAEMC members: 5 India 1 Bangladesh 1 Bhutan 1 Nepal 1 Pakistan 1 Sri Lanka)  <i>Travel expenses</i>	Confirm SAEMC members: 5 India 1 Bangladesh 1 Bhutan 1 Nepal 1 Pakistan 1 Sri Lanka)  <i>Travel expenses</i>	Supply: (1) Air tickets (2) Accommodation in collaboration with BUET (3) Venue (4) Produce workshop materials (5) Registration	
<b>3</b>	March 2004	-	-	-	-	-	Assess PART A	
<b>4</b>	<u>PART B</u>  April to May 2004	(1) Communicate with SAEMC, utilities, & governments for modeling data.  (2) GIS interface <i>Time expenses</i>	Communicate with SAEMC, utilities & governments for modeling data  <i>Time expenses</i>	Compile data  <i>Time expenses</i>	Compile data	Compile data		
	June/July 2004  Technical Modeling Workshop (10 days duration)  West Lafayette Indiana USA  BUET 5weeks at Purdue	(1) Prepare presentations on modeling and data needs  (2) Install user friendly interface on all laptops with solvers  (3) Build national market models  <i>Time expense</i>	(1) Prepare presentations on modeling and data needs  (2) Support SAEMC with data inputs  (3) S. Asia modeling development <i>Time &amp; travel expenses</i>	Build national electricity model and start individual national policy Paper  <i>Time &amp; travel expenses</i>	Build national electricity model and start individual national policy Paper  <i>Travel expenses</i>	Build national electricity model and start individual national policy Paper  <i>Travel expenses</i>	Supply: (1) air tickets (2) accommodation in collaboration with Purdue (3) Purchase 9 laptops (4) Solver licenses for 9 laptops	

**Appendix 6 B  
Summary of Activities for Budgeting Requirements (Continued)**

<b>Dates</b>	<b><u>Institutions</u></b>						
	<b>Partnerships in the South Asia Electricity Modeling Consortium, SAEMC</b>						
	<b>Purdue:</b> Purdue University,			<b>BUET:</b> Bangladesh University of Engineering & Technology			
	<b>Univs:</b> South Asian Universities,			<b>Utilities:</b> Representatives from utility planning			
	<b>Planners:</b> Government planners/regulators			<b>IIE:</b> Institute of International Education			
	<b>2004/5</b>	<b>1. Purdue</b>	<b>2. BUET</b>	<b>3. Univs</b>	<b>4. Utilities</b>	<b>5. Planners</b>	<b>IIE</b>
<b>6</b>	August 2004 to February 2005	(1) Collaborations on policy analysis  (2) GIS interface  <i>Time expenses</i>	Collaborations on policy analysis  <i>Time expenses</i>	Collaborations on policy analysis  <i>Time expenses</i>	Collaborations on policy analysis	Collaborations on policy analysis	
	March 2005	Conference planning, preparation, & presentation  <i>Time &amp; travel expenses</i>	Conference planning, preparation, & presentation  <i>Time &amp; travel expenses</i>	Conference planning, preparation, & presentation  <i>Time &amp; travel expenses</i>	Conference planning, preparation, & presentation  <i>Travel expenses</i>	Conference planning, preparation, & presentation  <i>Travel expenses</i>	Supply: (1) air tickets (2) accommodation in Delhi
<b>7</b>							

## Appendix 7 A

### Resume: **FREDERICK T. (TOM) SPARROW**

Director, Center for Coal Technology Research, Purdue University  
 Director, Power Pool Development Group, Purdue University  
 Professor of Industrial Engineering, School of Industrial Engineering, Purdue University  
 Professor of Economics, Department of Economics, Krannert School of Management, Purdue  
 Adjunct Professor, Department of Agricultural Economics, Purdue University

1953	BS	Geology	University of Michigan
1956	MBA	Managerial Economics	Cornell University
1962	PhD	Economics and Operations Research	University of Michigan

On the staff of Purdue since 1978, Dr. Sparrow's teaching responsibilities include graduate courses in economic engineering analysis, and mathematical programming. Until 1999 he served as the director of the Schools of Engineering's Institute for Interdisciplinary Engineering Studies (IIES), which houses several centers, laboratories, and programs focused on particular problem areas such as biomedical engineering, renewable resources engineering, and transportation. From 1990 to August 2003 he served as the director of the State Utility Forecasting Group. Dr. Sparrow is currently the director of the Center for Coal Technology Research (CCTR), created at Purdue University by the Indiana legislature in 2002. Effective July 1, 2003, the legislation allows CCTR to implement public education programs and requires CCTR to appoint a panel of at least eight members, consisting of scientists, engineers, or other professionals, to review and make recommendations about applications for coal research grants.

Prior to his association with Purdue, Dr. Sparrow taught for 10 years at The Johns Hopkins University, as well as serving as chairperson of the Industrial Engineering Department at the University of Houston. He also worked for two years for the Atomic Energy Commission as an Operations Analyst, and for three years for the National Science Foundation, where his last appointment was Deputy Director for Planning and Evaluation for NSF's Research Applied to National Needs Directorate.

Dr. Sparrow's primary concerns are interdisciplinary, with an emphasis on energy modeling and analysis, electrotechnology commercialization, industrial electrification, and transportation. He is the author or co-author of more than 100 papers, presentations, and reports on these topics, as well as on matters relating to economics, operations research, and industrial engineering. His honors include selection as a Ford Foundation Research Professor and invitations to speak before various organizations in the U. S., Europe, and Japan. Dr. Sparrow is consultant to various government agencies, electric utilities, and to the iron and steel industry.

F.T. Sparrow, Director

Center for Coal Technology Research  
 500 Central Drive, Room 270  
 West Lafayette IN 47907-2022

Phone: 765/494-7043

Fax: 765/494-2351

Email: fts@purdue.edu

FREDERICK T. (TOM) SPARROW (Continued)

**Recent Publications:**

Bowen, B.H., Sparrow, F.T., Yu, Z., and Granum, G., "Economic Benefits From Integrated Electricity Markets," prepared for presentation at the South Asia Regional Initiative in Energy Training Program, July 19-23, 2003, Dhaka, Bangladesh.

Sparrow, F.T., Bowen, Brian H., and Aouam, Tarik, "Technology Options in West Africa's Electricity Generation Expansion Planning for 2003 to 2013," prepared for the West Africa Power Pool (WAPP) Meeting, Cotonou, Benin, February 17-25, 2003.

State Utility Forecasting Group, Staff Report, "Indiana Electricity Projections: The 2003 Forecast," September 2003.

State Utility Forecasting Group, Staff Report, "2003 Indiana Renewable Energy Resources Study," September 2003.

Sparrow, F.T., Sanogo, Diakalia, and Bowen, Brian H., "Demonstration of Generation Expansions for 2002 to 2012," Power Pool Development Group Staff Report, March 25, 2002.

Yu, Z., Sparrow, F.T., Gotham, D.J., Holland, F.D., Nderitu, D.G., and Morin, T.L., "The Impact of Transmission on Imperfect Electricity Competition," Proceedings of the IEEE PES Winter Power Meeting 2001, New York, NY, January 2002.

Sparrow, F.T., Bowen, B.H., Yu, Z., "Regional Hydropower Policy and Capacity Expansion Modeling for the Countries of Southern Africa," International Water Power & Dam Construction, February 2001.

**Recent Presentations:**

Sparrow, F.T. and Holland, F.D., "The Supply and Demand for Indiana Electric Energy," presented to Indiana Conference on Energy, Indianapolis, IN, October 1, 2002.

Sparrow, F.T., "Factors Affecting Indiana Electricity Prices in (Not So?) Competitive Wholesale Markets," presented to the 2001 Indiana Energy Conference, Indianapolis, IN, November 8, 2001.

Sparrow, F.T., "Projections of Indiana Electricity Supply and Demand," presented to the Regulatory Flexibility Committee, Indianapolis, IN, August 23, 2001.

Sparrow, F.T., and Yu, Zuwei, "Simulating the Impact of Mergers and Other Wholesale Electricity Prices in Indiana," presented to the Electric Power Industry Special Institute Conference, Halifax, Canada, July 10-14, 2001.

## Appendix 7 B

### Resume: RONALD L. RARDIN

#### EDUCATION

Univ of Kansas, Lawrence, KS	BA	1965	Mathematics and Political Science
	MPA	1967	Municipal Administration
Georgia Institute of Technology, Atlanta, GA	PhD	1974	Industrial and Systems Engineering

#### PREVIOUS EMPLOYMENT AND EXPERIENCE

1967-68	Budget Analyst, Office of Research and Budget, City of Ft. Worth, TX
1968-70	Research Analyst, Stanford Research Institute, Menlo Park, CA
1970-71	Assistant Director of Data System, Kimbell, Incorporated, Ft. Worth, TX
1971-82	Graduate Assistant, Assistant Professor and Associate Professor of Industrial and Systems Engineering, , Georgia Institute of Technology, Atlanta, GA
2000-03	Program Director for Operations Research and Service Enterprise Systems, National Science Foundation, Arlington, VA
1982-Pres.	Professor, School of Industrial Engineering, Purdue University, West Lafayette, IN
2003-Pres.	Director, Purdue Energy Modeling Research Groups, Purdue University, West Lafayette, IN

#### RECOGNITION AND GRANTS

- Book *Optimization in Operations Research* chosen book-of-the-year in industrial engineering by the Institute of Industrial Engineering, 1999
- Associate Editor, *Operations Research*
- Associate Editor, *Management Science*
- Associate Editor, *INFORMS Journal on Computing*
- Pritsker Award for outstanding undergraduate teaching, 1991, 1997 and 1999
- Visiting Researcher, Department of Industrial and Operations Engineering, University of Michigan, Ann Arbor, Michigan, 1996
- Research Fellow, Center for Operations Research and Econometrics (CORE), Catholic University of Louvain, Louvain-La-Neuve, Belgium, 1989
- Consultant, “Method to Guarantee the Quality of Radiotherapy Planning,” contractor Advanced Process Combinatorics, STTR Phase I grant, National Cancer Institute, 2001-02. Principal Investigator, “Advanced Academic Computing,” Purdue University Computing Initiative, 1997
- Principal Investigator, “Implementation of Commodity Extended Formulations for Network Design,” AT&T Foundation, 1992
- Co-Principal Investigator, “University Research Initiative in Computational Combinatorics,” Office of Naval Research, 1986-91
- Co-Principal Investigator, “Tight Relaxations of Fixed Charge Problems in Graphs and Networks,” National Science Foundation, grant number ECS-8312755, 1981-84
- Co-Principal Investigator, “Development of Operations Research Modules for Interactive Decision Support Systems,” United States Army, 1979-83
- Sigma Xi, Purdue University, 1983
- Phi Beta Kappa, University of Kansas, 1965

## RONALD L. RARDIN (Continued)

## SELECTED PUBLICATIONS

- “A Coupled Column Generation, Mixed-Integer Approach to Optimal Planning of Intensity Modulated Radiation Therapy for Cancer,” *Mathematical Programming*, to appear, 2004.
- “Tractable Nonlinear Capacity Models for Aggregate Production Planning,” *Operations Research*, submitted, 2002.
- “Experimental Evaluation of Heuristic Optimization Algorithms: A Tutorial,” *Journal of Heuristics*, 7, 2261-2304, 2001.
- “Fractal Layout Organization for Job Shop Environments,” *International Journal of Production Research*, 17, 501-521, 1999.
- *Optimization in Operations Research*, Prentice Hall, 919 pp, 1998.
- “A Design Methodology for Fractal Layout Organization,” *IIE Transactions*, 29, 911-924, 1997, with B. Montreuil and U. Venkatadri.
- “Large Scale Classroom Scheduling,” *IIE Transactions*, 28, 369-378, 1996, with E.L. Mooney and W.J. Parmenter.
- “Valid Inequalities and Projecting the Multicommodity Extended Formulation of Uncapacitated Fixed Charge Network Flow Problems,” *European Journal of Operational Research*, 71, 95-109, 1993, with L.A. Wolsey.
- “Gainfree Leontief Substitution Flow Problems,” *Mathematical Programming*, 57, 375-414, 1992, with R.G. Jeroslow, R.K. Martin and J. Wang.
- “Partial Polyhedral Description and Generation of Discrete Optimization Problems with Known Optima,” *Naval Research Logistics*, 39, 839-858, 1992, with C.A. Tovey and M.G. Pilcher.
- “Polyhedral Characterization of Discrete Dynamic Programming,” *Operations Research*, 38, 127-138, 1990, with R.K. Martin and B.A. Campbell.
- *Discrete Optimization*, Academic Press, 472 pp, 1988, with R. Gary Parker.
- “Surrogate Search and Branch and Bound,” *European Journal of Operational Research*, 33, 326-333, 1988, with S. Sarin and M.H. Karwan.
- “Guaranteed Performance Heuristic for the Bottleneck Traveling Salesman Problem,” *Operations Research Letters*, 6, 269-272, 1984, with R. Gary Parker.
- “Controlled Experimental Design for Comparison of Integer Programming Algorithms,” *Management Science*, 25, 1258-1271, 1979, with B.W. Lin.

## Appendix 7 C

### Resume: MD. QUAMRUL AHSAN

Department of Electrical & Electronic Engineering

University of Engineering & Technology, Dhaka1000, Bangladesh.

Ph:9665650/7196(office)/7101 (Residence), Fax:880-2-863046, 880-2-863026, Em:[gahsan@eee.buet.ac.bd](mailto:gahsan@eee.buet.ac.bd)

### INTERESTS

Power System Reliability, Power System Planning, Load Management, Renewable Energy

### EDUCATION

1984: Ph.D Electrical Engineering, University of Ottawa, Canada

1980: M.Sc.Electrical Engineering, University of Engineering & Technology, Dhaka,Bangladesh

1975: B.Sc.Electrical Engineering, University of Engineering & Technology, Dhaka, Bangladesh

### HONOURS AND AWARDS

1. Best Research Award of Bangladesh University Grants Commission, 1990.
2. Best Teacher Award of Bangladesh University of Engineering & Technology, 1987.
3. Research Fellow of University of Ottawa, Canada, 1981-1984.
4. Technical Scholarship of Bangladesh University of Engineering & Technology, 1970-1975.

### EXPERIENCE

**Professional (1 year):** (a) Worked as an Assistant Engineer of PWD of Bangladesh from July 1975 to January 1976. The nature of the work was to plan the building electrification and to maintain and operate elevators. (b) Worked as an Assistant Engineer in the Power Development Board of Bangladesh from February 1976 to October 1976. The nature of the work was the maintenance and operation of Electric Supply.

**Teaching and Research (26 years):** (a) Worked as a Visiting Professor from January 2001 to January 2002 in the Department of Electrical and Electronic Engineering of Islamic University of Technology, an Institute of OIC. (b) Worked as a visiting faculty from September 1991 to June 1994 in the department of Electrical Engineering of University of Bahrain.

(c) Working as a Full Professor from August 1988 to date and worked as an Associate Professor from February 1986 to July 1988 in the department of Electrical & Electronic Engineering of University of Engineering & Technology, Dhaka. The duties involved are to teach in the undergraduate and post-graduate classes and also to guide the research of the post-graduate students. Worked as an Assistant Professor from February 1979 to December, 1980 as well as from December 1984 to January 1986 and as a Lecturer from November 1976 to January, 1979 and as an Assistant Professor from 1979 to December 1980 in the department of Electrical & Electronic Engineering of University of Engineering & Technology, Dhaka. The job was to teach extensively in the undergraduate classes and also to demonstrate in the Laboratories.

**Administrative Positions:** (1) Dean, Faculty of EEE, Bangladesh University of Engineering & Technology (BUET), (2) Head, Department of EEE, BUET, (3) Provost, Ahsanullah Hall, BUET.

## MD. QUAMRUL AHSAN (Continued)

**MEMBERSHIP**

1. Member of IEEE (Member No: 4871828 )
2. Former Member of CASR (Committee for Advanced Studies and Research) BUET
3. Member of Academic Committee at ICTVTR (Islamic Center for Technical and Vocational Training & Research) from 1989 to 1991.
4. Former Member of the Finance Committee of BUET.

**PUBLICATIONS, SELECTION**

1. Q. Ahsan and Masum Alam Bakshi, ' An Appropriate Method of Evaluating the Reliability of Small Power System: A Case Study.', Journal of the Institution of Engineers, India, vol.72, pp. 7-10, April 1991.
2. Q. Ahsan, 'Sensitivity Study of the Cumulant Method for the Evaluation of Production Costs of Two Interconnected Systems', International Journal of Electrical Power and Energy System, vol. 13, no. 1 , pp. 21-27, February , 1991.
3. Q.Ahsan, 'Reliability of Two Interconnected Systems with Jointly owned Units', International Journal of Electrical Power & Energy Systems , vol. 17, No.6, pp. 363-370,1995.
4. Q. Ahsan and A. Hoque, 'Probabilistic Model of a Wind Turbine Generator for use in Generation Expansion Analysis'Renewable Energy, vol. 4, No. 5, pp. 585-592, 1994.
5. Q. Ahsan and Masoom Alam Bakshi, 'Comparative Study of Different Methods in Power System Reliability Evaluation', International Journal of Electrical Power and Energy Systems ,vol.15, No.1, pp. 4-8, 1995.
6. A.Hoque, Q.Ahsan and W.C.Beattie, 'A Load Forecasting Technique for an Isolated Area', ISEDEM '93 (IEEE Singapore Conf.), 27-29 October, 1993, pp 289-293.
7. A.Hoque, W.C.Beattie and Q.Ahsan, 'Alternative Energy Sources in Bangladesh', Proc. IEE International Conf. on 'Renewable Energy - Clean power 2001', London, UK, 17-19 November, 1993, Conference Publication 385, pp.19-24
8. A.Hoque, Q.Ahsan, A.M.Z.Huq, W.C.Beattie, 'A Statistical Investigation of the Behaviour of an Isolated Photovoltaic Generator in Bangladesh', Renewable Energy, Climate Change: Energy and the Environment, Part-III, Reading, UK, 11-16 Sept., 1994, pp.1596-1598.
9. Q. Ahsan and S.R. Ahmed, 'Joint Ownership of Generation: Impacts on the Reliability of Interconnected System', Proceeding of IEE International Conference on Electricity Sector Development and Demand side Management( ESDDSM95), Kuala Lumpur, Malaysia, 1995, pp.135-141
10. B. Chakma, U.K. Saha, J.K. Khisa and Q.Ahsan,'Economic Benefits: Use of PV cells for an office lighting,' Proceedings of International Symposium on Advances in Alternative & Renewable Energy, pp.542-549, 22-24 July, 1997, Johor Bahru, Malaysia.
11. Q. Ahsan, M. Alam, R.Karim and H.Rahman, 'Isolated Home lightning system:'The Potential application of Photovoltaic Cell', Proceedings of International Conference on Energy Research and Development, Kuwait, 9-11 November, 1998.
12. Q. Ahsan and M. Alam,'Solar Power Lantern for flood affected areas', IEEE winter Meeting, January 23-27, 2000, Singapore.

## Appendix 7 D

### Resume: MOHAMMAD REZWAN KHAN

*Dept. of Electrical & Electronic Engineering*

*BUET, Dhaka, Bangladesh*

*Tel/Fax : 8611594 Email: rezwanm@eee.buet.ac.bd*

**INTERESTS:** 1. Microelectronics, 2. Digital Signal Processing, 3. Power electronics/renewable energy, 4. Electromagnetics and communication.

### **QUALIFICATIONS:**

1980: B.Sc.(Elec. Engg.) Bangladesh Univ. Of Engg. & Tech. (BUET) Honors.

1982: M.Sc. (Microwaves & Modern Optics) University College London, U.K.

1986: Ph.D. University College London, U.K., Thesis Title, "A beam steering technique using dielectric wedges".

### **EXPERIENCE:**

Lecturer : April 1980 - January 1986. Department of Electrical Engineering, BUET, Dhaka

Assistant Professor : January 1986 - July 1989, Department of Electrical & Electronic Engineering, BUET, Dhaka

Associate Professor : Sept. 1992 - August 1994. Department of Electrical Engineering, University of Bahrain, Isa Town, Bahrain

Professor: July 10, 1996 - to date. Department of Electrical & Electronic Engineering, BUET  
Visited Clarkson University, Potsdam, New York, USA, as a visiting faculty member for the Summer Session II, July 3 – Aug. 5, 2000, and taught the summer course on Microelectronics (EE341).

Part time teaching in the following universities:

- Ahsanullah University of Science & Technology, Dhaka, Bangladesh.
- Islamic Institute of Technology, (An OIC run institute), Tongi, Bangladesh

### **AWARDS & MEMBERSHIP OF PROFESSIONAL BODIES:**

1. Received the '**Dana Chase Memorial Award**' for the best paper "A Novel Dehumidification Technique Using Electric Field" presented at the 45th International Appliance Technical Conference held at Madison, Wisconsin, USA, May 1994. Also received the '**Best Presentation Award**' in the same conference.

2. Member of the Institute of Engineers, Bangladesh.

3. Member IEEE.

### **CONSULTING SERVICES:**

- Estimation of the harmonics injected to the power system by a steel mill
- Consulting service for the updating and modification of the National Load Dispatch Centre Project, Bangladesh
- Computer controlled automation for different industries in Bangladesh
- Earthing design for telecom stations around Bangladesh
-

## MOHAMMAD REZWAN KHAN (Continued)

- Consulting services to Unique Power Plant, Meghna Group of Industries, Bangladesh

**PUBLICATIONS & CONFERENCES SELECTION:**

1. M.K.Hasan, M.S.A.Zilany and M.R.Khan, 'DCT speech enhancement with hard and soft thresholding criteria', Electronics Letters, vol.30, no.13, 20<sup>th</sup> June, 2002, p669.
2. K.Alam, S.Zaman, M.M.Choudhury, M.R.Khan, A.Haque, 'Effects of inelastic scattering on direct tunneling gate leakage current in deep submicron metal-oxide-semiconductor transistors', Journal of Applied Physics, vol.92, no.2, July 15, 2002, p 937.
3. S.Salahuddin, S.Z.Al Islam, Md.K.Hasan, M.R.Khan, 'Soft thresholding for DCT speech enhancement', Electronics Letters, vol.38, no.24, Nov.2002, p1605..
4. Syed. S. Islam, M. Rezwán Khan and A.F.M. Anwar, 'Effects of impurity traps on gate current and trapped charge in MOSFETs', Solid State Electronics, vol.47, issue 2, Feb. 2003, pp 339-344.
5. K.M.Rahman, M.Rezwán Khan and Md. Ali Choudhury, 'Implementation of Programmed Modulated Carrier HCC Based on Analytical Solution for Uniform Switching of Voltage Source Inverters', IEEE Trans. Power Electronics, vol.18, no.1, Jan. 2003, pp188-197.
6. Md. Kamrul Hasan and M. Rezwán Khan, 'Identification of AR Systems at a Very Low SNR Using Cosine Modeling of Autocorrelation Function', Journal of Signal Processing (Japan), vol.7, no.1, Jan.2003.
7. M.S.Arefeen Zilany, Md.Kamrul Hasan and M.Rezwán Khan, 'Signal-Bias Compensated Noise Level For Wavelet Speech Enhancement', Journal of Signal Processing (Japan), vol.7, no.1, Jan.2003.
8. Md.Kamrul Hasan, Anowarul Fattah and M.Rezwán Khan, 'Identification of AR Systems at a Very Low SNR Using damped Sinusoidal Model of Autocorrelation Function', IEEE Signal Processing Letters, vol.10, no.6, June 2003, p157.
9. M.K.Hasan, A.K.M.Z.Rahim Chowdhury, and M.Rezwán Khan, 'Identification of autoregressive signals in colored noise using damped sinusoidal model', IEEE Trans.on Circuits and Systems - I: Fundamental Theory and Applications, vol.50, no.7, July 2003, pp966-969.
10. S.A.Fattah, M.Kamrul Hasan, M.Rezwán Khan, 'Identification of AR Systems at a Very Low SNR Using Damped Cosine Model of Autocorrelation Function', ICASSP 2002, 13-17 May, Orlando, Florida, USA.
11. M.S.A.Zilany, M.K.Hasan and M.R.Khan, 'Wavelet speech enhancement using fourth order cumulant', International Symposium on Communication system, Networks, Digital Signal Processing (CSNDSP 2002), pp. 387-390, July 15-17, 2002, Staffordshire, U.K.
12. M.K.Hasan, A.K.M.Z.R.Chowdhury, Rubyat Adnan and M.R.Khan, 'A new method for parameter estimation of autoregressive signals in coloured noise', Proc. of XI European Signal Processing Conference (EUSIPCO 2002), Sept. 3-6, 2002, Toulouse, France.
13. F. Ferdousi, A. Tahseen, M. Sharmin, M.Murshed, I. R. Kabir, N. Jahan, M. Rezwán Khan, Md. Kamrul Hasan, 'Parameter Estimation of AR Systems at a Very Low SNR Using Prefiltering in the Autocorrelation Domain', accepted for presentation at TENCON 2003, Bangalore, India.
14. M. Rezwán Khan, I Husain and M.F. Momen, "Paramagnetic rotor Bars for Three-phase Squirrel Cage Induction Machines," to be presented in the IEEE-IAS Annual Conference, Salt Lake City, UT, 2003.

## Appendix 7 E

### Resume: S. SHAHNAWAZ AHMED

**Director**, Center for Energy Studies, Bangladesh University of Engineering & Technology (BUET)  
**Professor** of Electrical and Electronic Engineering, BUET

1982	B.Sc.Engg	Elect. & Electronic Engineering	BUET
1984	M. Sc. Engg.	Elect. & Electronic Engineering	BUET
1987	PhD	Electrical Engineering	Univ. of Manchester Inst. of Science & Tech. (UMIST), UK

After serving a local consulting firm he joined the faculty in the Dept. of Electrical & Electronic Engineering of BUET in 1983. Since then until now he has been there where he became a full professor in 1996. Dr. Ahmed also served as a Professor of electrical engineering in Universiti Teknologi Malaysia (UTM; a leading public university of Malaysia) in the period April 2000 to March 2003 on lien from BUET. From 1997 to 2000 he was also an external Director in the Board of Dhaka Electric Supply Company Limited. Since July 2003 he has been assigned the additional responsibility to serve as the director of the Center for Energy Studies, BUET that coordinates the conventional and renewable energy related activities of interdisciplinary nature.

Dr. Ahmed is actively engaged in graduate and undergraduate teaching, research, consultancy and publications in the area of electrical power and energy systems modeling, control and simulations including deregulation perspectives. He has supervised 9 graduate theses including a PhD at BUET and UTM. Besides that he was co-supervisors and examiners for a number of graduate theses. He has to his credit over 45 publications mostly in international reputed journals and conference/symposium proceedings. Also he served as a reviewer to numerous international journals. He also produced about 20 technical reports for the testing and consultancy services rendered to the public utilities in energy sector of Bangladesh.

Dr. Ahmed has been engaged in SARI/E (South Asia Regional Initiative in Energy) program of USAID since May 2003 as a TIP (Training Institution Partner) representative, a resource person in training course, a reviewer of research report on cross-border energy trading, and a visitor under the link program (BUET-Purdue University Link).

His honors include "**2nd Annual Research Excellence Award; 1998**" by the **Southern California Chapter of American Association of Bangladeshi Engineers & Architects** for the paper "*Development of a Three-Part Time-of-Day Electrical Energy Tariff*" that was adjudged as the best one among the refereed publications received from Bangladeshi researchers in the 1998 contest. Also he was conferred on the title of "**Laureate of the annual (2002) competition**" hosted by the **Royal academy of Overseas Sciences, Belgium** for the study "*Photovoltaic Supplement to Diesel Generator Based Supply in an Off-grid Location of East Malaysia*" that was evaluated as the best one among the studies received under the category of Technical Sciences from international researchers. Dr. Ahmed is a Senior Member of IEEE (USA) and a Fellow of Institution of Engineers, Bangladesh.

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S. SHAHNAWAZ AHMED (Continued)

**Recent Publications:**

- 1) S. Shahnawaz Ahmed and Md. Mizanur Rahman : "Use of base case Jacobians in power flow solution under topological changes", *Computers & Electrical Engineering International Journal*, (U.K.), Vol 28, No.1, January 2002, pp 17-23.
- 2) S. Shahnawaz Ahmed, Mahes Rajaratnam, Hussein Ahmad and Abu Bakar Sidik : "Potential Benefits of Using Distributed Parameter Model for Transmission Lines in Power System Analysis", *IEEE (USA) Power Engineering Review*, Vol. 22, No.10, October 2002, pp.53-56.
- 3) S. Shahnawaz Ahmed, Mohammad Tawrit, Mohd Wazir b. Mustafa, Hussein b.Ahmad, Mohd Ruddin b.Abd Ghani and Abdullah Asuhaimi b. Mohd Zin: "Novel adaptation of the critical clearing angle formula for faults on a three phase and a six phase line", *Electric Power Systems Research*, (U.K.), Vol. 61, No. 2, March 2002, pp.119-126.
- 4) S. Shahnawaz Ahmed, Narayan Chandra Sarker, Azhar b. Khairuddin, Mohd Ruddin b. Abd Ghani and Hussein Ahmad: "A Scheme for Controlled Islanding to Prevent Subsequent Blackout", *IEEE (USA) Transactions on Power Systems* Vol.18, No.1, February 2003, pp.136-143.
- 5) S. Shahnawaz Ahmed, Tiow Wei Yeong, and Hussein Ahmad, "Wireless Power Transmission and its Annexure to the Grid System", *IEE (U.K.) Proceedings- GTD*, Vol.150, No.2, March 2003, pp.195-199.
- 6) Christopher W. Ajan, S. Shahnawaz Ahmed, Hussein B.Ahmad, Faridah Taha and Abdullah Asuhaimi B. Mohd Zin : "On the policy of photovoltaic and diesel generation mix for an off-grid site: East Malaysian perspectives", *Solar Energy* (U.K.), Vol. 74, No. 6, June 2003, pp.453-467.
- 7) Azhar B. Khairuddin, S. Shahnawaz Ahmed, Wazir b. Mustafa, Abdullah Asuhaimi b. Mohd Zin, and Hussein Ahmad: "A Novel Method for ATC Computations in a Large-Scale Power System", accepted for publication in *IEEE (USA) Transactions on Power Systems*.
- 8) Md. Abdus Salam and S. Shahnawaz Ahmed: "A New Method for Screening the Contingencies before Dynamic Security Assessment of a Multimachine Power System", accepted for publication in *European Transactions on Electric Power* (Germany).
- 9) S. Shahnawaz Ahmed: "Energy Management and Modern Control Centres", *Proceedings of Course 1.7: "Operational Issues in Interconnection among Utilities"* organized by AED (Academy for Educational Development) in Dhaka (19-23 July 2003) under South Asia Regional Energy Initiative in Energy (SARI/E) Program of USAID.
- 10) S. Shahnawaz Ahmed: "Energy Management and Modern Control Centers", *Proceedings of Course 1.7: "Strengthening Regional Energy Linkages in South Asia"* organized by AED (Academy for Educational Development) in Dhaka (19-23 July 2003) under South Asia Regional Energy Initiative in Energy (SARI/E) Program of USAID.

## Appendix 7 F

### Resume: BRIAN H. BOWEN

Potter Engineering Center, Room 270, Purdue University, West Lafayette, IN 47907  
 Ph: 765-494-1873, Fax: 765-494-2351, Email: [bhbowen@ecn.purdue.edu](mailto:bhbowen@ecn.purdue.edu)

Dr. Brian Bowen is an industrial engineer with interests in engineering in economic development and integrated energy planning. He is a registered professional engineer with substantial international experience. Prior to his present position, at Purdue University, (Associate Director, Power Pool Development Group), he trained with British Insulated Callenders Cables Ltd, UK, lectured full-time in Mauritius (1971-73), Sierra Leone (1974-86), United Kingdom (1986-90), and Zimbabwe (1990-93). The positions in Sierra Leone and Zimbabwe were sponsored by the British Government Overseas Development Administration (ODA), and the British Council. His Mauritius position was through the British International Voluntary Service (IVS). From 1996 to 2001 he worked with the Southern African Power Pool utilities (SAPP) and from 1999 to the present with the West Africa Power Pool (WAPP) development projects, at Purdue University. Power pool planning presentations and consultations have been given to the World Bank, DOE, USAID, private consultants, and to utilities and energy planners in government. Having management and analytical responsibilities he coordinates with supporting research agencies and international colleagues, disseminating analytical results. He coordinates training workshops and instructs.

#### Energy Collaborating Agencies & Companies

IURC, Indiana Utility Regulatory Commission	Sandia, National Laboratory, USA
AIRD, Assoc. Int. Resources & Development	USAID Regional Center for Southern Africa
USAID West Africa Regional Office	USAID Global Bureau
USAID Office of Energy, Environment & Tech	CRG Consulting, London, UK
World Bank	Department of Energy, DOE
Eskom, South Africa electricity corp.	Indiana Dept of Commerce, Energy & Coal
SADC, S. African Devel. Community	ECOWAS, Economic Comm. of W.Africa States
SAD-ELEC, S. African Devel.& Electricity	ZIMCONSULT, Zimbabwe Energy Consultants
ERB, Energy Regulatory Board, Zambia	BPC, Botswana Power Corporation

#### Academic & International Experience

1998-Present	Purdue University, Associate Director, Power Pool Development Group
1998-1999	Purdue University, USA, Visiting Professor, School of Technology
1994-1998	Purdue University, USA, Research associate & instructor
1993-1994	Manchester University & Manchester Metropolitan University, UK
1990-1993	University of Zimbabwe, Zimbabwe, Southern Africa (UK-British Council)
1987-1990	Liverpool John Moore University, UK
1974-1986	Fourah Bay College, University of Sierra Leone, West Africa (UK-ODA)
1971-1973	University of Mauritius, Indian Ocean, (UK International Voluntary Service)
1964-1971	British Insulated Callenders Cables Ltd, UK, Technical Officer & Junior Engineer

#### Education & Training

1998	Ph.D., Industrial Engineering, engineering economics, Purdue University, USA
1986	P.Grad.Dip.CAD/CAM, Liverpool John Moore University, UK
1985	M.Sc., Mechanical Engineering & Energy Studies, University College, Cardiff, UK
1978	C.Eng, M.I.Mech.E., Chartered Professional Engineer
1974	P.Grad.Dip.Education, Oxford University, UK
1971	B.Sc.Hons, Mechanical Engineering, Coventry University, UK

## BRIAN H. BOWEN (Continued)

### **Publications/Conferences Selection**

Brian H. Bowen, F.T. Sparrow, "The Benefits from Integrated Markets in Africa", Electricity Trading & Policy Analysis in Africa, London School of Economics, London, UK, August 18, 2003

Brian H. Bowen, F.T. Sparrow, Zuwei Yu, Geoff Granum, "Benefits to South Asia from an Integrated Electricity Market Infrastructure", AED-USAID Strengthening Regional Energy Linkages in South Asia, Dhaka, Bangladesh, July 19-23, 2003.

Brian H. Bowen, F.T. Sparrow, Tarik Aouam, "Technology Options in West Africa's Electricity Generation Expansion Planning for 2003 to 2013", ECOWAS Regional Summit, Cotonou, Benin, February 17 to 25, 2003

Brian H. Bowen, F.T. Sparrow, Zuwei Yu, Muhammad Al-Salamah, "Policy Analysis in the Development of Integrated Middle East Regional Energy Markets", 8<sup>th</sup> Power Generation Conference, Dubai, United Arab Emirates, October 6 to 9, 2002

Muhammad Al-Salamah, F.T. Sparrow, Brian H. Bowen, Zuwei Yu, "Optimal Construction and Operation of the Gulf Regional Natural Gas and Electricity Production and Transmission Systems", 8<sup>th</sup> Power Generation Conference, Dubai, United Arab Emirates, October 6 to 9, 2002

Brian H. Bowen, F.T. Sparrow, World Bank presentation/consultations on optimal new transmission lines in West African Power Grid Zone A, World Bank, Washington DC, March 5-6, 2002

F.T. Sparrow, Brian H. Bowen, Diakalia Sanogo "The Long-Term International Transmission Grid of West Africa with Low and High Demand Electricity Growth Rates", ECOWAS Regional Modeling Workshop & Technical Working Group Committee Meeting, Bamako, Mali, June 4-8, 2001.

Brian H. Bowen, F.T. Sparrow, "The West Africa Power Pool and Optimal Long-Term Planning of International Transmission with a Free-Trade Electricity Policy", ECOWAS Conference, Dakar, Senegal, March 20-22, 2001.

F.T. Sparrow, Brian H. Bowen, "Transferring the SAPP Electricity Planning Methodology to SAPP High Level Utility Planners", SAPP Management Conference Consultations, Windhoek, Namibia, February 20-22, 2001.

Brian H. Bowen and F.T. Sparrow, "Regional Hydropower Policy and Capacity Expansion Modeling for the Countries of Southern Africa," International Water Power & Dam Construction, February 2001.

Zuwei Yu, F.T. Sparrow, Brian H. Bowen, "Developing the Southern African Power Pool – Its Regional Electricity Trade Undergoes Modeling", TRANSMISSION & DISTRIBUTION, pp 58-68, February 2001.

Brian H. Bowen, "West Africa Power Pool and Preliminary Policy Analysis Results", Economic Community of West African States, ECOWAS, Energy Ministers Conference, Lome, Togo, September 23–25, 2000.

F.T. Sparrow, Brian H. Bowen, "The Southern African Power Pool (SAPP) Long-Term Pool Plan and modeling Improvements", Johannesburg, South Africa, February 23-25, 2000.

Brian H. Bowen, F.T. Sparrow, "Electricity Policy Analysis in Africa", DOE sponsored, US-AFRICA Energy Ministers Conference, Tucson, AZ, December 3-5, 1999.

Brian H. Bowen, F.T. Sparrow, Zuwei Yu, "Modeling Electricity Trade for the Twelve Nations of the Southern African Power Pool (SAPP)", UTILITIES POLICY 8 (1999), pp 183-197.