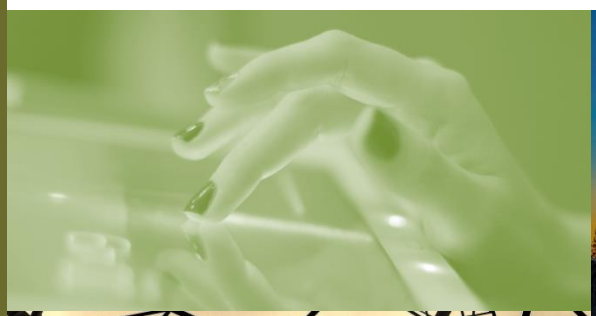
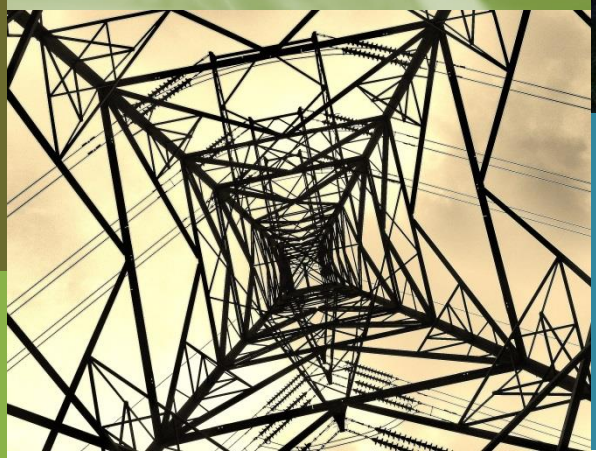
POWER SYSTEM DYNAMICS





Electrical Engineering Solutions

PSD

Consultancy Services for Electrical Engineering

PSD Consulting Engineering (Pty) Ltd.
P.O. Box 2215
Rivonia
2128
South Africa

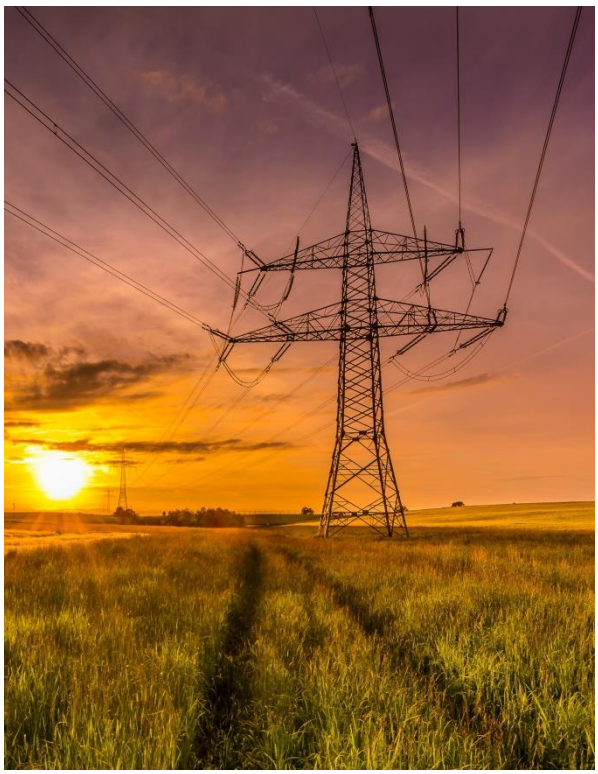
Tel +27(0) 11 807 1598
Fax +27(0) 11 807 0462
Mobile +27(0) 83 655 4430

Sep@PowerSystemDynamics.com

Table of Contents

1.0 Introduction

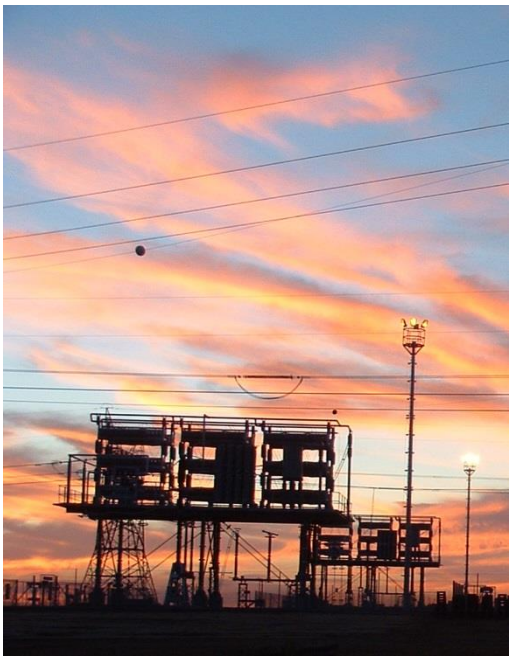
PSD was founded in 2001 to offer a range of consulting services based on planning, engineering, project management, construction, commissioning and maintenance of electrical facilities. PSD provides specialist electrical engineering services for High Voltage Direct Current (HVDC), series capacitors, dynamic reactive power compensation (SVC and STATCOM), shunt reactive compensation and harmonic filters for transmission and distribution networks. The range of services provided includes techno-economic feasibility studies, investigations, conceptual studies, power system studies, engineering studies, preparation of technical specifications, procurement support and bid evaluation and technical support during project execution including design reviews, witnessing of factory tests and witnessing of site acceptance tests an commissioning tests. Their consultants have specialised knowledge in their respective fields and they have, collectively, many years experience in the electricity supply industry, with considerable experience in Africa and the Middle East.



PSD offers a wealth of international and regional project experience in transmission and distribution systems and have put together a strong team of proposed international consultants. Details of our relevant experience are listed in section three.. Brief pen portraits are provided in section four. Given our background and expertise, we are confident of our ability to work with our clients and contribute to the success of the energy sector in Southern Africa.

2.0 Background & Organisation

2.1 PSD Consulting Engineering (Pty) Ltd



PSD of South Africa was founded in 2001 to offer a range specialist electrical engineering services for power systems.
PSD's main areas of expertise are transmission planning and development, power system analysis and design studies and investigations, generation integration, electrification, substations, lines, Static VAr Compensators (SVC's), AC and DC systems, reactive power compensation systems including shunt and series capacitor installations, and general power equipment. PSD has been engaged and doing work on sub transmission and transmission systems worldwide, at voltages from 380V up to 765kV.

The services provided by PSD are comprehensive, ranging from conceptual plans, feasibility studies, preliminary costing, budgeting, design and tender specifications, implementation and commissioning. It also covers the complete integration of primary and secondary plant.

2.1.1 Planning, Operations and Technical

PSD compiles master plans for the development of transmission and distribution networks. The aim is to balance expected electricity usage, capital investments, quality of supply, services levels, demand-side management, network optimization and economic returns in designing power systems. Our capabilities include:

- Planning studies and investigations, including generation of alternative solutions and basic conceptual design
- Power system analysis studies
- Load flow and short-circuit analysis
- Transient (machine) and dynamic stability studies
- Small signal stability analysis
- Technical evaluation
- Alternative selection (based on technical and economic evaluations)
- System operating studies and evaluation
- System reliability studies.

2.1.2 Economic and Financial

- Cost estimating
- Life –cycle cost analysis
- Economic evaluation studies
- Tariff analysis and electricity pricing studies.

2.1.3 System Design, Technical Specifications, and Engineering Support

PSD performs engineering design work for HVDC, series capacitors, dynamic and static shunt compensation and transmission and distribution lines and substations. Our engineers have, collectively, many years of experience in the transmission engineering environment and we are adept at performing engineering design studies and investigations, including

- Electromagnetic transient simulations
- Insulation coordination, including device switching and energisation studies
- Harmonic and other power quality studies and investigations
- Equipment rating
- Development of technical specifications and evaluation of bids.
- Engineering support during project implementation phase including design reviews, witnessing of factory tests, witnessing of site acceptance tests and commissioning tests.
- Witnessing of RTDS testing of control and protection systems for HVDC and FACTS devices

PSD, together with its associates, can design, supply, deliver, construct and commission substations and transmission lines up to 400 kV.

2.1.4 Commissioning of Primary and Secondary Plant

Our services include the commissioning of electrical installations, including:

- Indoor and outdoor substations (6,6 kV to 765 kV)
- Cable and transmission line distribution networks (6,6 kV to 132 kV)
- Electrical supply installations for large developments
- Protection control, metering and DC supplies relating to power systems

2.1.5 Power Reticulation

PSD and its associated companies have implemented supply technologies at low voltage, ranging from underground cabling to overhead topologies. Insulated aerial bundle conductor systems as well as open-wire designs have been used. They have integrated low voltage systems supplied from both mini-substations and pole-mounted transformer equipment.

PSD and its associated companies have worked on numerous projects ranging from small rural systems of 0,3 kVA after diversity maximum demand (ADMD) per user to urban networks in excess of 6,0 kVA ADMD per user. They have done small towns of less than 100 dwellings to large towns of more than 20 000 dwellings. In addition to residential settlements, they have reticulated industrial parks, large office complexes and commercial centres.

2.1.6 Energy Management

PSD and its associated companies/principals are experienced in integrated electricity planning, power system economics, tariff design, loss management and energy accounting. We always seek an optimal combination of

actions, risk and investment that will satisfy the customer's electricity needs, provide optimal electricity value and be financially viable to the utility.

2.1.7 Project Management

PSD and its associated companies principals are experienced project managers and they applied for registration as Professional Construction Project Managers. The have managed contracts using FIDIC, NEC and JBCC contract documents and have a sound knowledge and understanding of the OHS Act (including the construction regulations) and construction law.

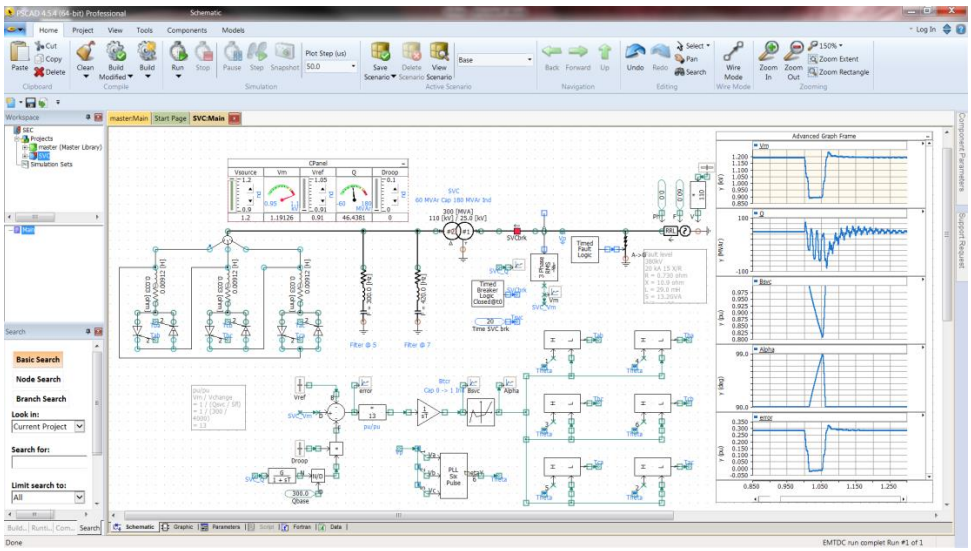
2.1.8 Employees

PSD is based on principles of high quality, professional service. The team of consultants has specialised knowledge in their respective fields and they have, collectively, many years experience in the electricity supply industry, both domestic and international. A large portion of the consultants have, in the past, been employed by an major utility; this gives us a unique understanding of the technical, commercial and business activities that pertain to utilities.

2.1.9 Facilities

PSD has a completely equipped office with general office support staff and modern facilities, including computers, printers and plotter, fax, copying facilities, internet, and telephone facilities. PSD operates a documentation system designed to comply with ISO 9000. PSD has access to most of the commercially available computer software as well as "in-house" developed software. In addition to Micro-Station, AutoCAD, MS-Projects, various graphics packages and the MS Office suite for general use, PSD or their staffs has been involved in the use of computer software for power system design and analysis work for more than ten years. During this period use has been made of 'proprietary' and also 'in-house' software. PSD has extensive experience in the use of the following power system analysis software:

- PSS/E & PSS/U power system simulation software developed by PTI (Power Technology Incorporated
- Power Factory network analysis software developed by DigSilent
- PSCAD/EMTDC Power Systems Simulation software developed by the HVDC Research Centre, Winnipeg, Canada.



3.0 Meet the Team

Presented below are pen portraits of our employees . Our senior personnel are recognised as experts in their professional fields. With PSD's expertise and experience, we are confident of our ability to work successfully with the Client to find and deploy the best solution for any project.

3.1 Septimus Boshoff

Managing Director/CEO - PSD Consulting Engineering
MEng cum laude (Electrical and Electronic), BEng, Pr.Eng

Septimus Boshoff has 30 years of professional experience, working on projects in South Africa, Mozambique, Namibia, Tanzania, Saudi Arabia, Kenya, Sweden, Germany, Iceland, Brazil, UAE (Dubai), Pakistan, Uganda, Finland and Canada. He has provided consulting services for analysis, design, specification and project engineering of power quality equipment, power electronic systems and reactive power compensation systems, including FACTS devices (SVC's, STATCOM) in the high voltage power transmission industry, as well as power quality matters. Septimus was a team member of IEEE in the development of the initial IEEE 1031 SVC specification. He is currently a member of IEEE WG on STATCOM specification, as well as IEEE WG on SVC protection specification.

Septimus has experience in bilateral power supply agreements between utilities (international) as well as between utilities and end users with specific reference to all technical matters including power quality and Grid Codes. He is experienced in Reliability, Availability and Maintenance (RAM) as well as re-engineering and maintenance of FACTS devices in the high voltage power transmission industry. Sep is skilled in engineering simulation and analysis of power system problems, including harmonic impact analysis and assessment high voltage power systems. Septimus brings strong team leadership and project management skills, which encompass technical, contract management and consulting services. Relevant projects he has undertaken include numerous SVC projects, STATCOM projects, series compensation projects and system studies.

3.2 Chris van Dyk

Specialist Electrical Engineer
BEng (Electrical)

Chris is a Specialist Electrical Engineer, co-founder and director of PSD, with over 18 years network studies experience. He has expertise in the SVC design, shunt, series and neutral reactive power compensation systems; Conducting harmonic and transient studies related to transmission line and substation equipment; Modelling FACTS device control systems using PSCAD/EMTDC and verification using RTDS; and presenting PSCAD training. Recent projects Chris has worked on include:

- Mozambique: Consultant to EDM for STATCOM design,
- Saudi Arabia: Consultant to SEC on Series compensation studies and projects
- Saudi Arabia: Consultant to SEC on Large SVC projects for load stability
- South Africa: Engineering consultant to Eskom for the development of a SVC specification for 2x350MVAr at 400 kV for the Coega smelter project
- GMPC network, Eskom - ZESA – HCB interconnection, South Africa, Zambia, Mozambique
- Namibia: HVDC VSC feasibility for NamPower
- Namibia: Auas SVC model, NamPower Transmission network
- South Africa: Cape network 400 kV series capacitor upgrade, Beta to Koeberg 400 kV backbone, for Eskom

3.3 Reinette van der Merwe

Pr. Electrical Engineer
BEng (Electrical & Electronic), Pr. Eng.

Reinette van der Merwe is an Electrical Engineer registered as a professional Engineer with the Engineering Council of South Africa. She has six years of experience as an engineer and is an active member of the South African Institute for Electrical Engineers. Reinette has been involved in turnkey projects in the High Voltage Transmission industry as well as the Industrial Sector and has been responsible for the design of electrical systems, preparing technical documentation, adjudicating tenders, inspecting equipment and supervision of commissioning activities and factory and site acceptance tests. Recent projects include:

- EdM STATCOM project; Specification of equipment and compiling equipment data sheets of the 150MVAr STATCOM that will be connected to the 220kV busbar at the Chimuara substation in Mozambique.

- DEWA SVC project consists of coordinating with protection specialists on the specification for 2x400MVAr SVCs to be installed at CARX and NADHA substations in Dubai.

- Aries SVC project; Project engineering and coordination and specification of equipment and compiling equipment data sheets and drawings of the 400 MVAr SVC that will be installed at ESKOM's Aries Substation in the Northern Cape, South Africa

- STE transmission network, Project coordination and specification of Fixed Series Capacitors (FSC) and SVC system, compiling equipment data sheets and drawings for the FSCs and SVCs to be installed at Inchope, Lupata and Vilanculos Substations in Mozambique.

4.0 PSD's Experience

PSD has provided expertise for projects in South Africa, Saudi Arabia, Pakistan, USA, Mozambique, Zambia, UAE, Oman, Botswana, Uganda, Tanzania, Namibia, Kenya, Philippines and Democratic Republic of Congo. Selected projects are detailed below:

PSD Selected Technical Experience		
Date	**Client**	**Project**
2018	**Lake Turkana Wind Power, KPLC and KETRACO**	**Lake Turkana Wind Power Task Force** PSD, in their capacity of STATCOM specialist consultants, has been appointed by LTWP to provide technical support and join forces with KPLC and KETRACO to mitigate various operational issues of Lake Turkana Windfarm Project (LTWP) and its interface to the overall Kenyan grid. PSD provides engineering consultancy services on 4 of the 5 task force groups, including *Training, System Studies, Protection, Operations and Dispatch* as well as *Commercial Commissioning*.
2018	**Connect, St Helena, South Atlantic Ocean**	**St Helena power quality measurements and study** As part of their power quality monitoring program CONNECT appointed PSD to measure the power quality of the electricity supply on St. Helena island. This included the installation of 11 power quality measurement instruments and analysis of the results. Concerns had to be identified and solutions recommended.
2018	**Botswana Power Company (Sub-Consultant to Norconsult)**	**Maun Substation Reactive Power Compensation** PSD was responsible for Power System studies to determine the level of reactive power compensation required at Maun 132/11 kV Substation. PSD also undertook Harmonic Measurements, verification of loading parameters of the PSS/e software model and designed an optimized network reactive power compensation solution. Further services provided included preparation of tender documents for the design, supply, installation, testing and commissioning of the reactive power compensation equipment, witnessing of factory and site acceptance tests and engineering support during the warranty period
2017	**OETC (sub consultant to Tractebel) Muscat, Oman**	Engineering Consultancy Services Static Var Compensators (SVC's) Consultancy Service for Reactive Power Compensation Strategy: PSD is responsible for the SVC/STATCOM specification, and SVC Control modifications. Review of International Criteria, Study Methodology and Assumptions, Steady State Assessment, Load Modelling, Dynamic Reactive Power Assessment
2016	**Ministry of Energy and Water**	**Complementary Study on Power Trade Volumes, Wheeling Arrangements and Impact on the Interconnected Networks for the**

PSD Selected Technical Experience		
Date	**Client**	**Project**
	development Zambia	**Zambia-Tanzania-Kenya (ZTK) Interconnector Project** PSD performed the technical feasibility studies relating to the interconnection of EHV transmission grids of Zambia, Tanzania and Kenya. The studies included small signal stability studies, transient fault analysis, load flow studies and dynamic stability studies for the interconnection of the Southern African Power Pool (SAPP) and the East African Power Pool (EAPP). PSD also offered best practice solutions to load flow and stability constraints that were encountered during the study.
2015	**Sterling Wilson, South Africa**	**90 MW Solar Plant in De Aar, Northern Cape** Third Party Inspection of electrical equipment during the manufacturing process in order to verify that the equipment complies with International and local standards. Services included: • Reviewing of equipment technical parameters • Reviewing of manufacturer's inspection and test plans/procedures • Witnessing of routine testing • Witnessing of type testing • Inspection of overall workmanship The equipment which were inspected and evaluated included MV Cables, 22 kV Station Transformers, Inverter Stations, String Combiner Boxes and Module Mounting Structures.
2015	**Juwi Renewable Energies, South Africa**	**Swartland Solar Park** PSD developed a PSCAD Model suitable for EMT Simulations for the Swartland Photovoltaic Plant with a 5 MW generation capacity.
2015	**SEC, Saudi Arabia**	**Dynamic Reactive Compensation projects** Detailed design reviews and project execution support for SVC's, STATCOM 's and Hybrids, including tender preparation, bid adjudication - phased over several years. Detailed network models are developed to calculate the harmonic impedance and perform EMT studies.
2014 - ongoing	**Hidroelectrica Cahora Bassa, Mozambique** **(Sub-Consultant to WSP|Parsons Brinckerhoff)**	**Songo HVDC converter station upgrade, Cahora Bassa HVDC scheme, Mozambique** Engineering consulting services for ongoing support to client for definition, specification and implementation of projects to improve the reliability and technical performance of existing HVDC station in the short to medium term. Phase 1 included replacement of 3 x single phase converter transformers, DC smoothing reactors, DC surge arresters and DC optical CT's. Phase 2 includes the refurbishment of converter transformers, replacement of a back-up diesel generator,

PSD Selected Technical Experience		
Date	**Client**	**Project**
		purchase of a spare converter transformer, replacement of 220kV ac surge arresters and replacement of critical components on the valves and valve base electronics. Preparation of technical specifications for a major upgrade to Songo converter station to improve reliability and technical performance in the long term. The scope of the project includes replacement of HVDC control and protections systems, converter valves, valve cooling, ac filters, dc filters, ac and dc equipment, ac and dc auxiliary systems and the installation of a 220kV transfer busbar. It also includes the replacement of the Grid Master Power Controller with a Grid Power and Frequency Controller.
2017	**Transco (sub consultant to Tractebel) Abu Dhabi, UAE**	Engineering Consultancy Services Static Var Compensators (SVC's) Consultancy Service for Reactive Power Compensation Strategy: PSD is responsible for the SVC/STATCOM specification, and SVC Control modifications. Review of International Criteria, Study Methodology and Assumptions, Steady State Assessment, Load Modelling, Dynamic Reactive Power Assessment Install 50MVAR capacitor banks at AASW 220 kV SS, Install new POD at AASW 220 kV SVC, Modify the existing SVC POD at Musaffah 400/220 kV SS from the 220 kV side to the 400 kV side Refurbish the existing SVC cooling system for AASW and Musaffah SVCs.
2014	**ALDWYCH TURKANA LIMITED, Kenya**	**Lake Turkana Wind Power (Jointly with DNVGL)** Consulting Services during the design and construction phase of the DRPC (STATCOM) project – 3 x +/-100MVAr STATCOM s. Scope of services includes STATCOM design review – primary plant component design, control and protection system, valve and cooling design, layout etc – and witness of factory tests, site supervision and commissioning. Cold commissioning of STATCOM has been completed, however project delayed due to TX line construction (not part of RXPE scope).
2014	**NamPower Namibia**	**TECHNICAL CONSULTANT FOR THE ADDITION OF 20MVAR CAPACITIVE REACTIVE POWER AT KHAN SUBSTAION** The scope of work includes: Harmonic measurements, Harmonic integration studies, Electromagnetic Transient switching studies, Electrical parameter optimisation, Functional Specification of the full project to add 20MVAr capacitive reactive power at Khan Substation, and contractor design reviews, including supervision during

PSD Selected Technical Experience		
Date	**Client**	**Project**
		commissioning and protection settings.
2013	**EdM (Subconsultant to Norconsult), Mozambique**	**EdM's Chimuara and Namialo DRPC's (SVC/STATCOM)** System studies, harmonic measurements, harmonic apportioning and Specification writing for the 250MVAR, 220kV SVC / STATCOM at Chimuara and Namialo 220kV substation. Assistance during the project execution phases, including design reviews, Factory witnessing and final commissioning /performance verification testing
2014	**Lesotho Electricity Company (sub consultant to Hifab), Lesotho**	**Feasibility Study (FS) for the 132 kV transmission line Mohale's hoek-Mphaki** Undertake feasibility study on possibility of Linking Isolated network of Qacha's Nek with LEC transmission grid through 132 KV line from Mohale's hoek substation to Mphaki. Perform detailed system studies and stability analysis (load flow analysis, fault level analysis) for LEC transmission grid with proposed line for different scenarios.
2013	**ESKOM South Africa**	**Aries 400kV SVC** System studies, harmonic measurements, harmonic apportioning and Specification writing for the 350MVAR, 400kV SVC / STATCOM at Aries 400kV substation.
2012- on going	**NTDC Pakistan (together with NESPAK and PPI)**	**NTDC Kotlakpat SVC** Consulting Services during the design and construction phase of the SVC project. Scope of services includes SVC design review – primary plan component design, control and protection system, valve and cooling design, layout etc – and witness of factory tests and commissioning.
2012	**STE (sub consultant to Norconsult), Mozambique**	**Mozambique Regional Transmission Development Project Integrated Transmission Backbone System - STE** Scope of services include EMT studies (with PSCAD) for the 400kV system comprising of +/- 1400km AC transmission line, multiple substations, SVC's, series capacitors and line and busbar reactors.
2011 – 2016	**EdM (sub consultant to Hifab), Mozambique**	**Nampula STATCOM project Cabo Delgado** Specification review and assistance in tender preparation, bid adjudication, design review of a SVC/STATCOM at Nampula Substation, Assistance during the project execution phases, including design reviews, Factory witnessing and final commissioning /performance verification testing
2011 - 2012	**Isolux, Brazil**	**SVC Assistance - Amazon Project** Specification review and assistance in tender preparation, , design review of a SVC's and RTDS testing at OEM works of SVC control

PSD Selected Technical Experience		
Date	**Client**	**Project**
		systems
2011	**Landsnet, Iceland**	**Klafastadir SVC tender review and project design review support:** Assist Landsnet on the tender review and adjudication of the Klafastadir SVC. Assistance to Landsnet during the project execution phases on design reviews, etc.
2010	**SEC, Saudi Arabia**	**Safaniyah and other Dynamic Reactive Compensation projects** Detailed system studies and specification up and including contract award for 15 SVC's including shunt capacitor banks, including tender preparation, bid adjudication - phased over several years. The project included Harmonic measurements at each of the sites.
2010 – 2015	**DEWA, Dubai, UAE**	**CARX & NADHA 400kV SVC Projects** Engineering Consultancy Services for 2 Nos. Static Var Compensators (SVC's) at NHDA & Carx 400 kV Buses and Associated Modification Works. PSD is a sub consultant together with Kema to Energo. Inclusive of harmonic measurements. PSD is responsible for the SVC specification and technical tender evaluation, and during the contract execution phase responsible for design reviews, technical review of the SVC design, factory witnessing of key components, such as the thyristor valves, control and protection including RTDS testing, and finally site services during final commissioning and performance verification.
2012	**CALEDONWIND, South Africa**	**CALEDONWIND 138MW Wind Farm Development** Grid impact studies for the 400kV connection of a 138MW wind farm facility to be located close to the town of Caledon in the Southern Cape, South Africa
2012 – 2013	**EdM (sub consultant to Hifab) Mozambique**	**Grid study; EdM Northern network** Desktop system study for reactive power system support to the EdM northern grid.
2011	**Al-Jazirah Engineers & Consultants (AJEC), Saudi Arabia**	**Voltage Regulation Study for SWCC Shaqaiq-2 Water Pumping Scheme** Study to determine optimal shunt capacitor size and location for 132kV voltage support to accommodate motor starting for the water pumping scheme. The study included the optimal configuration for harmonic integration.

PSD Selected Technical Experience		
Date	**Client**	**Project**
2011	**Ilanga, South Africa**	**Renewable project grid integration for a 125MW solar geothermal plant:** Grid integration and Grid Code compliance studies to connect CSP plants to the Eskom grid.
2011- 2012	**Mainstream, South Africa**	**Renewable project grid integration studies for a 50MW PV and a 138MW windfarm.** Grid integration and Grid Code compliance studies to connect PV and Wind Generation plants to the Eskom grid.
2011	**JUWI, South Africa**	**Preparation of Connection Cost Estimates** Responsible for the preparation of cost estimates for the connection of a 20MW PV plant, to be located near the town of Lephalale in South Africa, to the Eskom grid.
2011	**EdM (PSD sub consultant to Vattenfall), Mozambique**	**Mozambique Regional Transmission Development Project** Integrated Transmission Backbone System, "CESUL Transmission Project", Consulting Services For Technical and Economic Feasibility Study for CESUL Transmission Project HVDC as 400kV HVAC : insulation co-ordination studies, harmonic studies, SSR screening studies, reactive compensation (series and fixed) SVC's and FSC's.
2011- 2012	**UETCL, (sub consultant to Hifab), Uganda**	**Reactive power system studies and specifications for reactive power systems and project technical support** Conducted a system studies to determine reactive power compensation requirements for the Uganda Transmission grid up to the year 2018. The assignment included the development of technical specifications for the proposed reactive compensation projects.
2011	**Eskom, South Africa**	**ZESA Power transfer capability study** Steady state Analysis of the North to South power transfer capability of the ZESA transmission grid.
2011	**ABB, Saudi Arabia**	**Insulation co-ordination study for Raz Al-Khair Aluminium smelter** Perform insulation co-ordination, inrush current and short circuit current study for 380kV, 220kV and 34.5kV equipment at the 1.35GW Raz Al-Khair aluminium smelter in Saudi Arabia.
2011	**Eskom, South Africa**	**NER study for Ferrum Mookodi transmission system**
2011	**Eskom,**	**NER study for Medupe transmission system**

PSD Selected Technical Experience		
Date	**Client**	**Project**
	South Africa	
November 2010 – March / April 2006	**Xstrata Mining Company, South Africa**	**Xstrata Project Lion** **Mpumalanga, South Africa** PSD was commissioned by Xstrata, a large mining company, to do the Engineering, Design, Implementation and Commissioning of an expansion to an existing 275/33 kV, (2X) 180MVA Substation for their ferrochrome smelter project near Steelpoort, South Africa. The scope of work included: • Power factor correction design and specification. • The installation of all LV and HV plant, which will include the installation of a 180 MVA 275/33 kV transformer, the equipping of the four 33 kV feeder bays • The installation of all LV equipment (protection, metering, DC and telecomms) in the control building • All conductoring and cabling associated with the above equipment. (HV,LV and Control) • The installation of the yard earth mat and the bonding of all equipment earth tails with the earth mat • The stoning and fencing of the yard. The services provided include: • Power System Studies and Analysis • Substation Engineering and Design • Testing and Commissioning supervision
2010	**NTDC, Pakistan**	**PSCAD training** Training on PSCAD software and modeling
2010 – 2011	**ERC, Philippines**	Review of the Expenditure Forecasts of the National Grid Corporation of the Philippines for the Third Regulatory Period (2011 – 2015) Under Performance Based Regulation
2009 – 2010	**Tenke Fungurume Mining Company, DRC**	A Technical Study of the Voltage Stability of the Tenke Fungurume Mining/D.R.C. Southern Katanga 220 kV 50 Hz System (STATCOM project), Inclusive of harmonic measurements.
2009 – 2012	**Kema, Kenya**	Dynamic Reactive Power Compensation (3xSTATCOM with shunt capacitors and reactors) for the Lake Turkana Windfarm project in Kenya. Perform dynamic EMT studies and prepare a detailed specification. Assist with technical tender preparation, bid adjudication up to final contract award.

PSD Selected Technical Experience		
Date	**Client**	**Project**
2009	**HVT/CEC, Zambia**	**Shunt capacitor design study** Capacitor bank studies for the Zambian utility throughout their network. Inclusive of harmonic measurements.
2009 – 2011	**NTDC, Pakistan (together with NESPAK and PPI)**	**SVC harmonic study and measurements** Harmonic impedance studies and measurements for SVC projects in Pakistan.
2009 - 2011	**SEC, Saudi Arabia**	**Central Western Fixed Series compensation project** Detailed system studies and specification up and including contract award for two Fixed Series Compensation banks, including tender preparation, bid adjudication.
2009	**CTC/ Norconsult, Zimbabwe**	**SVC study** Detailed SVC specification studies and specification up and including contract award for a SVC at Dema Substation (Zimbabwe), including tender preparation, bid adjudication up to final commissioning verification
2009 - 2011	**Eskom Distribution (jointly with Aurecon), South Africa**	**Eskom Distribution masterplans** Network master planning for Eskom Distribution.
2009 - 2010	**Quanta Technology, USA**	**PSCAD model development** SVC model development and verification in PSCAD.
2009 - ongoing	**TransAfrica Projects, South Africa**	**SVC Technology training** Training course on SVC technology and systems
2009 - 2011	**Vaal Pipeline Consultants (VRESAP TCTA), South Africa**	**VSD failure investigation** Failure investigation into VSD drive (4 x 6.6MW) failures, including harmonic measurements, modelling and simulations.
2008 - 2010	**EdM,**	Technical and Economic Feasibility Study for Mozambican Integrated Transmission Backbone System

PSD Selected Technical Experience		
Date	**Client**	**Project**
	(NorConsult)	
2008	**Motraco/TGC, Mozambique**	**FSC failure investigation** Failure investigation into Fixed Series Compensation failure on the Motraco Baberton FSC 400kV bank.
2008 - 2011	**NamPower, Namibia**	**Shunt capacitor bank integration and detailed studies** Detailed capacitor tuning and rating studies, including insulation co-ordination studies for transmission shunt capacitor banks at Omburu substation and Otjikoto substation. Assistance during project execution up to final commissioning. Inclusive of harmonic measurements.
June 2007 -	**EdM, Mozambique (sub consultant to Hifab)**	**Nampula SVC project. Cabo Delgado** Detailed system studies and specification up and including commissioning and performance verification of a SVC at Nampula Substation, including tender preparation, bid adjudication, design review.
September 2007	**Suez, Mozambique**	**Generation integration and network planning and substation design** Detailed system studies and network integration studies, cost estimates for the integration of the Suez 100MW gas power station in Mozambique.
2007	**Eskom, South Africa**	**Transmission Nuclear power station integration studies:** Feasibility studies regarding insulation co-ordination and integration of nuclear power stations into the Eskom Transmission Grid.
2007	**HVT, South Africa**	**Shunt capacitor neutral surge arrester rating study** **Athene 400 kV, 100MVAr** **Esselin 275kV, 150MVAr** The manufacturer installed a surge arrester in parallel to the inrush reactor of a shunt capacitor bank to reduce the BIL rating of the reactor. The study determined that the energy rating of the arrester during switching and lightning surges.
2008	**Eskom, South Africa**	**Transmission 765kV Series Capacitor banks EMT studies:** Detailed EMT studies on six (6) 765kV series capacitor banks, including TRV studies (Alpha – Beta and Zeus/Mercury/Perseus)

PSD Selected Technical Experience		
Date	**Client**	**Project**
2008	**Black Rock Mountain, South Africa**	**Generation integration studies:** Detailed grid code compliance studies for 14MW standby power station at mine.
2008	**Eskom, South Africa**	**Transmission 400kV Series Capacitor banks EMT studies:** Detailed EMT studies on three (3) 400kV series capacitor banks, including TRV studies.(Iziko and Serumela)
2008 - 2012	**SEC, Saudi Arabia**	**Central Area Static Var Compensation project** Detailed system studies and specification up and including commissioning and performance verification for four (4) 660MVAR SVC's, including tender preparation, bid adjudication, design review. Various shunt capacitor banks is also part of the scope of work: harmonic investigations, filter design and specifications.
2008	**TiepCo Saudi Arabia**	**Dammam Static Var Compensation project** Detailed system studies and specification up and including commissioning and performance verification for a 200MVAR SVC's, including tender preparation, bid adjudication, design review.
2006 - 2008	**Electricidade de Moçambique (EdM)** **Jointly undertaken with Maunsell**	Maunsell Ltd (New Zealand) in association with PSD Consulting Engineering (Pty) Ltd. (South Africa) developed a Low Cost Rural Electrification Plan (LCREP) to assist the Government of Mozambique (GOM) in fulfilling their vision of 20% of the nation's population having access to electricity by 2020. This project was funded by the Danish Ministry of Foreign Affairs (Danida). Services to Client: • Site supervisor and project management • Compilation of master plans for the development of electrical networks in rural areas • Preparation of equipment specifications, standards and drawings • Preparation of rural electrification packages for presentation to donor and funding institutions • Participation in donor conference Project Detail • The project assignment included: • Establishment of site office in Maputo, Mozambique • Provision of site supervision and project management services, and project facilities

PSD Selected Technical Experience		
Date	**Client**	**Project**
		• Extensive data collection, processing and electronic capturing • Development of rural electrification ranking criteria • Identifying, defining and quantifying of potential rural electrification projects • Mapping of existing power lines and production of network single-line drawings • Power system studies and analysis including system modelling, power transfer, fault level and losses • Cost estimating • Compilation of rural electrification master plan • Preparation of equipment specifications, standards, drawings, and guidelines • Preparation of rural electrification packages for presentation to donor and funding institutions • PSD participated in an international donor conference that were held in Maputo (Feb. 2008)
2007	**Eskom, South Africa**	**Transmission Shunt capacitor bank for Coega network development including SVC specification and related studies on SVC rating and :** Detailed rating and tuning studies for the shunt capacitor bank and SVC's on 400kV
2007	**Eskom Distribution; jointly with Thabile Engineering South Africa**	**Distribution Network MP** Network master planning for Eskom Distribution
2006	**TransPower New Zealand - Maunsell/AECOM,**	**Vector disaster recovery plan** Network studies and investigations, and the compilation of Vector substation disaster recovery plan (Auckland and Wellington Regions).
2006	**SEC, Saudi Arabia**	**Sakaka shunt capacitor banks** Harmonic integration study for the shunt capacitor banks at Sakaka A & B. Inclusive of harmonic measurements.
2006	**SEC, Saudi Arabia**	**Qurayyah surge arrester study** Investigate energy rating and location of 380kV surge arresters for the GIS at Qurayyah.

PSD Selected Technical Experience		
Date	**Client**	**Project**
2006	**Eskom, South Africa**	**Shunt capacitor bank insulation co-ordination study** **Hydra 400kV, 100MVAr** **Perseus 400kV, 100MVAr** The manufacturer installed a surge arrester in parallel to the inrush reactor of a shunt capacitor bank to reduce the BIL rating of the reactor. The study verified that the energy rating of the arrester is sufficient during switching and lightning surges.
2006	**Eskom, South Africa**	**Transmission Shunt capacitor bank:** **Esselen Capacitor Bank** **Athene Capacitor Bank** **Mersey Capacitor Bank** Detailed rating and tuning studies for the shunt capacitor bank
2006	**Eskom, South Africa**	**AEG SVC external device switching controller** Replace the external device switching controller with a digital PLC and include the two new shunt capacitor banks in the switching logic. The project included both hardware and software development, installation and commissioning.
January 2006 – ongoing up to 2008	**Eskom**	**AEG SVC Control and protection upgrade project** Engineering support, specifications and project management support for the SVC Control, Protection, Thyristor Valve and Cooling replacement of 5 x 400kV SVC's with a 500 MVAr dynamic range each.
2005	**SEC, Saudi Arabia**	**Western Area Static Var Compensation project** Detailed system studies and specification up and including commissioning and performance verification for three (3) 660MVAR SVC's, including tender preparation, bid adjudication, design review, RTDS testing of the SVC Control system. Inclusive of harmonic measurements.
2005	**SEC, Saudi Arabia**	**Shunt capacitor bank integration and detailed studies** Detailed capacitor tuning and rating studies, including insulation co-ordination studies for transmission shunt capacitor banks. Inclusive of harmonic measurements.
2007	**CEC, Zambia**	**Protection co-ordination study, system adequacy** Pilot study

PSD Selected Technical Experience		
Date	**Client**	**Project**
2004	**SEC, Saudi Arabia**	**Shunt reactor studies** Detailed reactor studies, including insulation co-ordination studies for transmission connected busbar and line/cable connected reactors
2006	**Eskom, South Africa**	**Vaal South 275kV Transmission Grid Investigation: Re-integration of Lethabo Power Station** A planning study was undertaken to evaluate the performance of Eskom's Vaal South 275kV network. A main feature of the Vaal South 275kV system is that Lethabo Power Station, a base-load power station of some 3600MW, is integrated, at 275kV, into this system. The study investigation evaluated the technical performance of the system, and alternative transmission reinforcement options were identified and investigated from both a technical and economic standpoint. The planning study also included a review of the grid compliance status of Lethabo Power Station to ensure that the requirements as stipulated by the National Energy Regulator was met and satisfied. This required, amongst other things, detailed load flow, fault level and transient stability investigations.
January 2007- June 2007	**Eskom Transmission, South Africa**	**Cape Corridor 765kV insulation Co-ordination Study** Detailed insulation co-ordination studies for the Cape Corridor 765kV system.
November 2005 – January 2006	**BHP Billiton, Mozambique**	**Mphanda Nkuwa Hydropower Station: Review of Transmission Integration Study** **Central and Southern Regions, Mozambique** PSD was contracted to conduct a review on a study investigation that were done by UTIP looking at future generation and associated transmission projects in Mozambique. The review study considered the transmission integration of a 1300MW hydropower station to be located on the Zambesi River in Mozambique. The review study included the steady state analysis of the proposed 400 kV AC system solution (load flow fault level and power transfer capability calculations), an assessment of the risk of operating the planned AC system with the existing Cahora Bassa HVDC transmission system, and a review of the transmission capital cost estimates for the project. The project is still in the feasibility stage and will represent a major investment in the economy of the Region if it goes ahead. The services provided include: • Power System Modelling • Power System Studies and Analysis • HVDC System Analysis • Cost Estimating.
September	**Xstrata Mining**	**Xstrata Project Lion**

PSD Selected Technical Experience		
Date	**Client**	**Project**
2004 – March / April 2006	**Company, South Africa**	**Mpumalanga, South Africa** PSD was commissioned by Xstrata, a large mining company, to do the Engineering, Design, Implementation and Commissioning of a new 275/33 kV, (2X) 180MVA Substation for their new ferrochrome smelter project near Steelpoort, South Africa. The scope of work included: • The installation of all LV and HV plant, which will include the installation of a two 180 MVA 275/33 kV transformers, the equipping of the four 33 kV feeder bays • The installation of all LV equipment (protection, metering, DC and telecomms) in the control building • All conductoring and cabling associated with the above equipment. (HV,LV and Control) • The installation of the yard earth mat and the bonding of all equipment earth tails with the earth mat • The stoning and fencing of the yard. The Electrical Contract included the following: • The provision, testing and commissioning of the complete transformer bays and 33 kV feeder bays, including steelwork and foundations. The services provided include: • Power System Studies and Analysis • Substation Engineering and Design • Electrical Installation Work • Testing and Commissioning
August 2005 – October 2005	**Eskom, South Africa**	**Open Cycle Gas Turbine Project: Insulation Coordination Study Investigation** **Natal and Eastern Cape Regions, South Africa** PSD was commissioned by Eskom, the South African electric utility to conduct insulation coordination studies on the transmission systems that are planned to integrate proposed Open Cycle Gas Turbine (OCGT) generation facilities in South Africa. The scope of work included transmission line energization and switching study investigations, lightning studies, line ARC investigations, and an evaluation of the adequacy of installed surge arrestors. The simulations were conducted using PSCAD software and the affected parts of the transmission system were modelled in detailed in the transient domain. The services provided include: • Power System Modelling • Power System Studies and Analysis • Substation Engineering.
June 2003 -	**PB Power,**	**Morupule Power Station: Transmission Integration Studies**

PSD Selected Technical Experience		
Date	**Client**	**Project**
April 2004	**Botswana**	**Morupule, Botswana** PSD was sub-contracted to PB Power South Africa to conduct a study investigation looking at the integration of additional generation capacity at the existing Morupule Power Station in Botswana. Various generation scenarios were evaluated ranging from 200MW to 600MW of additional generation capacity, phased in over a period of 20 years. For each of these scenarios the transmission impact was evaluated and appropriate long term transmission development plans were put together to meet the demands of expanded generation at the Morupule site. For feasibility study purposes, the investigation also included a study to assess the impact of importing energy from neighbouring countries in future, i.e. no additional generation sources were established in Botswana. Future imports from South Africa and north of Botswana (Zambia and Zimbabwe) were evaluated. In both cases, the studies showed that new 400 kV inter-connectors were required to facilitate the import of additional bulk power in the future. The services provided include: • Power System Modelling • Power System Studies • Identification of Alternative Options • Study Investigations
2003	**Motraco 400kV and 275kV shunt capacitor filter bank project - Motraco and Alstom South Africa**	PSD was responsible for the complete engineering design, technical project management and testing and commissioning of the 400kV and 275kV Shunt Filter Capacitor banks.
April 2003 – June 2003	**Western Mining Corporation, Mozambique**	**Corridor Sands Project: Transmission System Integration Study Close to the town of Chibuto, Mozambique** WMC is investigating the feasibility of establishing a new silicone smelter in Mozambique, close to the town of Chibuto, approximately 200km northeast of Maputo. As part of the feasibility studies, PSD investigated the technical feasibility of supplying the new smelter project at 275 kV from the existing Komatipoort 275/132 kV Substation in South Africa. A number of alternative supply options were investigated from both a technical and economic point of view; study results were used as input into financial models. The services provided include: • Turning ‘customer requirements’ into ‘electrical requirements’ • Steady state power system analysis • Identification of required electrical infrastructure to make supply solutions technically feasible • Planning type studies, e.g. optimal time phasing of

PSD Selected Technical Experience		
Date	**Client**	**Project**
		reinforcement projects, system MW losses evaluation, etc. • Preparation of abridged technical specification for required 275 kV series and shunt connected capacitors.
September 2002 – October 2003	**NamPower: Auas Smelter / Namibian Electric Utility, Namibia**	**Electrical Supply Study** **Windhoek, Namibia** Study investigation to find the best techno-economic solution to supply a possible 600 MW Ferro-Si/Manganese smelter load, to be located close to the town of Windhoek, from Auas 400/220 kV Substation. Investigations were also conducted to assess the impact of the new load on power quality and to determine Quality of Supply (QOS) limits. The services provided include: • Identification of alternative electrical supply options • Steady state power system analysis and planning studies • Power Quality assessment and calculation of appropriate QOS limits • Transient (EMT) and temporary over voltage studies.
2002 - 2003	**Eskom - Luckhoff 400kV Series Capacitor Bank Installations, South Africa**	Eskom (Transmission) replaced and upgraded the three 400kV Luckhoff series capacitor banks. The banks series compensate the 400kV lines between Beta/Perseus and Hydra Substations on the Cape Power Corridor. The project was required to provide increased supply capacity to consumers in the Cape Regions. The capacitor banks were supplied by General Electric of America and it was the first MOV protected series capacitor bank to be installed in the Eskom Transmission Grid. Another unique feature of the project was the joint venture between General Electric and Alstom South Africa which was facilitated by PSD. PSD were appointed as a Technical Consultant on the project and was responsible for project management and the testing and commissioning of the three banks. Services to Client • Design review • Factory test witness • Technical coordinator between supplier and utility • Testing and commissioning of HV plant
December 2002 – July 2003	**NamPower (Nambian Electric Utility), Namibia**	**Feasibility study on the proposed Caprivi High Voltage Direct Current (HVDC) Link** **Caprivi strip, Namibia** NamPower, the Nambian electric utility, is evaluating the feasibility of establishing a 1st HVDC transmission line, using voltage source converter (VSC) technology, in Nambia. The HVDC system connects the Katima Mulilo network, currently supplied at 66 kV from Zambia, with the main NamPower Transmission System, thereby providing increased supply capacity to the Katima Mulilo load area. Apart from

Date	Client	Project
		the supply upgrade to meet the expected growth in load demand, NamPower is also interested in the possibility of using such a HVDC system to establish a new inter-connector with their neighbour country, Zambia. PSD conducts an investigation into the technical feasibility of the proposed HVDC (VSC) transmission system. The services provided include: • Network Planning Studies • EMT studies • Determination of electrical parameters as input into functional specification • Development of functional specification.
August 2002 – June 2003	**Eskom Transmission, South Africa**	**Specifications for two Static VAr Compensators (SVC) Grassridge Substation, South Africa** Two new 400 kV 400MVAr SVC's are required as part of the Eastern Cape network strengthening plan. System strengthening is required to make provision for the integration of a possible 1000 MW aluminum smelter, located close to the town of Port Elizabeth in the Coega Industrial Zone, and to meet the forecasted growth in load demand in the region. PSD is responsible for the development and compilation of the technical specifications for the two SVC's. The services provided include the following power system analysis and engineering design studies: • Transient Studies (EMT) • Load Flow Studies • Harmonic Studies • Technical Specifications.
2002 - 2004	**SEC, Saudi Arabia**	**East Central Series compensation project Saudi Arabia** Extensive studies including specifications for 380kV series capacitor banks. Bid adjudication, design review as well as detailed verification studies on: • TRV and RRRV • MOV rating verification • Fault performance verification
December 2002 – February 2003	**Eskom, Transmission South Africa**	**Coega Insulation Coordination Study South Africa** Eskom (Transmission) appointed PSD to conduct the necessary Insulation Coordination study investigations for the proposed network extensions under the Coega IDZ development scheme. The studies were divided into 3 phases: (1) Energization and statistical switching studies for the Beta – Delphi 1st 400 kV line, (2) neutral reactor studies for the Beta – Delphi and Hydra – Poseidon 400 kV lines, and (3) phase arrangement studies for the future 132 kV lines between Grassridge

PSD Selected Technical Experience		
Date	**Client**	**Project**
		400/132kV Substation and the site for the proposed Pechiney aluminium smelter in the Coega IDZ. The services provided include: • Transmission line energization and statistical switching studies • Sizing of transmission line neutral reactor • Unbalance/Phase Arrangement study investigations.