ADRIANÓPOLIS UNIT
The High Voltage Laboratory (AT1), set up in 1980 by Cepel, is one of the largest of its kind in the Southern Hemisphere. It carries out acceptance testing of dielectric isolation and supports R&D projects for equipment and components used in transmission systems up to 800 kV.

The main clients of the AT1 lab, located at the Adrianópolis Unit, are electric utilities and major equipment manufacturers in Brazil and other countries. In the 1990s this laboratory developed technology for the construction of High Surge Impedance Loading Lines (HSIL), which was a great technological achievement for the Brazilian electricity sector. Such technology is especially suitable for transmitting large blocks of electric power over long distances with minimal losses. The AT1 lab is kept in the forefront with top-of-the-line equipment and measuring systems.

Infrastructure

The AT1 lab is 44 m x 30 m x 27 m (high), and has two control rooms of 7 m x 3 m, which allow the monitoring of two tests separately or together.

Assembly and handling of cargo is managed by two 5-ton overhead cranes, fixed pulleys that can handle up to 0.5 ton each and 50 ton capacity air mattresses. Also it has aerial platforms to assemble test equipment.

The laboratory equipment includes:

- DC voltage source of 1 MV/2A, positive or negative polarities;
- Pulse generator 4.0 MV, 200 kJ, 20 stages;
- Set of 3 transformers 60 Hz for cascading, 600 kV, 2A each;
- Set of 3 single-phase voltage regulators (0 to 8 kV), 2.5 MVA each;
- RC voltage dividers 1.6 MV and 3.6 MV;
- Standard gas capacitor 1.2 MV;
- Coupling capacitor 1.2 MV;
- Assembly area with overhead crane 50 t;
- Sphere spark-discharger for 2.4 MV;
- Artificial rain equipment.
The Corona Testing Laboratory (AT2), which was started in 1980 by Cepel, carries out tests with high voltage to industrial frequency up to 150 kV, as well as tests of lightning impulse, switching impulse and drilling impulse up to 1 MV with 50 kJ of energy.

The tests support research projects and ensure the reliability, security and quality of high voltage electrical equipment. The main clients of the AT2 lab are electric utilities and manufacturers of electrical equipment.

The Corona lab, located at the Adrianópolis Unit, carries out different types of measurements, either in-house or in the field. The lab is one of the few labs in Brazil qualified to measure partial discharges, capacitance and tan-δ in generators and large motors in the field (industries, oil rigs and power plants). AT2 has also participated in the development and improvement of measurement methodologies and techniques to evaluate high voltage equipment.

Infrastructure

The AT2 lab is 10 m x 10 m x 8 m (high). The laboratory equipment includes:

- Resistive and capacitive voltage dividers;
- Impulse generator of 1 MV/30 kJ;
- Voltage transformer 0-150 kV/100 kVA;
- Capacitor-input filter (π Filter) 350 kV/4.5 A;
- Standard Capacitors of 200 kV and 35 kV;
- Measuring instruments in general: digital oscilloscopes; capacitance and tan δ bridge meter
- Partial discharge measuring system; radio interference voltage meter; calibrators and impedances for measurements.
The Pollution Laboratory (AT3), opened in 1983 by Cepel, is specialized in evaluating electrical equipment in locations where pollutants such as dust, salt spray and even bird droppings are present. The AT3 lab, located at the Adrianópolis Unit, is the only lab in Brazil equipped to carry out tests with saline fog or pre-deposit on insulators with equipment exceeding 138 kV.

One of the main activities of the laboratory is its participation in preparing a pollution map in the regions where Cemig (Companhia Energética de Minas Gerais), Escelsa (Espírito Santo Centrais Elétricas S. A.) and Coelce (Companhia Energética do Ceará) operate. The map provides information on seasonal pollution levels, highlighting the most critical times of the year for different types of pollutants. This and other data is used by the maintenance crews. The AT3 lab has also been participating, for more than 15 years, in the evaluation of polymeric insulators installed on the Eletrobras Furnas DC lines.

One of the research projects underway in the laboratory involves the evaluation of naturally aged polymeric insulators, to provide practical data for concessionaires when there is a failure in a transmission line due to the polymeric insulator. The project also undertakes failure analysis of polymeric insulators.

Infrastructure

The laboratory has the following equipment:

- Plastic chamber 5.2 m x 4.6 m x 4.6 m;
- Small chamber 5.2 m x 4.6 m x 4.6 m;
- Large chamber 16 m x 18 m x 20 m;
- Single-phase Voltage Regulator 0-8 kV/2.5 MVA;
- 600 kV, 2A, 60 Hz transformer;
- 180 kV, 1.11A, 60 Hz transformer;
- 50 kV, 5A, 60 Hz transformer;
- 30 kV, 2A, 60 Hz transformer;
- System to generate salt fog and clean fog (spray/steam).
The High Current Laboratory (AP1), opened in 1981 by Cepel, carries out electrical and thermo-mechanical evaluations of high, medium and low voltage equipment, manufactured in Brazil and abroad. It does tests with electrical currents up to 230 kA.

The AP1 lab, located at the Adrianópolis Unit, has a test area for large equipment and an overhead crane capable of handling loads up to 3.2 tons.

Prominent among the present activities at the laboratory is the internal arc test in low voltage panels. Internal electrical arcs are hazardous to distribution equipment therefore the results of such tests allow manufacturers to add protective devices to their products. Currently the laboratory is involved in an R&D project for fault current limiters in superconducting material, and in developing methodologies for special tests.

Infrastructure

The AP1 lab is 50 m x 10 m x 9 m high. It has installations with a short-circuit current of 140 MVA in up to 5 sec and 21 MVA in a steady-state, with voltages of 110 up to 3500 V three phase or in single-phase 110 to 6000 at 60 Hz. Depending on the equipment under test, it can reach up to 230 kA efficiency for 5 seconds or 50 kA in a steady-state.

The lab has the following equipment:

- 3 transformers of 138/4.16 kV ± 20%;
- 3 transformers of 4.16/0.137 to 1.65 kV;
- 10 disconnectors of 138 kV;
- 6 earthing switches of 138 kV;
- 1 3-pole breaker of 15 kV, 3150 A, 40 kA;
- 1 3-pole disconnector of 15 kV, 2000 A, 10 kA;
- 3 synchronous keys of 5 kV, 1700 A, 10 kA;
- 1 shielded duct for bars of 5 kV;
- 3 banks of reactors with reactors of 200, 100, 50, 25, 12.5, 6.4, 3.2, 1.6, 0.8, 0.4, 0.2, 0.1 and 0.05 Ω in each bank;
- 3 banks of reactors with reactors of 10, 5, 2.5, 1.25, 0.64, 0.32, 0.16, 0.08, 0.04, 0.02, 0.01 and 0.005 Ω in each bank;
- 3 banks of resistors with 108 resistors of 1.8 Ω in each bank;
- 3 banks of resistors with 6 resistors of 4.911 mΩ in each bank;
- 1 full wave three phase bridge rectifier – 6 pulses.
The High Power Laboratory (AP2), opened in 1983 by Cepel, uses the highest fault currents in South America to conduct R&D tests in high voltage equipment like circuit breakers, insulator strings, cubicles, reactors, etc.

The tests are video recorded with a high-speed camera. The main clients of the AP2 lab, located at the Adrianópolis Unit, are research institutions and electric energy companies with headquarters in Brazil and other South American countries such as Argentina, Uruguay and Venezuela.

The main research project that the laboratory is involved in at present is the Electric Arc Modeling for Single Phase Recloser Studies (Modelarco), which is being jointly developed with Eletrobras Furnas and COPPE/UFRJ (Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering, Federal University of Rio de Janeiro).

The results of this project are essential to provide details of the characteristics of the physical phenomenon of the arc power, which comes from surges in transmission lines caused by lightning or switching operations in the electric circuits.

**Infrastructure**

- Usable three-phase power of 750 MVA; maximum voltages of 100 kV single-phase and 60 kV three-phase (60 Hz);
- Three structures for mounting the test equipment and an open courtyard of 22 m x 32 m;
- Measuring system of transmitters and receivers for fiber optics and a signal digitizer. Entrance to testing area is a 8 m wide gate and free headroom or a 3.5 m wide gate with a 4.5 m headroom. Access to a 58 m² individual assembly room is through a 3.5 m wide gate with a 4.5 m headroom.
The Calibration Laboratory (CA1), opened in 1980 by Cepel, has been accredited by INMETRO (National Institute of Metrology, Quality and Technology) since 1983 and is a member of the Brazilian Calibration Network. It was one of the first laboratories accredited by INMETRO to join this network.

The main activity of the CA1 lab, located at the Adrianópolis Unit, is to calibrate instruments as well as systems for measurement and generation. Also it measures electrical quantities (voltage, current, resistance, capacitance and power), time, frequency and temperature used in the Cepel laboratories. Besides this the lab also provides services for other institutions and companies.

The adoption of the quality management system based on the ABNT NBR ISO/IEC 17025 standards ensures the technical competence of the laboratory to provide an extensive list of services.

Infrastructure

The laboratory equipment includes:

- Voltage and current calibrators;
- Standard decade resistance;
- Oscilloscope calibrator;
- Signal generators (standard frequency);
- Digital frequency counter;
- Voltage, current and resistance meters;
- Platinum resistance thermometers and calibration furnace;
- Power calibrators;
- Bridge capacitance and capacitance decade box.
The main activity of the High Voltage Laboratory (CA2), set up in 1996 by Cepel, is the high voltage calibration of measurement systems for full lightning surge, impulse switches, high voltage in AC (HVAC), high voltage in DC (HVDC), and current impulse, among others. These measurements and calibrations are primarily carried out for industrial laboratories, electrical equipment manufacturers, utilities and research institutions.

The CA2 lab, located at the Adrianópolis Unit, has been accredited since 2008 by INMETRO (National Institute of Metrology, Quality and Technology) for measuring high voltage AC of industrial frequency (60 Hz), in the range of 10 kV to 180 kV in accordance with the ABNT NBR ISO/IEC 17025 standards.

It is the only laboratory accredited by CGCRE (General Coordination of Accreditation of INMETRO) for full and chopped lightning surges up to 500 kV, with the ability to calibrate measuring systems up to 2.5 MV. The need to calibrate measurement systems in high voltage stems from the increasing demands of materials and electrical equipment markets, as well as from the standards of the ABNT NBR series ISO 9000, required by most countries that import Brazilian products and by domestic consumers.

The laboratory is also involved in R&D for new devices and new calibration and measurement techniques for high voltage testing. The lab designs, builds and calibrates special devices, such as standards for high DC voltage, resistive dividers for lightning impulse and drilling isolators, attenuators, current dividers and impedance of radio interference voltage.

The laboratory aims to obtain accreditations for HVAC in the range of 1.0 kV to 10 kV, capacitance in the range of 1.0 kV to 200 kV, HVDC in the range of 10 kV to 250 kV, switching impulse up to 500 kV, current impulse up to 100 kA and short-term current up to 5000 A.

The laboratory is preparing to implement the revisions of the IEC 60060-1/2010 and IEC 60060-2/2010 standards.

**Infrastructure**

The CA2 lab has an internal area of 12x11x7 m that is for high voltage measurement research and also to house the models. It has reference instrumentation and primary standards for ATCA, ATCC, full lightning impulse voltage, switching impulse, current impulse and impulse for drilling insulators.

The laboratory has the following equipment:

- Impulse generator 1000 kV, 50 kJ, 10 stages;
- AC power supply up to 200 kV/1.5 A;
- DC portable and modular power supply up to 240 kV/4.1 mA;
- Resistive voltage dividers of 500 kV;
- Mixed voltage dividers of 500 kV;
- System for acquisition and analysis of high voltage surges;
- Standard Capacitors of 100 pF/200 kV;
- Impulse current transformers up to 500 kA;
- Impulse current calibrators up to 20 kA;
- Impulse voltage calibrators up to 1900 V;
- AC/DC voltage calibrators up to 1000 V;
- Digital oscilloscopes of 1 GHz/10 GS/s;
- Crest voltmeters for impulse measurements;
- Multimeter 8½ Digit and precision RLC Bridges up to 100 MHz;
- Capacitance and tan delta bridge.

The standards allow the calibration of systems approved for tests with voltage impulses of up to 2500 kV crest and measuring current impulse up to 100 kA crest.

The High Voltage Laboratory partakes in interlaboratory comparisons of primary standards and mutual recognition for measurements of lightning surges with several international laboratories, among which are: Physicalisch Technische Bundesanstalt (PTB) in Germany; Centre for Metrology and Accreditation (MIKES), in Finland; Centro Eletrotecnico Sperimentale Italiano (Cesi), in Italy; Keuring van Elektrotechnische Materialen (Kema), in the Netherlands; National Institute of Standards and Technology (NIST) in the USA and L’Institut de Recherche d’Hydro-Québec (IREQ), in Canada.
The Laboratory for Safety in Electrical and Electronic Equipment (AP4), opened in 1986 by Cepel, was the first facility in Brazil to be fully equipped to do tests on all types of protection for electrical equipment to be used in potentially explosive atmospheres.

The AP4 lab, which is accredited by INMETRO (National Institute of Metrology, Quality and Technology), has facilities for testing transformers, frequency inverters and induction motors in order to evaluate their energy efficiency. The lab, located at the Adrianópolis Unit, carries out tests mainly for the chemical, petrochemical and oil industries. The AP4 lab tests assess whether electrical and electronic equipment are in accordance with standards and technical specifications. It participates in the Procel (National Program for Energy Conservation) and INMETRO classification program for electric motors. This program has resulted in higher performance and power factor of induction motors in the country. The lab also cooperates with institutions abroad, and has a mutual recognition agreement for test results with the Physikalisch-Technische Bundesanstalt (PTB), Germany.

**Infrastructure**

1) To evaluate electronic safeguards:
- Equipment for Comparative Tracking Index (CTI) tests up to 600 V;
- Standard electric discharge apparatus;
- System to evaluate temperature increases in AC and DC;
- Source for applied voltage tests (Hipot) up to 10 kV, 1 kVA.

2) To assess electromechanical protections:
- Dust test chamber with 3 m³ internal volume;
- Environment test chambers with internal volume of up to 1 m³;
- Hot-air sterilizers with internal volume of up to 1 m³;
- Surface Roughness Gauges;
- Gas analyzers;
- Autoclave with an internal volume of 1.4 m³;
- Chamber for testing explosion-proof enclosures with large volumes.

3) For electric motors, electronic drives and distribution transformers:
- Four sources of AC up to 500 kVA with variable frequency from 45 Hz to 400 Hz;
- Brake dynamometers up to 570 kW (500 hp);
- Source for applied voltage test (Hipot) up to 50 kV, 50 kVA;
- Power, resistance and relation of transformation and temperature meters;
The External Ultra High Voltage Laboratory (LabUA T Externo) is being set up at the Adrianópolis Unit of Cepel. This lab will carry out dielectric tests for experimental research, development and performance evaluation in AC and DC configurations of transmission lines, insulator strings and other high voltage components up to 1200 kV AC and ± 800 kV DC. Other equipment can be evaluated in special cases for which screened and weather controlled environments are not necessary.

The new infrastructure of this laboratory, pioneer in the Americas, will play an essential role in supporting the applied research of Cepel to overcome the technological challenges. One of these challenges is to develop new concepts for high capacity transmission lines capable of conducting large blocks of energy from the future hydroelectric undertakings of Belo Monte, the Teles Pires complex and others in the Amazon region.

The introduction of technological innovations in transmission projects requires the improvement of mathematical models, the development of theoretical studies, the building of prototypes and experimental research in laboratory facilities and along test lines. An example of such innovations is the concept of High Surge Impedance Loading (HSIL) AC Transmission Line, which Cepel has been developing and now has significant methodological and computational records on the matter. The new developments obtained in partnership with companies of the Eletrobras group such as Chesf and Furnas have already provided practical results for the National Interconnected System.

Once completed, the LabUA T Externo will have the capacity to carry out assessments of:

- AC transmission lines and insulator strings arrangements, single or three phase;
- DC transmission lines and insulator strings arrangements, monopolar or bipolar;
- voltage withstand tests for fast and slow front impulses in AC and DC arrangements;
- trials with combined voltage assembly (bias);
- AC phase-to-phase insulation tests;
- DC pole-to-pole insulation tests;
- radio interference and corona measurements in AC and DC;
- corona losses measurement in conductors under artificial rain with corona cage.

Infrastructure

LabUA T Externo has the following equipment for testing and support:

- Gantry for assembly of three-phase transmission line configurations;
- Corona cage for assessment of conductor performance under controlled artificial rain;
- 3 transformers with rated voltage of 750 kV, 1.0 A each, which can be combined for single phase assembly with rated voltage of 2,250 kV AC;
- 2 rectifiers with rated voltage of 1,000 kV, 50 mA each, which can be combined to monopolar assembly with rated voltage of 1,600 kV DC;
- pulse generator with rated voltage of 6.4 MV, 640 kJ;
- pulse generator with rated voltage of 2.0 MV, 100 kJ;
- voltage dividers and coupling capacitors;
- measuring instruments for AC, DC and impulse voltage; Corona related measurement: radio interference, electric fields, audible noise, and corona losses, etc.;
- Environmental parameters measurement (wind, temperature, pressure, solar radiation, etc.);
- platform with a 43 m boom;
- 17 m boom crane with a 2 t payload capacity;
- tractor to maneuver trailers carrying test equipment.
ILHA DO FUNDÃO UNIT
The Chemical Analysis Laboratory (MA1), set up by Cepel in 1974, carries out traditional and instrumental chemical analyses. The lab is able to develop methodologies and carry out chemical analysis according to national or international standards. These diagnostic services of MA1 cover a wide range of analyses to determine the useful life of the materials and electrical equipment for generation, transmission and distribution.

The MA1 lab, located at the Fundão Unit, also provides technical training for maintenance personnel of electric utilities.

The MA-1 is qualified to perform tests and technological services such as:

• Determination of the chemical composition of alloys;
• Chemical analysis of soils and water to assess aggressivity;
• Chemicals analysis of paints, resins, pigments, polymers, glass, cements etc.;
• Characterization of contaminants in insulating mineral oil;
• Evaluation of gas generation from an internal paint/oil system of transformer tanks;
• Compatibility of materials (papers, paints, rubbers etc..) with insulating liquids;
• Performance assessment of electrical insulating papers;
• Determination of the degree of polymerization (DP) in electrical insulation papers and cardboard;
• Transformer diagnostics using chromatographic analysis of the gases dissolved in insulating mineral oil and the analysis of the physicochemical parameters of insulating mineral oil.

Infrastructure

The chemical instrumentation and equipment of the MA1 lab for testing include:

• UV-VIS, IR and atomic absorption spectrophotometers;
• Thermogravimetric analyzer (TGA), differential thermal analyzer (DTA) and differential scanning calorimeter (DSC);
• Gas and liquid chromatograph (HPLC);
• Carbon and sulfur analyzer in ferrous and non-ferrous alloys (LECO);
• Sulfur in oil analyzer (LECO);
• Dielectric strength meter;
• Dielectric loss factor;
• Tensiometer;
• Digital hydrometer/density meter;
• Karl Fischer water analyzer.
Since 1974, at CEPEL, the Corrosion Laboratory (MA2) studies the different corrosion processes that affect equipments and metallic structures in a large number of companies in the electric sector, specifying corrosion protection techniques and researching new protection technologies seeking to increase the durability of equipments and structures to reduce the maintenance costs.

The laboratory conducts research activities and services with the goal of minimizing the different types of corrosion of metal structures, such as atmospheric corrosion, corrosion by soil and natural waters, among others. There are several techniques for corrosion protection using organic and metallic coatings, electrochemical techniques such as cathodic protection and electrochemical noise, besides technical inspection and expertise services.

The MA2 has also an Urban Atmospheric Corrosion Site, located in Fundão (RJ) and a Marine Atmospheric Corrosion Site, located in Mambucaba, Angra dos Reis (RJ).

The MA2 is able to specify appropriate techniques for corrosion protection for exposure conditions, identify corrosion problems and generating technical recommendations for solving these problems. It also provides technical training of maintenance personnel of the electric utilities.

Among the many tests and technological services performed by the Laboratory MA2 there are:

- Accelerated corrosion tests;
- Natural weathering tests;
- Analysis and physicochemical characterization of paints (liquid);
- Physicochemical characterization of coatings (dry film);
- Electrochemical studies of liquid and solid media;
- Characterization of soil properties.

The corrosion laboratory has the following facilities:

- Surface preparation room;
- Liquid coatings application chamber;
- Accelerated corrosion tests;
- Natural exposure test;
- Liquid paints analysis equipments;
- Mechanical tests for coatings characterisation;
- Electrochemical studies in liquids and soils.

Some equipments in the laboratory:

- UV Chambers;
- Salt Spray Chambers;
- Humidity chambers;
- Sulphur dioxide chamber.
The Metallographic Laboratory (MA3), started in 1978 by Cepel, performs a range of tests on metallic and non-metallic materials. They are the basis for studies and projects related to the structural integrity of equipment and for improving the properties of components that are used in a wide range of equipment.

MA3, located at the Fundão Unit, provides external services and technical support to research in metallurgy, thus meeting the requirements of the R&D programs at Cepel. The laboratory is divided into four special areas: I - Transmission electron microscopy (TEM); II - X-ray diffraction and sample preparation for TEM and SEM; III - Metallographic preparation, optical microscopy and scanning electron microscopy (SEM) and IV - Creep tests and heat treatment furnaces.

The Metallographic Laboratory provides assistance to electric utilities to analyze failures in components and equipment used in distribution and generation. Moreover, the lab gives technical training for the maintenance teams of electric utilities and issues technical expertise (reports) concerning equipment.

The main tests and technological services offered by MA-3 are:

- Structural failure analysis
- X-ray Diffraction
- Videoscope analysis
- Ultrasound fault detection
- Microstructural analysis by optical microscopy
- Microstructural analysis by SEM
- Microstructural analysis by TEM
- Fractography analysis
- Creep test
- Metallographic Replica test.

Infrastructure

The lab has a wide range of equipment including:

- X-rays diffractometer
- SEM and TEM with Energy Dispersive X-rays (EDX) Analysis
- Optical microscopes
- Laser Confocal Microscope (LEXT)
- Creep test equipment
- Heat treatment furnaces
- Hardness Testers (macro, micro and nano).

The laboratory also has specific equipment for non-destructive testing such as:

- Ultrasound
- Magnetic particles
- Metallographic replica
- Videoscope analyzer
- Portable X-Ray Fluorescence analyzer.
The Mechanical Properties Laboratory (MA4), set up in 1975 by Cepel, supports research projects of interest to the electricity sector and provides services to other industries. The lab carries out services and measurements in-house, in the field and at customer facilities.

MA4, located at the Fundão Unit, evaluates components and equipment and runs a materials acceptance program. The lab is involved in developing prototypes and lifespan studies, and also helps to develop predictive maintenance techniques by monitoring mechanical quantities.

The MA4 Laboratory has a dynamic testing area for equipment up to 500 kg and two long bays, one 60 m and the other 75 m long that can be kept at a stable temperature. These bays are used for testing TL cables, where long-duration mechanical load tests can be run and wind vibrations can be simulated.

The main products developed by the laboratory are prototypes, lifespan studies and predictive maintenance techniques.

The MA4 lab is qualified to run tests and technological services, such as:

- Tensile/compressive/flexural and impact tests on metal, polymer and ceramic specimens (max 500 kN);
- Creep tests on TL cables;
- Rupture tests of TL cables (max. 300 kN);
- Vibration tests on mechanical, electrical and electronic components;
- Frequency response tests on conductor cables;
- Efficiency of damper and frequency-sweep tests on cables;
- Data analysis of TL vibrations;
- Thermal fatigue tests.

Infrastructure

The MA4 Lab has the following infrastructure and equipment:

- A dynamic testing area for equipment with up to 500 kg including electrodynamic and hydraulic shakers on a vertical and horizontal vibration table measuring 0.9 m x 0.9 m;
- Two bays (60 m and 75 m long) with controlled temperature for testing TL cables, counterweights to apply long-duration mechanical load tests and an electromechanical exciter to simulate wind vibrations;
- Instrumentation to measure mechanical quantities (force, displacement, strain, acceleration etc.) and signal processing;
- Universal tension/compression testing machines for loads up to 500 kN;
- Cable testing machine with a 300 kN capacity;
- High temperature fatigue testing machine with a 100 kN capacity.
The Electric and Magnetic Properties Laboratory (MA6), set up by Cepel in 1976, is one of the few laboratories in Latin America capable of carrying out experimental investigations on the electrical and magnetic quantities in equipment and materials. The MA6 lab mainly carries out investigations for companies linked to the electricity industry; however, the lab also assesses parts and materials produced by Brazilian industry for export.

MA6, located at the Fundão Unit, provides services for the energy generating sector at thermoelectric and hydroelectric plants, as well as the nuclear sector. The lab also performs expert analyses on materials and equipments for identifying causes of failure.

This laboratory has developed techniques and methodologies for measuring electrical and magnetic quantities as well as test methodologies.

The lab is qualified to run tests and provide technological services to characterize electrical, dielectric and magnetic materials among others; some examples are:

- Analyses of partial discharges in high voltage components, up to 100 kV 60 Hz or in DC;
- Analyses of connectors and fixed or movable electrical connections, including contacts closing time;
- Expert analyses to identify causes of failures in materials, devices and electrical components in the laboratory;
- Evaluation of the electrical, magnetic and thermal behavior of materials under thermal cycling;
- Accelerated aging under temperature, current and high voltage tension of insulated bars for electric motors and hydro generators;
- Magnetic characteristics of metallic materials and nanofluids;
- Dielectric constant and dissipation factor as a function of frequency and temperature for solid dielectric materials, liquid, solid or paste, including petroleum;
- Critical current in metallic and non-metallic superconductors;
- Ferromagnetic losses in cables and connectors for transmission lines;
- Electrical resistance in DC and AC for transmission and lightning protection cables;
- Compounds efficiency analysis to improve electrical contacts and solders for electrical connections;
- Analyses of electrical transformers for metering and protection, assessment of accuracy and magnetic losses of the core. Short-circuit test and heating;
- Magnetic remanence factor in protective current transformers for electrical systems;
- Electrical tracking in solid polymeric compounds for outdoor use;
- Failure detection in electric welded joints (copper or aluminum), using non-destructive techniques, without removing any paint coatings;
- Expert analyses for materials, equipment and electrical systems to identify the causes of failure and/or accident, at the site and in the laboratory.

Infrastructure

MA6 is one of the most well equipped laboratories in its area in Brazil. The lab has high-sensitivity and accuracy instrumentations and is enabled to carry out measurements on voltages in the range of 10 pV to 200 kV and currents in the range of 10 nA up to 100 kA.
The Refrigeration Laboratory (MA7), opened in 1984 by Cepel, evaluates refrigerators, freezers and air conditioners for the Brazilian Labeling Program (PBE) and the National Program for Energy Conservation (Procel). It is located at the Fundão Unit.

The lab supports R&D projects in the “Energy Efficiency” research lines.

The experience gained by the laboratory from services and R&D projects has accredited it to partake in developing technical standards. Also it has an inter-laboratory comparison program with national and international institutions, and is a reference lab for other laboratories in the industry.

Accredited by INMETRO, the MA7 lab is qualified to test refrigerators and air conditioners as follows:

**Refrigerators**
- Classification;
- Power Consumption;

**Air Conditioners**
- Cooling capacity;
- Energy efficiency.

**Infrastructure**

MA7 has six environmental test chambers for refrigerators and freezers and one calorimeter calibrated for testing air conditioners. The lab is qualified to evaluate refrigerators of 127-220V and air conditioners of up to 48,000 BTU/h single-phase 127V/220V, and up to 60,000 BTU/h three phase 220V/380V.
The Lighting Laboratory (MA8), started by Cepel in 1984, supports government agencies in energy conservation and in energy efficiency for public, residential, commercial and industrial lighting systems and their components.

MA8, located at the Fundão Unit, is the technical arm of the partnership formed by Eletrobras, INMETRO (National Institute of Metrology, Quality and Technology) and Cepel to carry out the lighting programs of Procel and Ence (National Agency Labels for Energy Conservation). The lab is accredited by INMETRO to do the required tests on lamps and lighting in general. MA8 develops technical standards, and coordinates the implementation of performance indicators and test methods.

The MA8 lab does R&D into new technologies and energy efficiency projects.

The lab is able to test and provide technological services for lamps and lighting in residential, industrial and public systems, such as:

- Photometric and electrical characteristics
- Ultraviolet and infrared emission levels
- Spectroradiometric: color temperature, chromaticity coordinates and color rendering indexes
- Survey of photometric curves
- Transmittance and reflectance measurements of mirrors, windows and surfaces in general.

Infrastructure

The MA8 lab has the most up-to-date equipment for measuring and testing lighting, lamps and LEDs, including:

- Goniophotometer;
- Transmittance and reflectance meters;
- Integrating spheres;
- Spectroradiometer;
- UV meters;
- LED Tests.
The Washing Machine Laboratory (MAQLAV) was set up to evaluate washing machines following a request from Eletrobras to comply with Law No. 10.295, of October 17, 2001 that established the National Policy for Conservation and Rational Use of Energy. The MAQLAV lab is equipped to evaluate automatic and semi-automatic washing machines following the Brazilian standards for the industry, provides support for research and is involved in the development of testing methodologies.

The laboratory is qualified to carry out tests and technological services on washing machines in terms of:

- Energy efficiency;
- Water consumption;
- Cleaning efficiency of the wash;
- Water-extraction efficiency.

The MAQLAV lab has an Electrolux Wascator FOM 71 CLS washing machine as a reference model, washing machines with multi-loads, a calibrated colorimeter and an integrated digital system for test data acquisition. The lab has the capacity to evaluate automatic and semi automatic washing machines of 127V and 220V.

The MAQLAV lab has an Electrolux Wascator FOM 71 CLS washing machine as a reference model, washing machines with multi-loads, a calibrated colorimeter and an integrated digital system for test data acquisition. The lab has the capacity to evaluate automatic and semi automatic washing machines of 127V and 220V.
The Laboratory of Superconductivity, opened in 1996 by Cepel, carries out R&D in superconducting materials, devices and equipment for the electric power industry. The lab is multidisciplinary and combines basic sciences to applied research. It is one of the few Brazilian laboratories in the electric sector dedicated to the use of superconductivity.

Located at the Fundão Unit the laboratory has a focus on high critical temperature superconductors. These materials have zero resistance combined with high current densities (10 kA - 1 mA/cm², 77K), thus making the construction of compact and efficient equipment and devices possible.

Superconducting equipment can also substantially improve the reliability and quality of the electricity supply. Prototypes of superconducting equipment and devices, including power grid installations, have already been demonstrated in several countries. Superconducting equipment such as cables and fault current limiters can already be found commercially.

The main goals of the laboratory are: to acquire knowledge in applied superconductivity; provide human resources training (interns and fellows); and transfer knowledge to the electric power industry and other Brazilian industries.

A patent, PI0002965, 2001, was obtained by the Laboratory of Superconductivity from the National Institute of Industrial Property (INPI) for the sintering process in the production of ceramic superconductors using the powder-in-tube technique.

The Laboratory of Superconductivity carries out R&D projects and recently has been working on a superconducting fault current limiter and the processing and characterization of high critical temperature superconductors.

The lab is qualified to carry out DC voltage measurements up to 1000 A; accurate measurements of Pulsed Current (PC) voltage up to 1000 A (current pulses 10-500 ms); measurements of critical current up to 1000 A in a magnetic field of up to 1T; and the measurement of electrical resistance at temperatures from 20 K to room temperature.

The Superconductivity Laboratory also supports research on “Block Varistors” and “Fuel Cells” as both involve the study of advanced ceramics.

**Infrastructure**

- Critical current measuring systems (VxI curve) with DC and PC sources;
- Critical temperature measuring system (RxT curve) with cooling in a closed loop;
- A liquid helium cryostat with a 7 T superconducting coil;
- A liquid nitrogen cryostat with 1 T coils;
- Tube furnaces 1100 - 1500°C with atmospheric controllers;
- 1200°C Box furnace;
- 1700°C Box furnace;
- Impedance Analyzer (10 Hz to 110 MHz);
- Zirconia ball mill;
- Centrifuge;
- Analytical balance;
- Dry Glove Box;
- Drawbenches;
- Rolling Mills.
The Fuel Cell Laboratory (LabCelComb), which was set up in 2004, carries out R&D activities in three areas: Fuel Cell Based Power Generation Systems; Development and Characterization of Materials and Components for Fuel Cells; Production and Conditioning of Hydrogen.

The first area carries out research in power/energy analysis, technological and economic evaluation, electrothermal characterization and optimization of distributed generation (DG) systems made up of fuel cells or hybrid systems, operating in stand-alone or grid connected modes.

The second area is involved in improving the material properties of various components of fuel cell systems, such as electrolytes, anodes, cathodes, bipolar plates and interconnects in order to increase the performance and the life of these electric power generators. The characterization and failure analyses of these materials and components are also investigated.

The third area seeks the best processes for generating hydrogen from various primary fuels (natural gas, ethanol, biogas, etc.) or other energy resources under specific conditions and scenarios. In the LabCelComb also are made technical and economic evaluations of these processes or projects that use them.

Located at the Fundão Unit, the 5 x 3 x 15 m laboratory is equipped for electrothermal and electrochemical characterization of fuel cells, their materials and components.

The lab combines its theoretical and experimental activities, including setting up and operating the first system based on fuel cells – that is capable of running on hydrogen produced by steam reforming of natural gas - built by Electrocell, Brazil.

The LabCelComb supports the following research lines: “Fuel Cells”; “Energy Efficiency”; “Wind Power”; “Photovoltaic Solar Energy”; “Alternative Sources of Power Generation for Isolated Communities”; and “Nanotechnologies”. Eletrobras Chefs, Eletrobras Furnas and universities are among its main clients.
The Cepel Photovoltaic Systems Laboratory began over 15 years ago and has covered various research activities within the solar industry: from evaluation tests for the performance of photovoltaic components and systems to trials in end-user equipment, such as pumps and refrigerators for isolated systems.

The Photovoltaic Lab is part of the network of laboratories, which are members of the Brazilian Labeling Program, accredited by INMETRO (National Institute of Metrology, Quality and Technology).

The laboratory supports R&D projects for photovoltaic (PV) systems such as: assessment of the SIGFI20 and SIGFI30 systems for isolated communities under the ‘Light for All Program’; evaluations for efficient AC and DC refrigerators using PV systems; evaluation of batteries used in the SIGFIs of the Xapuri Community in Acre; analysis of water pumps used in the PV systems of the Energy Development Program of States and Municipalities (Prodeem) in the Northeast of Brazil, among other regions.

The lab has a team of researchers experienced in design and installation of PV systems. The main customers of the Photovoltaic Systems Laboratory are: Ministry of Mines and Energy (MME), companies of the Eletrobras group and power distribution concessionaires.
The Laboratory for the Development of Diagnostic Systems for Generation Equipment (LabDEq-G), opened in 2005, put the software SOMA (System for Monitoring Engineering Assets) into operation. This system monitors and diagnoses faults in generating equipment for the companies of the Eletrobras group.

SOMA monitors both mechanical and electrical data of electricity power generators giving the user analytical data via graphic interfaces as well as diagnoses of the operating conditions based on computational intelligence techniques.

LabDEq-G, located at the Fundão unit, has two main activities. The first is experimental, and provides the basis for software development; the second is dedicated specifically to software development.

The laboratory studies the dynamic behavior of rotary machinery; signal processing; mathematical modeling; corporate software and models to appraise generation equipment.

Infrastructure

The 54m² area of LabDEq-G is equipped with instrumentation (hardware) and its specific software; computers and test benches; servers; databases; and knowledge base software.
The Laboratory for Equipment Diagnostics and Electrical Installations (Labdig) was set up by Cepel in 1998. The lab is involved in projects, studies, expert reports, failure analyses, assessment of equipment and installations and aims to increase the reliability of the electrical system, to reduce maintenance costs, and also extend the useful life of equipment.

Labdig, located at the Fundão Unit, develops and applies potential techniques in projects for utilities; mainly companies of the Eletrobras group. In addition, the lab works with universities by supporting applied research and the development of specific tools for models and diagnostics.

The laboratory has top-of-the-line instrumentation and applies cutting-edge-techniques (state-of-the-art) in diagnosis, which, combined with a multidisciplinary team, enables the lab to identify different problems in a wide range of situations and to indicate the most appropriate techniques for each event and installation.

The lab is able to work with the following techniques:

- Partial Discharge (Electromagnetic);
- Acoustic Emission;
- Return Voltage (Polarization spectrum);
- Polarization / depolarization current (PDC);
- Frequency Domain Characterization (up to 10 MHz);
- Remote monitoring to characterize voltage transients in power transformers generated by equipment operations (circuit-breakers and disconnectors of conventional and SF6 substations);
- Gas chromatography of gases dissolved in insulating oil (in the field and online);
- Thermography;
- Radio interference;
- Leakage current.

All field measurements and evaluations are stored in a database, which contains data from more than 100 power transformers and 3,000 substations surge arresters. Algorithms and computational intelligence techniques (neural networks, fuzzy, wavelets) can be applied to increase the reliability of the diagnoses.

The activities of the laboratory include:

- Real time monitoring of On-Load Tap Changers (OLTCs);
- Development of methodologies to evaluate 500 kV CTs on-site;
- Monitoring of winding displacements of large transformers;
- Development of techniques to assess electrical insulation of transformers and reactors;
- Integration of diagnostic methodologies to assess surge arresters and instrument transformers on-site;
- Evaluation of interactions between autotransformers and the electrical system (Tijuco Preto substation - Furnas).

The electric utilities of the Eletrobras group - Furnas, Eletrosul, Chesf, Eletronorte and Electronuclear are the main customers of Labdig.

Infrastructure

Labdig has top-of-the-line instruments as well as special sources (a 200 kV AC source, free of partial discharges and a 700 kV impulse generator, which is being upgraded to 1000 kV), necessary for high voltage experiments and validation of techniques still in development.
The occurrence of Partial Discharges in the insulating systems of high voltage equipment is a sign of weakness in the dielectric strength. The evolution of the PD can lead to the breakdown of the dielectric, and may result in serious consequences for the equipment and the electrical system.

Partial Discharge detection inside an insulating system is essential to evaluate the operating state of virtually all insulation systems used in high-voltage equipment. PD detection techniques can prematurely diagnose deteriorations of the dielectric strength.

The Partial Discharge Research Laboratory (IMA Lab-e) carries out assessments and experimental research in high-voltage (up to 100 kV) at the utility frequency of 60 Hz. The lab supports research involving IMA systems (Instrumentation for Monitoring and Analysis of High Voltage Equipment), such as:

- IMA-DP – Partial Discharge;
- IMA-CTD – Capacitance and Tan Delta;
- IMA-TransV – Transient Voltage.

The IMA Lab, located at the Fundão Unit, carries out measurements on generators, motors, power transformers, reactors, instrument transformers and surge arresters, either on its facilities or in the field. The lab helps to develop and improve measurement methodologies and techniques for the evaluation of high voltage equipment. It also has training programs for technical personnel in dielectric evaluations in electrical equipment, since it is the base laboratory for further professional training courses given by Cepel.

**Infraestrutura**

The IMA Lab has equipment such as:
- Voltage transformer 0–100 kV/100 kVA;
- Coupling capacitors and voltage dividers;
- Measuring instruments in general: partial discharge measurement systems, digital oscilloscopes, spectrum analyzers, capacitance and tan δ measuring bridges;
- Calibrators and measurement impedances.
The Laboratory for the Development of Diagnostic Systems for Transmission Equipment (LabDEq-T) was set up by Cepel in 2005. This lab develops software to support decision making in the maintenance and operation of power transmission equipment.

LabDEq-T, located at the Fundão Unit, is a support unit for Cepel R&D projects in monitoring and diagnosis. The lab helps to improve and integrate other products and models that have been developed by Cepel in partnership with the original developers. The lab also participates in research of new techniques and in new projects.

The main products of LabDEq-T are the DianE System, an integrated system for equipment analysis and diagnostics; DianE_AQ, a service for the automatic scheduling of data acquisition coming from different servers; and RCM_DianE, a system for documenting and auditing the Reliability Centered Maintenance (RCM) process for equipment evaluated by DianE and which provides the knowledge base used in this diagnostic system.

The DianE System integrates information on registration data, testing, functional testing, inspections, continuous online monitoring and maintenance activities of transmission equipment such as power transformers, reactors, circuit breakers, disconnecting switches, instrument transformers, batteries, surge arresters, bushings on load.

Due to its wide scope and large number of uses DianE is an innovation in global terms. This open and evolutionary tool can carry out simultaneously standardized analyses of all the utility substations, all the monitored equipment and evaluate their operational risk. DianE is constantly evolving, and incorporating new features.

The laboratory develops research activities in areas such as: corporate software; models to assess transmission equipment condition and computational intelligence.

**Infrastructure**

- Servers;
- Databases;
- Knowledge Base.
Established in the late 1990’s, the Power Quality Laboratory (LABQ) is located at the Fundão Unit. The lab carries out analysis, diagnosis, simulation and measurements of Power Quality (PQ) problems as well as research into PQ. LABQ is considered a pioneer in this field in Brazil.

The laboratory is able to investigate PQ problems in utilities and large electricity customers as well as to develop new tools and equipment to improve PQ diagnosis and performance. Over the last fifteen years the lab has worked extensively for different stakeholders such as: generation, transmission and distribution utilities and also for industrial and commercial consumers with high impact of power electronic loads and controllers sensitive to PQ problems.

The team of researchers and technicians at LABQ has extensive experience in PQ measurements and research. Moreover, the lab has infrastructure with PQ analyzers and associated software, and three phase electric sources that can be used either in the field or in the lab.

At present the lab is working on developments related to load modeling for dynamic stability software based on active and reactive power measurements in the presence of voltage sags; development of a power quality analyzer for wind generators; and propagation of harmonics in the electric grid. The LABQ is able to carry out tests up to 520 V phase-to-phase and 4.500 VA.

The main clients of LABQ are: the Brazilian System Operator (ONS); industrial consumers of various sizes; generation, transmission and distribution utilities and wind park owners with harmonic and flicker problems.

Infrastructure
- Three Phase Sources: HP6834B (Agilent) up to 300 V phase to neutral and 4,500 VA; AMX-345 (Pacific Power) up to 270 V phase to neutral and 4,500 VA, programmable to play different waveforms and perform various types of PQ tests.
- PQ Meters and analyzers compatible with the standard IEC 61000-4-30.
- Programmable PQ meters and analyzers.
- Portable measuring devices.
- Phase measurement unit devices synchronized by GPS.

Standards and Procedures
- IEC 61000-4-30
- IEC 61000-4-15
- IEC 61000-4-7
- ONS’ Grid Code.
The Electric Energy Measurement Laboratory (LabMed), set up in 1987, has developed various products and Cepel has applied for patents of some of these products, such as the Centralized Metering System, the Ampere-hour Meter, the Centralized Telecontrol System For Load Control And Multiple Tariff Structures and, more recently, the Self-Monitoring Instrument Transformers. These products have patent applications (most already granted) in Brazil and abroad.

The LabMed, located at the Fundão Unit, supports R&D projects for equipment and systems development focused on power measurement and energy efficiency as well as on the improvement of measurement procedures related to power consumption and the reduction of electric energy losses.

## Infrastructure
- ZERA Stationary Meter Test Systems;
- MTE Portable Meter Test System;
- Radian Energy Standard Meters;
- Rotek Power Calibrators;
- California Power Source;
- Oscilloscopes;
- Spectrum Analyzers.

## Standards and/or procedures adopted
- ABNT (NBR14519, NBR14520, NBR14521, NBR14522);
- Inmetro Metrological standards;
- IEC and ANSI related standards.
The Advanced Supervision and Control Laboratory (Lasc), located at the Fundão Unit, has the infrastructure of a control center for research, development, testing and demonstration of technologies for monitoring and control of electric power systems in real time.

Established in 1995 Lasc has state-of-the-art equipment through continuous modernization and simulates the environment of a modern control center of an electric utility. This lab develops methodologies, algorithms and software that are tested and validated in an environment that encourages and promotes the sharing and exchanging of knowledge among researchers.

Organized around a modern visualization system, based on DLP and LED technologies, Lasc has workstations for software development that are connected to a powerful cluster of heterogeneous servers through a high-capacity communication network.

This laboratory is the basic platform for developing, testing and giving demonstrations of SAGE (Open Energy Management System), which is a powerful suite of computational applications aimed at the real-time operation of electrical systems, and used for the supervision and control of most of the network that makes up the Brazilian National Interconnected Electrical System.

SAGE encompasses all the features of a powerful energy management system (EMS): network analysis; closed-loop simulation; management of historical data, automatic generation control etc. This system is updated and receives new features on a regular basis, which promotes an intense use of the laboratory.

More detailed information on SAGE and other software being developed at Lasc are shown below.

Infrastructure

The laboratory has all the equipment necessary for the development of next-generation software (workstations and servers, PC’s, DLP visualization panel etc.).

To meet one of the basic principles of SAGE, which is to guarantee independence from any specific manufacturer, the Lasc platform is organized around a heterogeneous cluster with dozens of servers based on different technologies and operating systems, from the most important suppliers, and is interconnected through a high speed dedicated network:

- Intel/Linux;
- Sun/Solaris;
- HP/HPUX;
- HP/Linux etc.

**ADVANCED SUPERVISION AND CONTROL LABORATORY**

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The Intensive Computer Laboratory (LABCIN) supports the development and execution of high-performance parallel applications with the use of clusters. This laboratory also develops methodologies for users control, storage services and backup.

Currently, the laboratory consists of 3 (three) clusters and 7 (seven) servers totaling over 1,000 (one thousand) processing cores, enabling the execution of high-performance environment of NEWAVE model (long term operation planning program), DECOMP model (medium term operation planning program) and SUISHI model (Detailed simulation model of power plants operation for interconnected hydrothermal systems).

The NEWAVE program, with application in planning the operation long term, was the first to run with distributed processing, followed by DECOMP model, used in the planning of medium-term operation and in the beginning of 2015 the researchers of CEPEL developed the parallel version of SUISHI model. The CEPEL’s goal is to modify other programs of the chain models for distributed processing environment in order to lower their final run times.
The Laboratory of Geographic Information System (LabGIS) is equipped to support the use of GIS technology in the different research projects developed by CEPEL. The main objective is to provide hardware and software resources for the use of geographic information systems (GIS) concentrated in one laboratory unit, increasing exchanges among users.

LabGIS centralizes infrastructure and support, including map collection, data processing units with large processing capacity and data storage, displays, printers, scanners and large plotters, slide projectors and specific software licenses. LabGIS supports CEPEL’s activities in the development and integration of georeferenced information and image processing.

GIS is an evolution of CAD systems (Computer Aided Design), widely used in engineering, allowing a raster representation of images (represented by dots, as in a conventional photographic process) suitable for representing existing images on paper, such as maps.

GIS systems also allow the coexistence of vector and raster images. Among the available commercial GIS software, ArcGIS™ was chosen for standard use in the several projects in LabGIS. It is a complete package, with all the necessary resources for GIS activities, including tools for map scanning and image processing.

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The main LabGIS areas of activity:

- Application of GIS technology in river basin hydropower inventory studies and water resource management, especially including GIS at the SINV computational tool developed by CEPEL for river basin hydropower inventory studies;
- Structure of a georeferenced information system for the planning of hydropower projects in order to support new inventory and feasibility studies;
- Development of a computational tool for the best corridor choice for transmission lines according to environmental criteria, indicators and variables (AMBIENTRANS system);
- Support the development of inflow forecast models for the Brazilian hydropower system with the use of rainfall forecast models;
- Support the development of hydrodynamic and water quality models for reservoirs including the balance of greenhouse gases.
Cepel’s Synchrophasor Laboratory (LabPMU) is an infrastructure that allows tests of PMUs units and provides a computational platform for testing software applications using PMUs data. The main objective of the Lab is to provide the necessary ability to Cepel meet the requirements involving synchrophasor measurement.

LabPMU will also provide support for the Center’s activities, including the development and integration of new methods and techniques to their products already used in the Brazilian system and other electrical networks. In the future, it can perform advanced analysis to contribute to the development and improvement of national and international standards taking in account specific needs based in the Brazilian transmission and generation system.

LabPMU is able to provide technological support to PMU’s applications that runs in the Brazilian Interconnected System, helping the System Operator, electric utilities and equipment manufacturers. The lab will support the research for new computer applications and the implementation of PMU’s networks operating in the Brazilian System.

The main areas of LabPMU are:

• Reference tests on PMU units, in order to verify if they meet to the international standards and also the corrections needed in hardware and software before their installation in the field;

• Evaluation of synchrophasor concentrators through examination of their results under a controlled environment;

• Assessment of synchrophasor applications before their implantation on the Control Center. Besides, PMUs units from different vendors may be tested previously for those applications in typical situations of National Interconnected System, providing the development of new technologies and products.

The reference tests can already be performed by the Lab using a calibrator called PMUCal System, a pioneer in Latin America. The second and third areas of activity are under development and have a hardware and software infrastructure already available, that is, PMUs from different vendors, data concentrators (PDCs), commercial phasor visualization tool, as well as testing tools developed in LabView platform.

The funding of LabPMU was done using Cepel’s resources and MME (Ministry of Mines and Energy) & IBRD (International Bank for Reconstruction and Development) resources, through Energy and Mineral Sectors Strengthening Project. That project supports competitiveness and sustainable economic growth of energy and mining sectors.
The Efficient Technologies Application Center (Cate) was set up in 1996 and is a demonstration unit of technology and equipments for efficient use of electric energy. The Center is also a laboratory. 

Located at the Fundão Unit, Cate also provides energy diagnostic services, human resources training and elaborate technical papers and publications.

The Center has gathered a vast amount of technical know-how based on energy audits in different industrial plants ranging from textiles and beverages to automobiles and nuclear fuels. Other fields and activities such as environmental sanitation companies, commercial buildings, administrative headquarters of public services and schools have also been examined.

Cate has two locations at the Fundão Unit, to demonstrate commercially available technology for energy reduction. The first is the Efficient Solar House, which is run jointly with the Reference Center for Solar Energy and Wind Sérgio de Salvo Brito (CRESES), and the second is a permanent exhibition area to demonstrate some alternative. Technologies to reduce energy consumption in areas like architecture, lighting, industrial systems, electric motor driving, and home appliances include in the efficiency Labeling Program of Procel (National Program For Energy Conservation).

Cate also supports software development programs such as BDMotor (electric motor database). This software helps the providing for the acquisition, replacement and repair of electric motors, via economic analysis and engine load factors.

The center conducts training courses with an emphasis on practical classes and specific approaches for each specialty. Wide support is provided by the Cepel laboratories and their experienced consultants.

Its numerous clients include: Eletrobras; electric utilities; public institutions; universities; industries; engineers and architects; construction companies and industrial and building maintenance firms.

Infrastructure

- Efficient Solar House: Alternative controls and systems to reduce energy consumption (presence sensors, power meters, remote control and monitoring systems, efficient lighting and energy saving showerheads, etc.)
- Permanent exhibition: household appliances, included in the Procel Labeling Program; a room assigned entirely to efficient lighting systems with panels equipped with meters, lamps and light fixtures; fluid pumping systems for industries; software and manuals; techniques to reduce heat gains through windows and roofs; optimized engine design.
- Diagnostics and training: software to evaluate and simulate energy consumption; training rooms and top-of-the-line multimedia equipment for local and distance training.
- Tools for energy audits: meters and registers of electric energy and power quality; meteorological data acquisition equipment; luxmeters; anemometers; combustion emissions analyzer; thermometric probes; video thermography; ultrasonic flow meters; compressed air leak detectors; geophones; acquisition, data processing systems and energy audit simulators.
The Reference Center for Solar and Wind Energy Sérgio de Salvo Brito (CRESESB) was created in 1994 to promote the development of solar and wind power by sharing know-how, extending dialogue between related organizations and encouraging the implementation of research and programs.

The Center is named in honor of Sérgio de Salvo Brito, an engineer who took up the cause of renewable energy. He was one of the most internationally known and respected Brazilian in this field.

CRESESB supports the Ministry of Science, Technology and Innovation (MCTI) and the Ministry of Mines and Energy (MME) programs such as the National Program for Universal Access To and Use of Electric Power ("Luz para Todos"). The Center also prepares and gives training courses; participates in meetings and work groups; conducts feasibility studies for projects; promotes or supports events related to solar and wind energy; and edits technical publications (books, newsletters and reports).

CRESESB organizes technical visits to the Efficient Solar House, a demonstration center that acts as a disseminator of solar (thermal and photovoltaic), wind energy and energy-efficient technologies. The Center also carries out research into integrated operations of these technologies.

The Center has a library on solar and wind energy and a website with specific information concerning these two alternative energy sources. It also has a link for a virtual tour of the Efficient Solar House.

The Center supports research into "Solar Thermal Energy", "Solar Photovoltaic Energy" and "Wind Energy". Researchers, engineers, technicians, students and teachers of universities and high schools, national and foreign institutions and companies are all users of the Center.

Both CRESESB and the Efficient Solar House are located at the Fundão Unit.