THE BEST APPROACH

ARGENTINA | CHILE | USA

electrical-studies.com

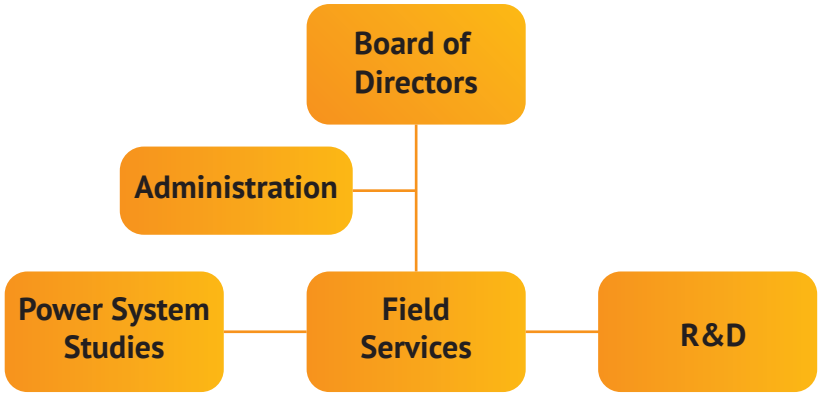
ELECTRICAL STUDIES

ELECTRICAL STUDIES GROUP

Overview

Electrical Studies Group (ES) is a team of 50+ Power System Engineers, focused on the persuit of specific solutions for each special problem.

With offices in **Argentina** (headquarters), **Chile** & the **US**, ES is comprised of three technical units, each of which is focused on developing and applying technology in a particular area of expertise.

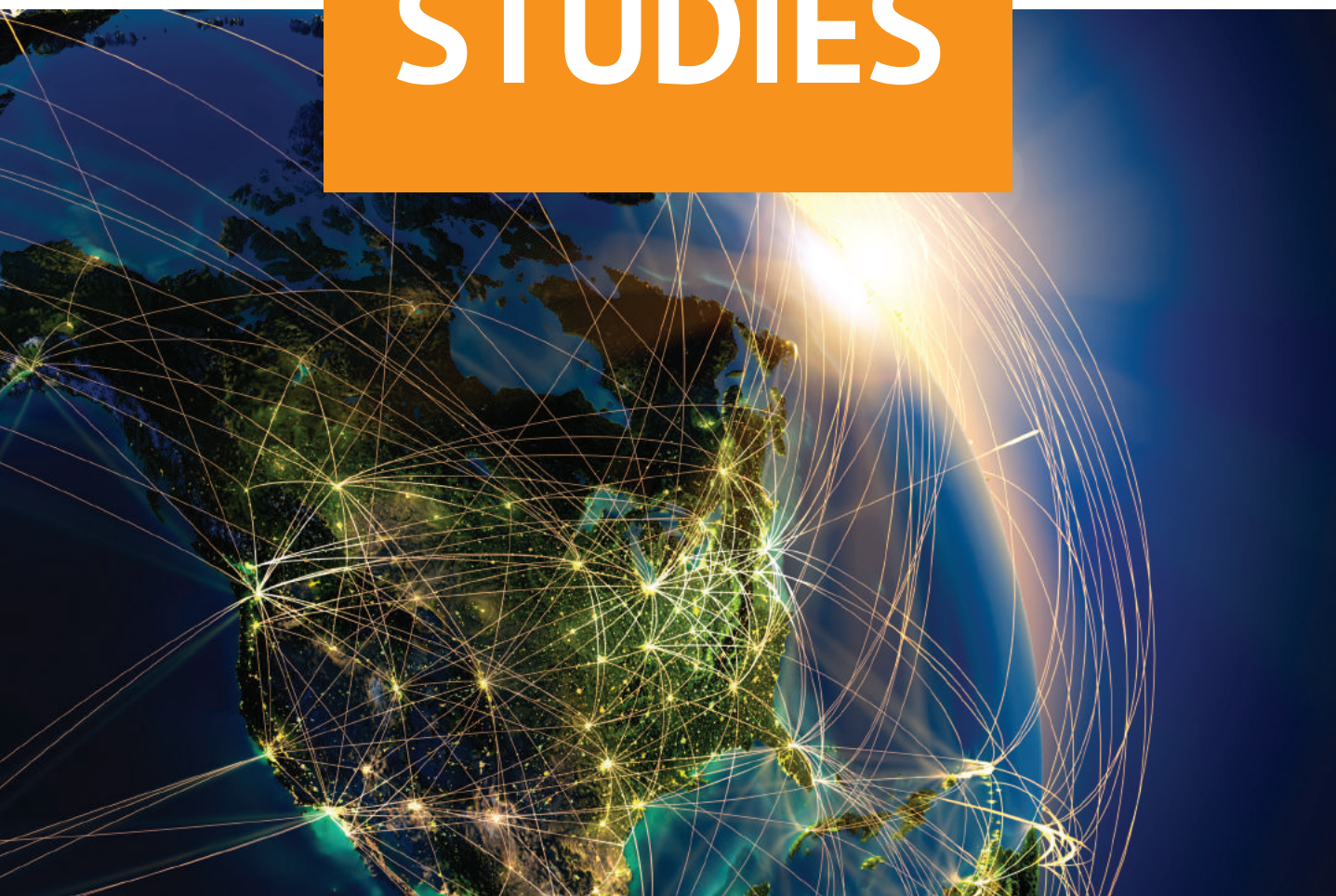


The combination of our experience in the field and simulations guarantees the best approach to each project. The R&D group is the creative kernel that develops software & hardware tools, both for internal use and creation of new products.

We also combine the development of engineering projects with academic tasks; providing university teaching, collaborating in technical commitees of international organizations such as CIGRE or IEEE, writing & presenting technical papers, etc.

In order to assure that our processes are in accordance with the highest international standards, ES is **certified ISO9001-2008** in **"Power Plant Electrical Testing, Commissioning Field & Simulation Studies".**

POWER SYSTEM STUDIES



2.1. General Description

Based on power flows, short circuits & dynamic simulations (electromechanical & electromagnetic), we have been developing and conducting Power System Studies in multiple countries for more than 15 years.

We have legal software licenses for all the tools we use which are suitable for the development of consultancy services. As a result, the specialists of this department have all the necessary resources to adapt to each particular case and country. The development of the databases, together with the experience in different types of interconnected and industrial systems, ensures optimum results in terms of execution time, conclusions and basically, validity and acceptance of reports from the dispatch centers and control bodies.

In the same way, the precision in the dynamic modelling of generating units, regulators and FACTS devices has been key in demonstrating, through studies, the feasibility of increasing limits in transmission systems. A detailed analisys of electrical power systems allowed us to design systemic protection schemes (SIPS) to cope with extreme contingencies and mitigate power fluctuations through a robust and coordinated stabilizers (PSS) adjustment, while maximizing the reliability of Power Systems and reducing operating costs.

2.2. Studies, Training & Software

Listed below the main types of studies that we have conducted during the last few years, for all types of power plants, and different kinds of Clients (Owners, Manufacturers, Utilities, and Operators):

- Load Flow
- Short-Circuit
- Transient Stability
- Small-Signal Stability
- Frequency Regulation
- Sub-Synchronous Resonance (SSR)
- Protection Selectivity
- Load / Generation Shedding
- Power System Stabilizer Tuning
- Harmonics & Flicker
- Inrush
- Insulation Coordination
- Transient Recovery Voltage (TRV)

We carry on our work with worldwide accepted simulation softwares, for which we have several commercial licences:

DIgSILENT Power Factory
www.digsilent.de/

Siemens PSS/E
www.siemens.com/

ATP Draw
www.atpdraw.net/

EMTP-RV
www.emtp-software.com/

CYMGRD
www.cyme.com/es/software/cymgrd/

Aspen
www.aspeninc.com/web/

Photon
www.estudios-electricos.com/software/)

PSS Designer
www.estudios-electricos.com/software/

As a complement to the specific projects development, our department provides **customizable training courses** on a variety of applicable topics to enhance the knowledge and skill-sets of assistants.

Training courses are offered at ES's home offices in Argentina or Chile, as well as at user's site.

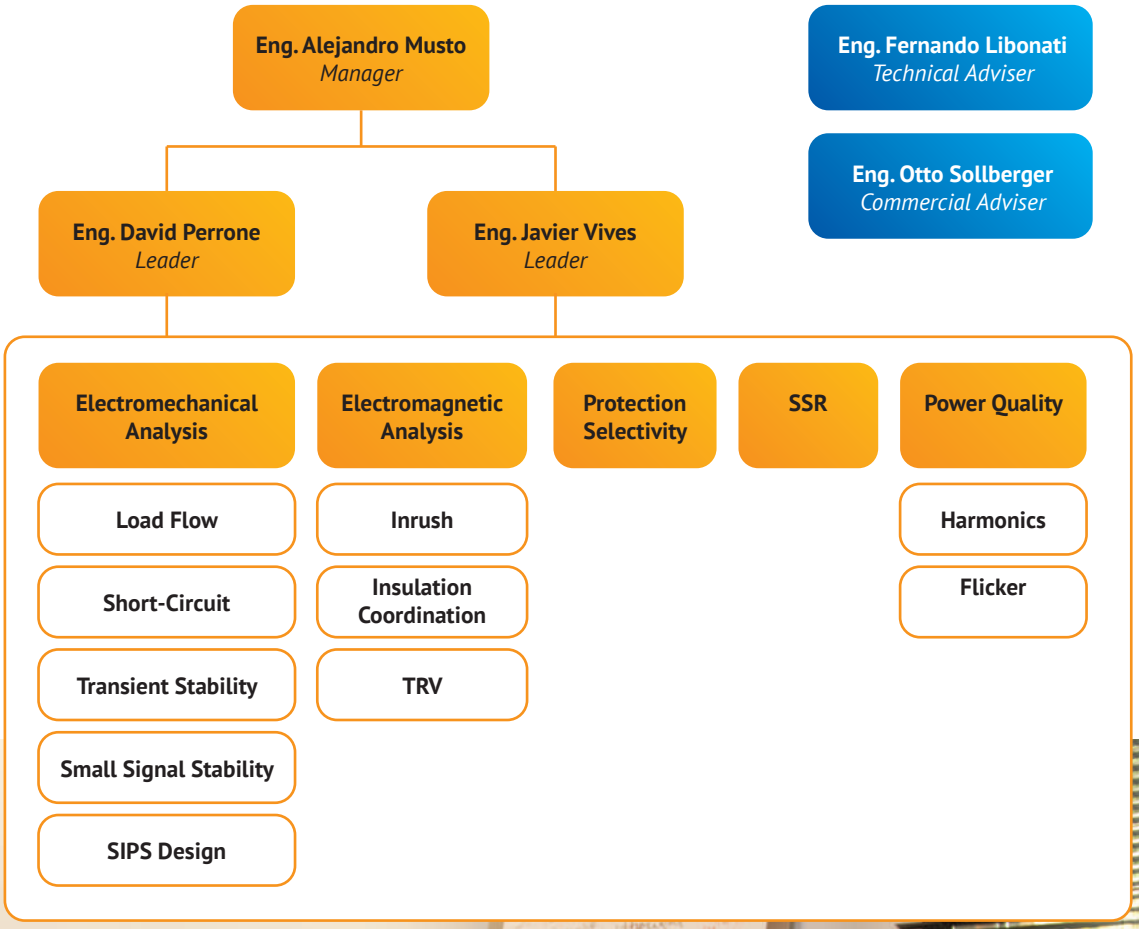
Our training topics are based on our experience, and include:

- **Generators' Control Systems**
  AVR
  Governors
  PSS
- **Power Systems Stability**
  Voltage
  Frequency
  Transient
  Small Signal
  (modal analysis)
- **Operation & Control of Medium Power System**
- **Protection Systems**
  Modelling
  Tuning
  Coordination

Additionally, as we are partners of DIgSILENT in Argentina and an intensive user of the Power Factory simulator, we provide both basic and advance training courses (Database management, Load flow, Short-circuit, RMS simulation, Protections & Programming).

2.3. Organization & Key team members

With more than 25 engineers, our Power System Studies Department is organized as shown below:



2.4. Notable Studies

Below you can find a description of selected projects completed by our Studies Department over the past few years. All the following consulting study projects were delivered at high quality and high customer satisfaction. The duration of these projects ranged from two months to one year, and on average they were completed in 4 months.

PROJECT EE-7073
Design verification of the Nva. Cardones – Polpaico Transmission System: 755km of 2x500kV 1700MVA lines (Nva. Cardones – Nva. Maitencillo – Nva. Pan de Azúcar – Polpaico), 3 new substations, 4 series capacitor's banks, and 3 transformers 500/220kV 750MVA.

The studies include:
• Load Flow
• Short-Circuit
• Busbar Capacity
• TRV
• Energizing
• Insultation Coordination

Client: Interchile (ISA)
Location: Chile

PROJECT EE-5013
Design verification of the SIC-SING Transmission System: 590km of 2x500kV 1500MW lines (Los Changos – Cumbre - Nva Cardones), 20km of 2x220kV 1500MW lines (TEN – Los Changos – Kapatur), 4 new substations, 6 series capacitor's banks and 2 transformers 500/220kV 750MVA.

The studies include:
• Load Flow analysis
• Busbar capacity
• Short-circuit calculation
• Transient Stability (RMS simulations) & Small Signal (modal analysis)
• Insulation Coordination
• Energizing
• TRV & RRRV
• Sub-synchronous resonance

Client: Alstom / General Electric
Location: Chile

PROJECT EE-7071
Interconnection Studies for Polpaico – Kapatur Transmission System. It considers the studies required by the Utility to validate the interconnection of the north and central Electrical Power Systems, by the connection of the new transmission system: Kapatur – Los Changos 2x220kV 1500MW, Los Changos – Cumbre – Nva Cardones 2x500kV 1500MW, and Nva Cardones – Nva Maitencillo – Nva Pan de Azúcar – Polpaico 2x500kV 1700 MVA).

The studies include:
• Load Flow
• Short-circuit
• Stability
• Protection Coordination
• Transformers Energizing (Inrush)
• Sub-Synchronous Resonance

Client: Transmisora Eléctrica del Norte (TEN), Engie, Transelec & Interchile (ISA)
Location: Chile

PROJECT EE-6061
Chile´s SIC SING (Central – North) Interconnection Studies, focused on the system operation.

The studies include:
• Primary & Secondary Frequency Control
• Analysis of the existing SIPS (EDAC, EDAG, ERAG & others)
• Voltage Control & Stability
• Small Signal Stability, and PSS Tuning
• Analysis of the Multiple/Extreme Contingencies (severity 6, 7, 8 & 9)
• Energizing & TRV

Client: CDEC-SIC; CDEC-SING (Chile's Utility)
Location: Chile

PROJECT EE-6139
Small Signal and Transient Stability Studies to analyse the feasibility of the Chile Argentina Power System interconnection. The studies include the identification of the generators units that participate in the inter-area oscillation modes, and their PSS tuning to improve the oscillation damping.

Client: CDEC-SING (Chile's Utility)
Location: Argentina / Chile

PROJECT EE-1027
Determination of the maximum Wind Power Capacity in the Peruvian Power System, by load flow and transient stability analysis.

Client: COES SINAC
Location: Perú

PROJECTS EE-1009 / EE-3144
Design of the Defense Plan against Extreme Contingencies in the Chilean Power System, with the following stages:
• Stage 1: Analysis of multiple contingencies, diagnosis, classification and conceptual design of the recommended SIPS (System Integraty Protection Schemes).
• Stage 2: Analysis and detailed design of the required SIPS to avoid the worst extreme contingencies.

The development includes:
• Database adequacy
• Definition of Base Cases, both frasibles and extremes according to each specific contingency.
• Contingency analysis, and conceptual design of the SIPS
• Transient stability validation, and detailed design of the SIPS

Client: CDEC-SIC Ltda (Chile's Utility)
Location: Chile

PROJECT EE-3101
Technical & Economical Study to analyse the performance of the frequency control (primary frequency control, secondary frequency control, and load shedding) in the Central America Power System, and calculate their optimal reserves.

Client: Consejo de Electrificación de America Central (CEAC)
Location: Centroamérica

PROJECT EE-1052
Development of the IMPSA wind turbines models for the Arauco Wind Farm, in PSS/E and DIgSILENT format, and its interconnection studies.

Client: Impsa Wind
Location: Argentina

PROJECT EE-5085
Development of the Alto Cielo Wind Farm static and dynamic models, in PSS/E (electromechanical) and ATP (electromagnetic) format.

Client: SolarPack
Location: Uruguay

PROJECT EE-0049
Stability analysis in the Chilean Central Power System, in order to increment the power transport capacity of the 500kV transmission system, by an incorporation of a STATCOM in Cerro Navia substation.
• Stage 1: Feasibility and STATCOM design
• Stage 2: Detailed analysis to calculate the new power transport capacity

Client: Transelec S.A.
Location: Chile

PROJECT EE-6010
Analysis of the low-damping electromechanical oscillations in the Chilean 154kV transmission system, and proposals for solution based on PSS tuning, in order to comply with the Chilean Grid Code. The scope includes small and transient stability analysis.

Client: HydroChile
Location: Chile

2.5 Interconnection Studies

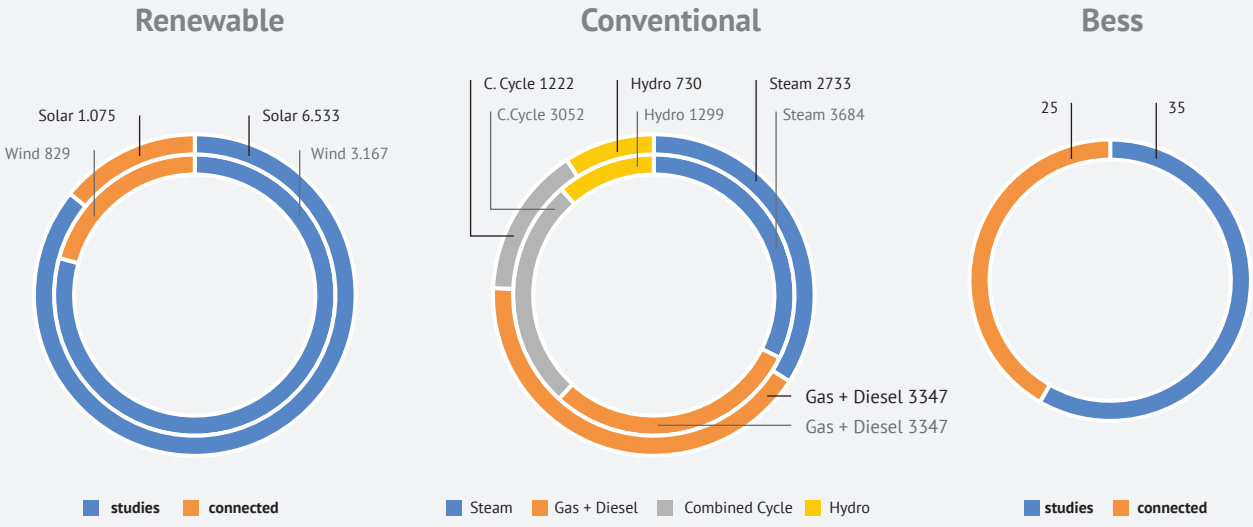
Electrical Studies has performed Interconnection Studies over the past 10 years.

The main activities developed in most of these studies were:
- Load Flow
- Short-Circuit
- Transient stability (RMS dynamic simulations)
- Inrush
- Protection selectivity

The following activities were also developed in some projects:
- Small signal stability (modal analysis)
- Power Quality
- Transient Recovery Voltage (TRV)
- Insulation Coordination

Table below shows a summary of the Generators' MW that have been studied, and which of them have been effectively connected to the grid (projects currently in service).

	MW studies	MW connected
Renewable	**9.700**	**1.904**
Wind:	3.167	829
Solar:	6.533	1.075
Conventional	**11.382**	**8.032**
Steam:	3.684	2.733
Gas + Diesel:	3.347	3.347
Combined Cycle:	3.052	1.222
Hydro:	1.299	730
BESS:	**35**	**25**
BESS:	35	25
TOTAL:	**21.117**	**9.961**



FIELD SERVICES

3.1. General Description

Competitive electricity markets and the subsequent operation near the limits of stability require that specialists from the national dispach centers, utilities and generator owners perform studies to determine safe conditions.

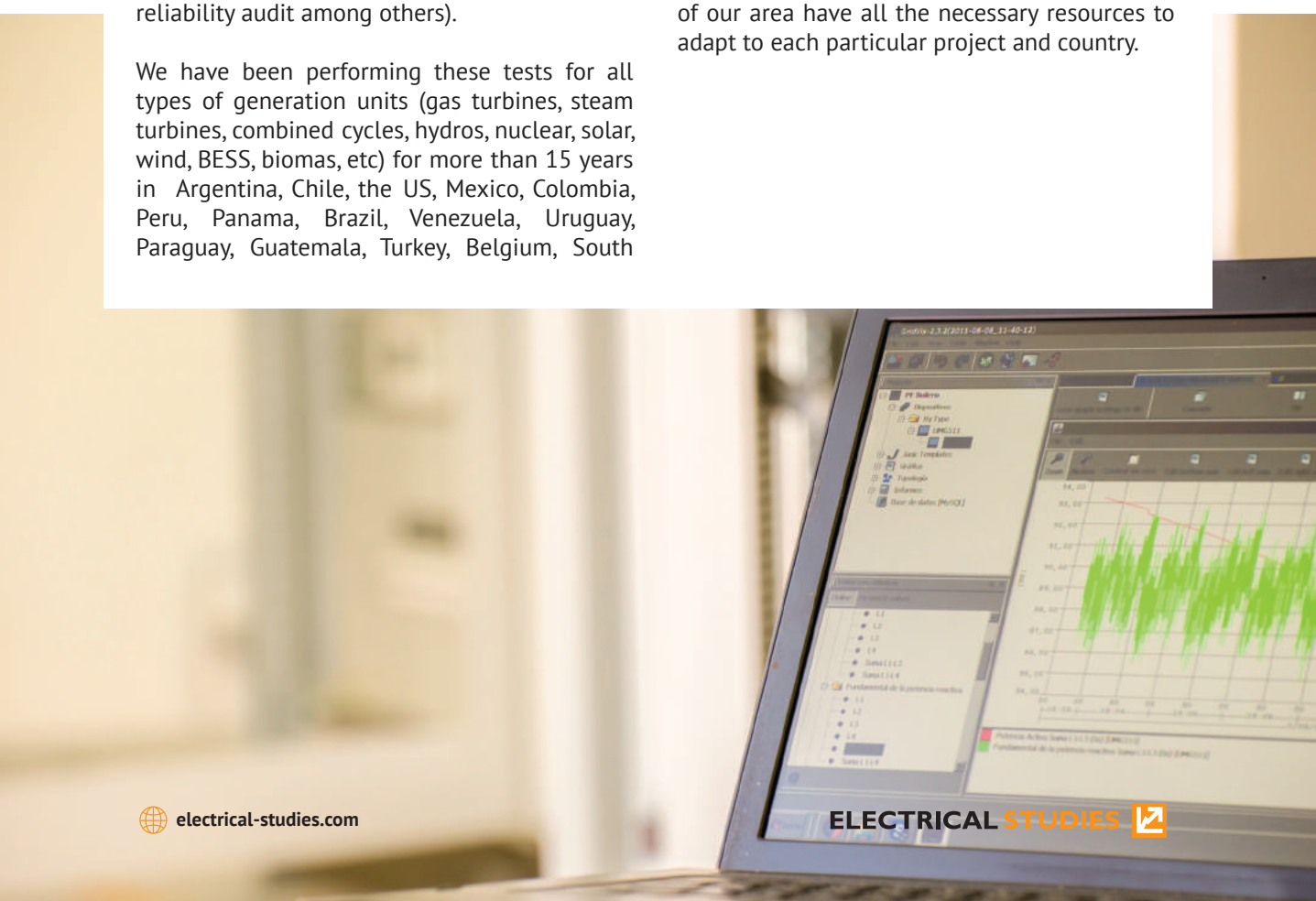
To ensure that the conclusions of these studies are valid, it is necessary to use validated mathematical models whose structure and parameters can reproduce the actual behavior of the units. This makes it possible to improve the performance of the whole grid and reduce the safety margins adopted, consistent with the economic dispach of the units.

In this regard, our Field Services Department has been performing field testing, analysis and adjustment of control systems, tests for identification of dynamic parameters, design of stabilization systems for power systems, generator enablement tests, power quality measurement, commissioning tests, training courses and several types of technical audits (such as black-start, capability curve verification, maximum and minimum active power determination, and reliability audit among others).

We have been performing these tests for all types of generation units (gas turbines, steam turbines, combined cycles, hydros, nuclear, solar, wind, BESS, biomas, etc) for more than 15 years in Argentina, Chile, the US, Mexico, Colombia, Peru, Panama, Brazil, Venezuela, Uruguay, Paraguay, Guatemala, Turkey, Belgium, South Korea, El Salvador, Costa Rica, Italy, China and Portugal.

The fact that we develop our own data adquisition equipment and software tools to record the main electrical variables that are taken directly from the generator and unit's controls (automatic voltage regulator, governor, PSS, inverters, wind turbines, etc) helped us to gain and maintain a competitive edge. Consequently, in many opportunities we can avoid using vendor softwares and specific software applications to perfom the measuments needed for validating the generator and associated control's mathematical models.

Furthermore, we have also developed our own software (Photon™) to conduct the validation of the dynamic mathematical models. Eventually, these models can be implemented and exported to typical power system simulators such as PSS/E, DigSilent or PSLF.
We have legal software licenses for all the tools we use which are suitable for the development of consultancy services. As such, the specialists of our area have all the necessary resources to adapt to each particular project and country.



3.2. Field Testing, Software & Training

Listed below the main tests and audits that we have conducted, for all types of technology, and different types of Clients (Owners, Manufacturers, Utilities, and Operators):

- Automatic Voltage Regulators (AVRs).
- Under and Over Excitation Limiters (UELs and OELs).
- Power System Stabilizers (PSSs) (Tuning studies and field testing).
- Governors (GOVs).
- Power Plant Controllers - PPC (Voltage, Reactive, Power Factor).
- Primary and Secondary Frequency Controls.
- Synchronous Machine.
- Solar Inverter Controls.
- Wind Turbine Controls.
- BESS (battery energy storage systems).
- Protections Relay Settings and Primary / Secondary Inyection Tests.
- Insulation Measurement.
- Black-Start Audits and Tests.
- Capability Curve Audits.
- Maximum and Minimum Active Power Determination.
- Power System Stabilizer Tuning.
- Harmonics & Flicker Measurements (Power Quality in accordance to standard EN 61000-2-4).
- Commissioning Tests (Motor & Generator Testing, Instrument and Power Transformer Testing, Cable Testing, Battery Tests, Switchgear Breakers & SwitchgearTesting, Ground and InsulationTesting).

We carry on our work with worldwide accepted simulation softwares, for which we have several commercial licences:

DIgSILENT Power Factory
www.digsilent.de/

Siemens PSS/E
www.siemens.com/

MATLAB
www.la.mathworks.com/products/matlab.html

Photon
www.estudios-electricos.com/software/

UBY
www.estudios-electricos.com/software/

Acqua
www.estudios-electricos.com/software/

PlotCapability
www.estudios-electricos.com/software/)

Load Manager
www.la.mathworks.com/products/matlab.html

PSSDesigner3
www.estudios-electricos.com/software/

Our staff also conducts customizable training courses on a variety of applicable topics to enhance the knowledge and skill-sets of assistants. Training courses are offered at ES's home offices in Argentina or Chile, as well as at Client's premises.

Our training topics are based on our experience, and include:

- **Generators' Control Systems**
  - AVR
  - Governors
  - PSS
- **Power Systems Stability**
  - Voltage
  - Frequency
  - Transient
  - Small Signal (modal analysis)
- **Operation & Control of Medium Power System**
- **Power System Symulation Software Tools**
  - Photon™
  - PlotCapability™
  - PSSDesigner3™
  - MATLAB / Simulink®
  - SimPwr Tool
- **Protection Systems**
  - Testing

3.3. Field Testing Equipment

In addition to the software tools listed previously, our deparment possesses the most advanced hardware and field testing equipment. Some of our key equipment include:

- **DATA ACQUISITION SYSTEMS:**

EE has developed its own acquisition systems based on National Instruments DAQ boards that allow the register of both analog and digital variables at high speed rates and quality. One of our instruments, Cirion j16.2®, provides 16 fully isolated analog channels. The system can be connected to a computer through USB communication using a dedicated software called Acqua, developed by EE. All channels of the data acquisition system have an opto-isolator manufactured by Dataforth.

• CURRENT MEASUREMENT:
For either Synchronous Generators or Inverters / WTG, current measurement can be performed in two different ways, depending on the availability of current transformers on the AC output. If there is an available CT, current measurement is performed with the aid of an additional toroidal CT. Otherwise, if there is no CT available (especially in WTG and Inverters), Rogowski's coils are the best choice. This piece of equipment also has an active signal conditioning stage, which provides a voltage proportional to the measured current. The use of this instrument requires the access to the AC output bar. The output of the coil can be directly connected to the data acquisition system provided by EE.

• FLUKE MULTIMETERS AND CURRENT CLAMPS:
Our department relies on the world leader in digital multimeters and current clamps to perform all different types of electrical measurements in the field. Within our equipment list we also have a

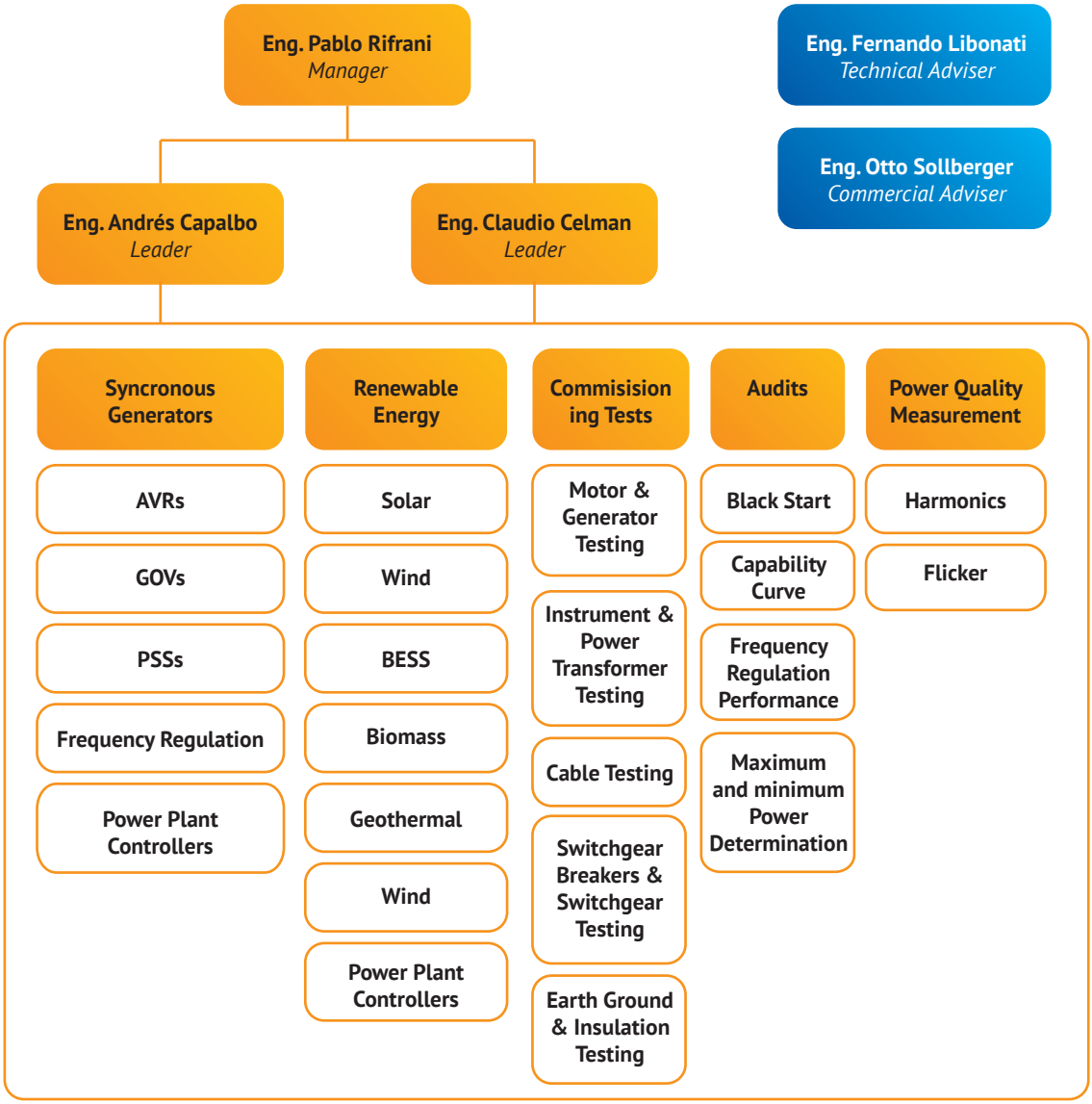
• JANITZA ENERGY & POWER QUALITY ANALYSERS:
We have several Class A power monitoring devices (UMG Series) which monitor energy and power quality according to the general valid standards (e.g. EN50160).

• YOKOGAWA DIGITAL POWER METERS:
We also count on WT300E series digital power analyzers for maximum power determination tests due to its accuracy (0.1%) and fast display update rate (100ms).

• OMICRON TEST SETS:
Our commissioning area relies on OMICRON for relays testing and primary injection tests, such as CMC-256, CPC-100, CT Analyzer among others.

3.4. Organization & Key team members

With more than 20 field engineers, our Field Services Department is organized as shown



3.5. Notable Projects

The following list shows a selection of projects completed by our Field Testing Department over the past few years. All of these consulting projects were delivered at high quality and high customer satisfaction.

PROJECT EE-7036

Rising Tree Wind Farm (198MW), EDP Renewables, California, U.S.A. (June 2017): Development of Field Testing Procedure, Field Testing and dynamic modelling according to MOD-026 and MOD-027, by NERC. This project was executed along with MEPPI (Mitsubishi Electric Power Products).

The wind farm is located in Kern County, California, and it is divided into three stages, called Rising Tree 1, 2 and 3.

All stages are connected in a HV bus and they are conformed by:

• 60 Vestas V112 3.3MW, full converter – type WTG.
• 34.5kV distribution network.
• 230kV/34.5kV Step-Up Transformer

RST1, RST2 and RST3 are connected to a common HV bus at the wind farm sub-station. A 4 miles length line connects the wind farm with the electrical grid at the Windhub sub-station.

The studies include:

• Field Testing Procedure
• Field Testing over 3 individual Wind Turbines and Power Plant Controller (PPC)
• Dynamic model validation in PSS/E for Wind Turbine mathematical model.
• Dynamic model validation in PSS/E for PPC mathematical model.
• Final Report for CAISO (California Independent System Operator)

Client: MEPPI / EDPR
Location: USA

PROJECT EE-7171

Villanueva (I & III) and Don Jose Solar Parks, +870MW in total, Enel Green Power Mexico, Mexico (October 2017): Dynamic modeling of PV inverter and PPC control loops in PSS/E v32. Aggregated dynamic model development. Development of Field Testing Procedure, Field Testing (HFRT) and dynamic modelling according to Mexican Grid Code.

Villanueva solar park is composed of two stages Villanueva I y III. This PV facility, located in the Mexican state of Coahuila, is the first energy project to start operation after the entry into effect of Mexico's energy reform. Once fully operational, Villanueva will be the largest PV facility producing energy in the Americas and Enel's largest solar project worldwide.
Villanueva I has 356 inverters that adds up to 364.9MW, while Villanueva III has 260 inverters that totalize 266.5MW. The inverters in both stages are FIMER, model RT11015TL which have an individual capacity of 1.025kVA and 400V nominal output voltage. Inverters are connected to a MV network in 34.5kV through transformers (0.4kV/0.4kV/34.5kV).
Don Jose solar park (238MW) has 68 inversores, whose nominal power is 3.2MWAC. These inverters and PPC control belong to NIDEC.

The studies include:

• Inverter and PPC Model Development in PSS/E v32.
• Field Testing Procedure for HFRT Tests.
• Field Testing over 3 Inverters (HFRT Function).
• Dynamic model validation in PSS/E for Inverter mathematical model.
• Dynamic model validation in PSS/E for PPC mathematical model.
• Final Report for CENACE according to Mexican Grid Code.

Client: ENEL GREEN POWER MEXICO
Location: Mexico

PROJECT EE-6031

AES GENER has hired ES to conduct the field tests and models for a 20MW BESS (battery energy storage system) that was installed in Cochrane Thermoelectric Power Station (532MW), located in Mejillones, Antofagasta region (north of Chile). The project took place in 2016 and involved tests over the four 5MW modules that this BESS has. The Cochrane project combines low cost, reliable power with an innovative lithium ion battery storage system (BESS) to increase available capacity and efficiency.

The studies include:

• Inverter Model Development in DigSilent.
• Field Testing Procedure according to CEN requirements.
• Field Testing on the BESS.
• Dynamic model validation in DigSilent
• Final Report for CEN according to Chilean Grid Code.

Client: AES GENER
Location: Chile

PROJECTS EE-6028, EE-7137 & EE-7214

Since 2016, Grupo Albanesi has carried out with ELECTRICAL STUDIES a lot of new thermal generation projects (+580MW in total) in Argentina:

• Expansion of La Rioja Thermoelectric Plant (GRISA), one Siemens SGT-800 gas turbine (50MW).
• Expansion of Modesto Maranzana Thermoelectric Plant:
- 1st stage: two Siemens SGT-800 gas turbines (100MW).
- 2nd stage: one Siemens SGT-800 gas turbines (50MW).
• Expansion of Independencia Plant, one Siemens SGT-800 gas turbine (50MW).
• New installation in Alejandro Petión (Ezeiza), Province of Buenos Aires, two Siemens SGT-800 gas turbines (100MW).
• Expansion of Roca Thermoelectric Plant, steam cycle closure, GET-10R turbine (60MW).
• New installation in Timbues, Renova Power Plant, Province of Santa Fe, one Siemens SGT-5 gas turbine (170MW).

All the Studies, PSS tuning and Field Testing necessary for the commercial operation of these new units were conducted by ES.

The studies include:

• Field Testing Procedure for CAMMESA.
• Field Testing over 9 different units.
• Dynamic model validation in PSS/E for synchronous generators, excitation and governor controls and PSS.
• Field Testing Report for CAMMESA's approval.
• Final Report for CAMMESA according to Argentinian Technical Procedures.

Client: GRUPO ALBANESI
Location: Argentina

PROJECT EE-5170

ES was hired by ENDESA Chile for this big project to carry out tests for validation of the dynamic models of synchronous generating units in Chile according to Chilean Grid Code (NTSyCS) and its technical annex: Authorization of Installations for Frequency Control, Voltage Control, EDAC, Multitasking Protection Systems, and PRS, defined by the National Energy Commission, attached to the Chilean Ministry of Energy. The tests are performed on the voltage and speed regulators installed on the machines themselves. This project also involved the PSS tuning for all the units that were part of the scope.

STAGE 1:

• San Isidro I Combined Cycle Power Plant, GT and ST.
• San Isidro II Combined Cycle Power Plant, GT and ST.
• Pangue Hydroelectric Power Plant, Units 1 and 2.
• El Toro Hydroelectric Power Plant, Units 1, 2, 3 and 4.
• Palmucho Hydroelectric Power Plant.

STAGE 2:

• Antuco Hydroelectric Power Plant, Units 1 and 2.
• Cipreses Hydroelectric Power Plant, Units 1, 2 and 3.
• Bocamina Thermal Power Plant (Steam Turbine), Unit 1.
• Pehuenche Hydroelectric Power Plant, Units 1 and 2.
• Rapel Hydroelectric Power Plant, Units 1, 2, 3, 4 and 5.
• Ralco Hydroelectric Power Plant, Units 1 and 2.

STAGE 3:

• Curillinque Hydroelectric Power Plant.
• Bocamina Thermal Power Plant (Steam

Turbine), Unit 2.
All the Studies, PSS tuning and Field Testing necessary for CEN's approval of these units were conducted by ES.

The studies include:
• PSS tuning study by means of PSSDesigner3 (ES's software tool).
• Field Testing Procedure for Coordinador Electrico Nacional (CEN).
• Field Testing over +28 different units (hydros, wind and thermal).
• Dynamic model validation in DigSilent for synchronous generators, excitation and governor controls and Power System Stabilizers.
• Final Report for CEN according to Chilean Technical Procedures (Grid Code).

Client: ENDESA CHILE
Location: Chile

PROJECT EE-6009
Enel Green Power Chile Wind Farms and Solar Parks: Field testing and dynamic model validation according to Chilean Grid Code "Norma Tecnica" for: Los Buenos Aires Wind Farm, Renaico Wind Farm, PV Pampa Solar Norte, PV Carrera Pinto I, II, and III, PV Finis Terra I and II.

The studies include:
• Field Testing Procedure for CEN.
• Field Testing in at least 2 Inverters or Wind Turbines (depending on the Site).
• Dynamic model validation in DigSilent for Inverter / WTG mathematical model.
• Dynamic model validation in DigSilent for PPC mathematical model.
• Final Report for CEN according to Chilean Grid Code.

Client: ENEL GREEN POWER CHILE
Location: Chile

PROJECT EE-5004
Nuclear Power Plant Atucha I (350MW), Nucleoelectrica Argentina S.A. (NASA), Argentina. Tests for commercial habilitation under Argentinian code (PT4 CAMMESA) of a Nuclear power plant.

The studies include:
• Field Testing Procedure for CAMMESA.
• Power System Stabilizer Tuning Study.
• Field Testing according to CAMMESA's Technical Procedures.
• Dynamic model validation in PSS/E for synchronous generator, excitation, governor control and PSS.
• Field Testing Report for CAMMESA's approval.
• Final Report for CAMMESA according to Argentinian Technical Procedures (Grid Code).

Client: NASA
Location: Argentina

PROJECT EE-2005
Nuevo Puerto Combined Cycle Power Plant (2x1 — 770MW), Central Puerto, Argentina. Design, commissioning and tests of control system to enable primary frequency control on combined cycle steam turbines for commercial habilitation under Argentinian code (PT9 CAMMESA).

The studies include:
• Feasibility Tests
• Basic Engineering Studies
• Detailed Engineering and Implementation.
• Field Testing Procedure for CAMMESA.
• Commissioning Tests
• Field Testing according to CAMMESA's PT) Technical Procedure.
• Dynamic model validation in PSS/E.
• Field Testing Report for CAMMESA's approval.
• Final Report for CAMMESA according to Argentinian PT9 Technical Procedure (Grid Code).

Client: Central Puerto S.A.
Location: Argentina

PROJECT EE-1108
ES was hired by EMGESA Colombia for this project to carry out tests for validation of the dynamic models for 14 synchronous generating units (~2.400 GW) according to Colombian Grid Code (Acuerdo Nro 640).

The hydro units that were part of this process:
• Guavio Hydroelectric Power Plant (1250MW): 5 units
• La Guaca Hydroelectric Power Plant (324.6MW): 3 units
• Paraiso Hydroelectric Power Plant (276.6MW): 3 units
• Betania Hydroelectric Power Plant (540.9MW): 3 units

The studies include:
• Field Testing Procedure for XM (Colombia).
• Field Testing over 14 different hydro units.
• Dynamic model validation in DigSilent for synchronous generators, excitation, governor controls and Power System Stabilizers.
• Final Report for XM according to Colombian Grid Code.
Client: EMGESA Colombia
Location: Colombia

PROJECTS EE-6175, EE-7010, EE-7011, EE-7019 and EE-7047
Field testing to show technical inability to perform Primary Frequency Control according to Peruvian Grid Code (PR-21) and Mathematical Modelling.

The Plants that were part of this projects are listed below:
1. Kallpa
2. Chilca Uno (Engie Perú)
3. Ventanilla (Enel Perú)
4. Malacas (Enel Perú)
5. Chimay (Enel Perú)
6. Huinco (Enel Perú)

Clients: Kallpa Generación S.A., Engie Peru and Enel Peru.
Location: Peru

PROJECT EE-1108
TEIAS (Turkish Electricity Transmission Company – Utility authority) – Turkey
Test and mathematical modeling of thermal and hydraulic power plants at Turkey. Field testing, technical assessment and writing of technical specifications to modernization of control systems.

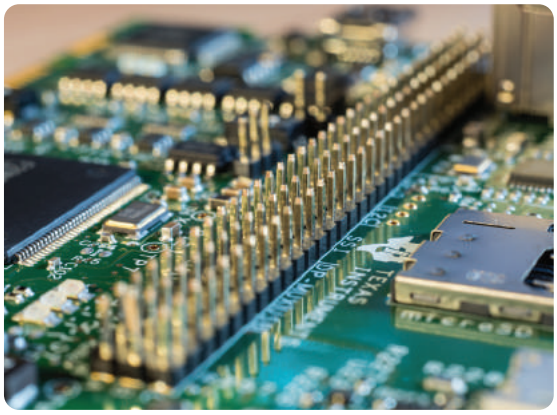
Tested power plants (+3.5 GW):
1. Elbistan B, a lignite fired thermal power plant 4 x 360MW
2. Berke, hydraulic power plant 3 x 170MW
3. Bursa, 2x CCPP: 2 x GT 240 MW + 1 x ST
4. Çan, steam power plant 2 x 160MW
5. Altinkaya, hydraulic power plant 4 x 195MW
6. Ambarli 3 x CCPP: 2 x GT 138 MW + ST
7. Hydraulic Power Plants Seyhan, Kadincick I y Kadincik II – Turkey

Client: TEIAS
Location: Turkey

3.6. Main vendors tested

The following list shows our principal AVR, GOV, Inverter and Turbine experience:

Turbine / Inverter	AVRs	AVRs	GOVs
GE LM6000	GE EX2000	Mitsubishi MEC-700	GE Mark II
GE LMS100	GE EX2100	Voith Thyricon	GE Mark V
GE LM2500	GE EX2100e	Ansaldo	GE Mark VI
GE TM2500	ABB Unitrol 1020	Reivax RTVX	GE Mark VIe
Siemens SGT5-2000E	ABB Unitrol 1010, Stamford MX-321	SIEMENS RG3	Wartsila UNIC C3
SGT5-5000	ABB Unitrol 1010	GE Semipol	EasyGEN 3000 y EGCP-3
Siemens SGT-800	Unitrol P	GE Silco V	Woodward Micronet
Vestas V82 1.650MW	Unitrol F	Digu Reg	Siemens SGT-800
Vestas V90 1.5MW	ABB Unitrol 6080	ABB Micro Reg	Andritz 1703
Vestas V112 3.3MW	ABB Unitrol 6800	Toshiba (analog & digital)	Woodward NetConn 5000
Vestas V110 2.0MW	Andritz Thyne 1	Westinghouse/Cuttler Hammer WDR2000	Caterpillar CMGC
Vestas V112 3.0MW	Andritz Thyne 5		Wartsila UNIC C3
Vestas V126 3.45MW	Brush A30		Reivax RTVX
Fimer RT11015TL	Brush A32		SIEMENS SPPA-T3000
Fimer R7500TL	Brush A10		Ansaldo
Santerno Sunway TG760 1000V TE-380 OD	Brush MAVR		Woodward 505
GE ProSolar PSC - 680 MV - L - QC	Brush MicroAVR		EMERSON Ovation
Power Electronics FS1500	Stamford MX321		
Pratt & Whitney F8T	Stamford MX321 / Basler DECS-100		
Pratt & Whitney FT8-3	Basler DECS-100		
"SMA Sunny Central 800CP XT, 880kVA"	Basler DECS-125		
Acciona AW82 1.5MW	Basler DECS-200		
ABB ULTRA-1400.0-TL (1.560MVA)	Brouwn Boveri AC Brouwn Boveri KC		
"Parker PCS-890 GTB, 2MW, 480V"	Caterpillar CMGC		



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For updated information and references, please contact us at:
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