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Professional Experience

Aug 2017 - Present
Associate Professor at the University of Tennessee at Chattanooga

Aug 2014 – Aug 2017
Visiting Professor at the University of Tennessee at Chattanooga

Oct 2012 – Jul 2014
Head of the Electrical and Electronics Engineering Department, University of Khartoum. Second term of duty, since October, 2012

Mar 2011 – Oct 2012
Program Coordinator for the M.Sc Program at the Electrical Engineering Dept.

Oct 2008 – Mar 2011
Head of the Electrical and Electronics Engineering Department, University of Khartoum.

2003 – 2008
Head of Electrical Engineering sub-department, University of Khartoum,

2001 – 2003
Assistant Professor at Yanbu Industrial College, Saudi Arabia

1992 – 2001
Assistant Professor in Electrical Engineering, University of Khartoum
- Teaching Power Systems to the higher classes in electrical engineering and supervising projects, M.Sc & Ph.D research.

1987 – 1992
Teaching Assistant in the Dept. of Electrical Engineering, University of Khartoum
- Supervising laboratory experiments, administrating tutorial sessions and carrying out research.

Education

Ph.D (Elect. Engineering), Loughborough University of Technology, United Kingdom 1992; thesis title: "The application of contingency analysis to stability and security planning of the Blue Nile Grid"

M.Sc (Elect. Engineering), University of Khartoum, Sudan, 1988, thesis title: "Voltage Control of the Blue Nile Grid"

B.Sc (Elect. Engineering), University of Khartoum, Sudan, 1985

Industrial Experience

Analyst with C-Power Company 1993 - 2001:

- Kennana pump station design (did not participate in actual project but supplied locally developed software for analysis purposes), Kennana Sugar Company, **1993-1994**.
- Earth measurements for Kennana pump stations, **1996**. Carried out measurements for grounding purposes according to standard procedures and issued certificates.
- Participated in electrical design of El-Waha Towers, designing electrical fittings, supply and issuing Tables of Quantities, **1994**.
- Installation, and testing and commissioning of 110/33/11 kV transformers, plus erection of 33 kV lines and cables for Giad industrial Complex, **1998**.
- Several other minor projects, including electrical rehabilitation of a number of hospitals, farms and commercial facilities in Khartoum.

Consultant with National Electricity Corporation (NEC), 2003-2010. (Afterwards consultant for the Sudanese Electricity Transmission Company, SETCO and for Ministry of Electricity and Dams in general, 2010-2014)

- Developed software for the purpose of load-flow analysis of the National Grid, for use by both the operation and planning directorates. Software also calculates fault levels and ampacity ratings of transmission lines. Software was in use by NEC **since 2003 and up to 2010**.
- Upgrading of the 11 kV & 33 kV protection: developed software for the purpose of coordinating overcurrent protection in all 33 kV and 11 kV levels in the Khartoum ring network. **2003**.
- Conducted harmonic investigations for the new matrix turbine units at Jebel Aulia Dam. **2004**.
- Conducted studies for improving the voltage profile in the National grid by optimizing reactive power resources in the network. **2003 -2005**.
- Implemented systematic procedures for interpreting the fault analyzer data records and conducted analysis groups for analyzing faults. **2003 – 2005**.

- Lead investigation team for analyzing the frequency droop behaviour of the grid following work on automation of the hydro units at Roseires station. Proposed modification and new settings which were implemented by ABB automation. **2004**.
- Investigated problems related to operation of new emergency high speed diesel units (Cummins) at Port-Sudan along with remaining low speed units. Recommended changing operating mode and determined settings for new mode. Recommendations implemented successfully. **2004**.
- Proposed changes (now implemented) in the protection of Garri power stations, following observations of unnecessary tripping of station Gas turbines in the event of minor disturbances. **2003, 2004** and **2008**.
- Participated with the planning and projects departments in analyzing, revising and changing scopes of many of the projects being executed or scheduled for execution in the near future. **2005 to 2014**.
- Lead the NEC team for procurement and scope of design for the new fault recorders implemented in the Third Circuit project. Nanjing, China **2007**.
- Led the NEC team for modifications in the busbar design of Garri IV project and for the Freezone Substation design. Frankfurt, Germany **2007**.
- Leading the NEC design team for Energy Management System revision and acceptance. Contract awarded to Siemens within the framework of the new dispatch center. Attended three tours of design meetings and supervised factory tests at Nurnburg, Germany **2004 – 2006**.
- Leading the NEC design team for Backup Energy Management System. Major contenders were the Chinese Nari Automation company, together with Areva and others. Contract awarded to Nari. Completed three tours of discussions in Frankfurt and Nanjing to finalize SCADA, NA and EMS design. **2008 - 2010.**
- Leading the NEC team for Roseires Hydro Automation Change to the new system based on the NARI open-3000 system. **2009 – 2010**.
- Investigated problems for failure of communications between Roseires power station DCS system (Procontrol 14) and ABB station RTU (ABB 560A). Communication essential for interlocking conditions and successful start-up of station. I was able with an assistant I & C engineer to determine cause of failure and hence to recommend solution. Until solution was implemented (for one month) we simulated the ABB RTU on a laptop computer using MODBUS communication protocol in slave mode and consequently power station was able to operate successfully.**2010**.
- Leading the NEC team for the Joint Interconnection Committee discussions in preparation for purchasing power through the Ethiopian – Sudan interconnection. Addis Ababa, **2010**.
- Investigated voltage collapse problems in the National Grid and recommended study of potential use of Static VAR compensation as a solution and wrote terms of reference (TOR) for the study. Study awarded to Swiss group BCP, I

participated with other Sudanese experts in follow-up of study. November, **2010**.

- Wrote terms of reference (TOR) for procurement and installation of Static VAR Compensation (SVC) at nine substations in the National grid. Project awarded to a Joint Venture between Shanghai Electric Power Transmission and Distribution Engineering Co.(SPTDE) and NR Electric Co. August **2011**.
- Head of team for study of conditions of network for introduction of nuclear generation in Sudan on the level of 600 – 1000 MWs. Also participated in negotiations with PMD and ENCOnet (Austrian consultants) on preparation of draft BIS (Bidder Information Specification) for use in tender of nuclear generation. September – October **2012**.
- Wrote terms of reference (TOR) for the Khartoum Transmission Development Roadmap study. It was awarded to Lahmeyer International of Bad-Vilbel, Frankfurt, July **2013**.
- Head of team for studying impact of SVC equipment on voltage performance of the National Grid. Completed tour of factory acceptance tests in Nanjing, China including real-time-digital-simulator RTDS study of SVC impact on the Sudanese National Grid October **2012 – 2014**.

Consultant with University of Khartoum Consulting Corporation (UKCC), **2003-to 2014.**

- As an electrical consultant for the Pump Stations at New Amri Agricultural scheme. Approved low voltage systems, earthing and lightning systems implemented by China Water & Electricity Co. (CWE). Project Completed **2005**.
- As an electrical consultant for the Pump Stations at Makabrab Agricultural scheme. Proposed designs for the 33 kV overhead line and the two 33/11 kV substations (implemented by ABB) and approved the H.V. and L.V. systems implemented by China Water & Electricity Co. (CWE). Project Completed **2007**.
- As an electrical consultant for the Pump Stations and Power Houses at Kehaila Agricultural scheme. Approved design and performance testing of the power house comprising diesel generators (at FG Wilson headquarters in County Antrim, Northern Ireland) and the HV and L.V systems implemented by China Water & Electricity Co. (CWE). Project Completed **2008.**
- Headed team responsible for carrying out an electrical network audit of the Central Petroleum Labs, Khartoum. Study covered inspection and documentation of the network, investigation of the major problems – particularly with reference to reported standby and UPS problems – and recommended solutions to be implemented. Completed February **2011**.
- As an electrical consultant for the DIU poultry farms at New Amri. Farm groups include Parent Stock, Broiler Farms, Grandparent Stock, Hatcheries, Mills and extensions. Project Completed **2012**.

- As an electrical consultant for the Weaving Mills rehabilitation at Kosti, Duweim and Shendi. Owned by Ministry of Industry and implemented as a turnkey project by Lucky Exports of India. Project Completed **2013**.
- Other smaller scale projects including extension of Faculty of Medicine buildings, Staff Club buildings at University of Khartoum, Customs X-Ray scanner projects at Port Sudan & Suakin, Cofftea Factory, Animal Production Centre and some other ongoing projects. **2005 – 2014**.

Participated with Higher Council for Environment as a member, and in three instances headed the evaluation team for Environmental and Social Impact Assessment reports on the following projects: **2005 – 2013**.

(1) Bageir Power Station.
(2) Garri Sponge Coke Power Station.
(3) Garri III Power Station.
(4) Um Dabakir (Kosti) Power Station.
(5) Kassala Power Station.
(6) El-Fula Power Station.
(7) South Kordufan Electrical Network
(8) New International Khartoum Airport
(9) Babanusa-Adiela-Al Deain-Nyala-Al Fashir transmission line.
(10) Pumps Replacement Program in the Northern State

Other Industrial Activities

- Participated with IES (Integrated Electrical Solutions Company) in finding solutions for failure of 11 kV motor starting equipment (liquid resistance tanks) for Makabrab Agricultural Project. I proposed designing steel tanks with copper electrodes, analyzed the design with a research student using Finite Element analysis and contacted Lambda Engineering to manufacture the tanks. After successfully testing a prototype at Lambda, we built the tanks and transported to the site where they were used successfully. 2012.

- Participated with IES (Integrated Electrical Solutions Company) in reprogramming the PLC responsible for motor starting at Makabrab Agricultural Project. PLC program reversed engineered at University of Khartoum, and program extracted and used to program new PLC units. 2012.

- Designed complete Electrical & Control system and supervised erection for well pump site (8 submersible pumps and two ground tanks) at Layoona, Damazine. Project commissioned by Lambda Engineering in the scope of resettlement plans for villages affected by Roseires Dam heightening. 2012.

Co-Founder and CTO of ELECON for technical services **2012**.

One of first assignments for the company was to carry out a review of Petro-Energy Electrical network (at Baleela) following occurrence of disturbances and blackouts. The scope of studies involved

- Power System Analysis; short circuit, transient stability study.
- Protection coordination analysis.
- EMTP study on transformer inrush current and lightning strike analysis.
- Solution the problem of load sharing on the two main step-up transformers TR1806 A&B (from 11 kV to 33 kV); we succeeded in solving the persistent problem of load sharing where three contractors prior to us failed.
- Carrying out polarity tests of VT's and CT's and phase sequence test;
- Preparing the study Reports and Final Proposal. **Completed 2013**

Another job was the design, manufacture and installation of one 400-V low voltage Bus-Coupler Switch Cabinet at Hadida Field Production Facility. The bus-coupler is designed to tie the two 400 V low voltage busbars A and B. Buscoupler designed with 4000 A busbar and 2500 A ABB EMAX 1 Circuit-Breaker. The scope of works involved

- Design metal cabinets, busbar dimensions and support system.
- Design Tripping and Closing and Voltage release scheme compatible with ABB EMAX Series.
- Design bus metering and synchro-check interlocking.
- Design dead-bus closing logic.
- Setting over-current and instantaneous protection
  Completed 2014

Elecon is also heavily active in industrial training. Two of the largest industrial firms, Petro-Energy & Kennana Engineering regularly send their engineers to be trained at our facilities; I designed the training programs and was actively engaged in teaching them. They cover the following topics:

- Load flow Analysis.
- Short Circuit Analysis.
- Voltage Control.
- Generation Systems and Control
- Harmonic Analysis.
- Protection Coordination.
- PLCs and Embedded Systems

Publications

(i) A. A. Karrar "*General Framework for Energy losses in the National Grid*" (Article in Arabic), El Muhandis, Vol 2, No 4 - July 1996.

(ii) A. A. Karrar, M. A. Mahmoud & A. Eldirdiri "*The Roseires-Khartoum Power transmission system Problem: Reconsideration of Conductor*

Layout Geometry and Ordering" Sudan Engineering Society Journal, Vol 45 No 36 – July 1998.

(iii) A. A. Karrar & M. A. Mahmoud "*Operational problems Related to the National grid of Sudan*" SESUKI Workshop on Energy Resources in Sudan– Middle-East Association, St James, London - 27 Feb 1998.

(iv) A. A. Karrar & K R. Daoud, "*A new method for Robust design of a decentralized PSS",* Sudan Engineering Society Journal, Vol 45 No 36 – Dec 2003.

(v) K. Ramadan, A. A. Karrar & O. A. Mansour "*Implementation of an Ungrounded System During the Rainy Season in the Oil Fields of Sudan*". Proceedings of the International Conference on Advanced Power System Protection and Control, APAP 2004, Jeiu, Korea – 25-28 Oct 2004.

(vi) A. A. Karrar & E. Z. Yahia "*Voltage Stability Evaluation in the Sudanese National Grid*" Sudan Engineering Society Journal, Vol 54 No 51 - Sept 2008.

(vii) M. S. Mannan , A. A. Karrar, "*Competitive Electricity Wholesale Market: A proposal for developing countries*", Proceedings of GCC-Cigre, GCC Power2008, Bahrain, 10-12 Nov 2008.

(viii) M. S. Mannan , A. A. Karrar, E. Hamouda "*A Proposal for Competitive Electricity Industry in Sudan: Drawing Upon International Electricity Restructuring Experiences and Trends*", Sudan Engineering Society Journal, Vol 56, No 54 -March 2010.

(ix) A. A. Abdelkarim, A. A. Karrar. "*An Accurate Approach for Demand Forecasting for the Sudanese National Grid*", Sudan Engineering Society Journal, Vol 56, No 54 - March 2010.

(x) A. A. Abdelkarim, A. A. Karrar & E. Hamouda, "*Generation Reliability Analysis for the Forecasted Scenarios of Sudan National Grid*", Sudan Engineering Society Journal, Vol 57, No 1 - March 2011.

(xi) A. A. Sharawi, E. Hamoda & A. A. Karrar "*High voltage stress and equipotential mapping Using FEM Method*", 2ème CIMGLE 2012 (Deuxième Conférence Internationale sur la Maintenance, la Gestion, la Logistique et l'Electrotechnique) - Oran – 19-21 November 2012

(xii) H. A. Omer, K. O. Mahjoub, A A. Karrar "*On the Stability of Generators Load Sharing*", Proceedings of the 19th IFAC World Congress, 2014, World Congress, Volume # 19, Part# 1 - Cape Town, 24-29 Aug 2014.

(xiii) A. A. Sharawi, E. A. Hamoda and A. A. Karrar, "*Evaluation of a Numerical Model Using COMSOL Multi-physics Package*," 2015 Fifth International Conference on e-Learning (econf), Manama, 2015, pp. 42-46. doi: 10.1109/ECONF.2015.62

(xiv) M. Kamel, H. Saeed, A. Karrar and A. Eltom G. Kobet and I. Grant, "*Effects of GIC Neutral Blocking Devices (NBDs) on Transmission Lines protection Performance and Potential for Resonance*", CIGRE US National Committee, 2015 Grid of the Future Symposium, Oct 11-13, 2015 in Chicago, Illinois USA

(xv) M. Kamel , A. Karrar, H. Saeed, M. Bowman, T. Womack, P. Cooper, & A. Eltom, "*On-site low voltage determination of zero sequence impedances for station auxiliary transformers*," 2016 IEEE Power and Energy Society

General Meeting (PESGM), Boston, MA, 2016, pp. 1-5. doi: 10.1109/PESGM.2016.7741771 (Selected as the prize paper in the Stability and Protection track – and one of the 4 prize papers overall from a total of about 1400 submitted papers).

(xvi) A. Karrar, E. Mohamed, M. Ahmed, W. Elballa, M. Kamel, M. Bowman, T. Womack, P. Cooper, & A. Eltom, "*Influence of zero sequence impedances of station auxiliary transformers on equipment performance under open-phase faults*," 2016 IEEE Power and Energy Society General Meeting (PESGM), Boston, MA, 2016, pp. 1-5.
doi: 10.1109/PESGM.2016.774201 (Presented in a Panel session in the Nuclear Power track).

(xvii) M. Kamel, H. Saeed, A. Karrar, M. Bowman & A. Eltom, "*Investigation of Open Phase Conditions in Three Leg Core Type Transformers*" Georgia Tech Protective Relaying Conference, April 20-22, 2016, Georgia Tech Hotel and Conference Center , Atlanta, Georgia, USA

(xviii) E. A. Mohamed, M. S. Zeyada, A. A. Karrar and A. H. Eltom, "*Prediction of System Frequency Excursions for Centralized Load Shedding Applications*", CIGRE US National Committee, 2016 Grid of the Future Symposium, Oct 30th-Nov 1st, Philadelphia, Pennsylvania, USA.

(xix) E. K. Mohammedsaeed and A. A. Karrar, "*Finite element method based design of a Liquid Rheostat motor starte*r," 2016 IEEE International Conference on Power Electronics, Drives and Energy Systems (PEDES), Trivandrum, India, 2016, pp. 1-6.
doi: 10.1109/PEDES.2016.7914381

(xx) M. Kamel, A. A. Karrar and A. H. Eltom, *"Development and Application of a New Voltage Stability Index for On-Line Monitoring and Shedding,"* in IEEE Transactions on Power Systems, *vol. 33, no. 2, pp. 1231-1241, March 2018*
doi: 10.1109/TPWRS.2017.2722984

(xxi) W. Elballa, A. Karrar and A. Eltom, "A Novel Optimization Formulation for the Direct Computation of the Voltage Collapse Point," *2018 IEEE Power & Energy Society General Meeting (PESGM)*, Portland, OR, USA, 2018, pp. 1-5.
doi: 10.1109/PESGM.2018.8585992

(xxii) E. Mohamed, W. Elballa, A. Karrar, G. Kobet and A. Eltom, "Fast Line Outage Detection Using PMU Measurements in Partially Observed Networks," *2018 IEEE Power & Energy Society General Meeting (PESGM)*, Portland, OR, USA, 2018, pp. 1-5.
doi: 10.1109/PESGM.2018.8586457.

(xxiii) M. Ahmed, A. Ali, S. Mohammed, A. Karrar, R. W. Hay and R. C. Johnson, "Investigation of Ferroresonance Incidents in the EPB Distribution Network," *2018 IEEE Power & Energy Society General Meeting (PESGM)*, Portland, OR, USA, 2018, pp. 1-5.
doi: 10.1109/PESGM.2018.8586202.

Technical Reports (at UTC)

(i) Ahmed H. Eltom, Abdelrahman A. Karrar, Haytham A. Saeed, Mariana M. Kamel "*Effects of GIC Neutral Blocking Devices (NBDs) on Transmission Lines Protection Performance and Potential for Resonance*" Internal report for Tennessee Valley Authority, TVA project no.742907-1 and under TVA contract no. 99998949, Sept 2015.

(ii) Ahmed H. Eltom, Abdelrahman A. Karrar, Mariana M. Kamel, Haytham A. Saeed, "*Investigation of Open Phase Conditions in Three-Leg Core-Type Transformers*" Internal report for Tennessee Valley Authority, Nuclear Power Group, Sept 2014.

(iii) Ahmed H. Eltom, Abdelrahman A. Karrar, Elamin Mohammed, Miyada Ahmed, Wafa Elballa, "Performance Of Large Auxiliary Motors In Nuclear Power Stations Under Open Phase Conditions In The Supplying Transformers" Internal report for Tennessee Valley Authority, Nuclear Power Group, April 2016.

(iv) Siddig Mohammed, Anas Ali, Miyada Ahmed, Abdelrahman Karrar "Ferroresonance Incidents in the EPB Network, Analysis Report", Internal Report for EPB, Chattanooga, Smart Grid Development, July 2017.

(v) Abdelrahman Karrar, Anas Ali , Akram Saeed "Validation of TVA's Transmission System Model for Local Oscillations and PSS Design; Final Report", Prepared for Tennessee Valley Authority, c/o Tamatha Womack, Program Manager – Offsite Power System Analysis Corporate Nuclear Design, September 2018.

Conferences Attended

(i) CIGRE US National Committee, 2015 Grid of the Future Symposium, Oct 11-13, 2015 in Chicago, Illinois USA.

(ii) 2016 IEEE Power and Energy Society General Meeting (PESGM), Jul 17-21, 2016, Boston, MA, USA.

(iii) CIGRE US National Committee, 2016 Grid of the Future Symposium, Oct 30th-Nov 1st, Philadelphia, Pennsylvania, USA.

(iv) 2018 IEEE Power and Energy Society General Meeting (PESGM), Aug 5 - 9, 2018, Portland, OR, USA.

Prizes and Awards:

(i) Mirghani Hamza prize for best performance in final year. Electrical Engineering department, University of Khartoum, 1985.

(ii) Co-authored paper "On-site Low Voltage Determination of Zero Sequence Impedances for SAT Transformers", which was selected as the prize paper in the Stability and Protection track – and one of the 4 prize papers overall from a total of 801 accepted papers; at the 2016 IEEE Power & Energy Society General Meeting, July 17-21, 2016, Boston MA, USA

(iii) Also received the Prize Paper Award for the same paper above from the Nuclear Power Engineering Committee, New Orleans, Feb 8th, 2017

Invited Speaker:

(i) Invited speaker at the 2016 SSCET & JSU Engineering Forum; topic "*Novel low-cost methods for transformer zero-sequence determination"*, Aug 26th, 2016 Hilton Garden Inn - Jackson, Mississippi.

(ii) Invited speaker at the IEEE/PES Nuclear Power Engineering Committee (NPEC) Meeting; topic *"On-site Low Voltage Determination of Zero Sequence Impedances for Station Auxiliary Transformers"*, February 8th, 2017 DoubleTree Hotel, New Orleans, Louisiana.

(iii) Invited Speaker at Sustainable Energies 2018; topic: "*Voltage Stability Indicators. Where are we?*", Orlando, USA, to take place on March 30-31, 2018, Orlando, USA.

(iv) Invited speaker at the 2016 SSCET & JSU Engineering Forum; topic "*Recent advances in calculation of the Voltage Collapse Point*", Aug 3, 2018, Charger Union & Shelby Center for Science and Technology, University of Alabama in Huntsville, Huntsville, Alabama.

Peer Review:

(i) Reviewer for IEEE Transactions on Power Systems; 4 Letters.
(ii) Reviewer IEEE Power & Energy society General Meetings (2018-2019).
(iii) Reviewer for IEEE IAS Annual Meetings,
(iv) Reviewer for a number of other conferences and publications

(v) Wrote editorial review for Load Flow Optimization and Optimal Power Flow 1st Edition, J. C. Das. CRC Press, 2017. ISBN 9781498745444.

Sponsored Research and External Funding:

(i) Supervised research supported by $50,000 Tennessee Valley Authority for "Open Phase research", 2015-16. Research advisor
(ii) Supervised research supported by $50,000 Tennessee Valley Authority for "Open Phase research", 2016-17. Research Advisor.
(iii) Continue to supervise research supported by the $50,000 Tennessee Valley Authority for "Modeling Loading effect of Motors and generators for voltage and frequency", 2017 – Date. Research Advisor
(iv) TVA research Grant "Validation of Transmission System Model for Local Oscillations and PSS Design", Funding Amount: $24,500 , Funding Agency: TVA, Role: PI.

Research Supervision

Supervised and co-supervised four Ph.D research Students on the following topics

1. Comprehensive overview of the National Grid of Sudan Stability degree awarded to Kamal Ramdan, 2004.
2. A Comparative study of Voltage Stability Evaluation for the National Grid, degree awarded to Elfadil Zakaria, 2010.
3. A Proposal for Competitive Electricity Industry in Sudan, degree awarded to Mohammed Sid-Ahmed, 2010
4. Least Cost Utility Planning for the National Grid, degree awarded to Abdelrahman Adam, 2011
5. High voltage stress and equipotential mapping, degree awarded to Adil Abd Elwahab Sharawi, 2013.

Supervised in excess of 30 M.Sc students on various topics related to electrical Power Systems.

Technical Skills

- Expert in computer aided analysis of power systems: PSS/E, ETAP, EMTP...etc. Developed software for Loadflow, Short Circuit, Transient and Dynamic Stability Analysis which was used by the National Electricity Corporation of Sudan from 2003- 2010.
- Expert in using MATLAB for a variety of applications in power systems and control.

- Expert in Automation equipment: Familiar with PLCs (Siemens in particular) and Human Machine Interface software (WinCC, Intouch.. etc); OPC servers and Various SCADA interfaces, protocols and equipment. Experience in handling microcontroller circuits (PICs and ATMEL series).

Memberships & Affiliations

- Senior Member of the Institute for Electrical & Electronics Engineering (IEEE) **2017 – Date**.
- Member of the Institute for Electrical & Electronics Engineering (IEEE) **1998 – 2017**.
- Member of the IEEE Power & Energy Society, **2000 – Date**.
- Member of the Board of Directors for the Sudanese Transmission Company. (SETCO) **Feb 2011 to July 2014**.