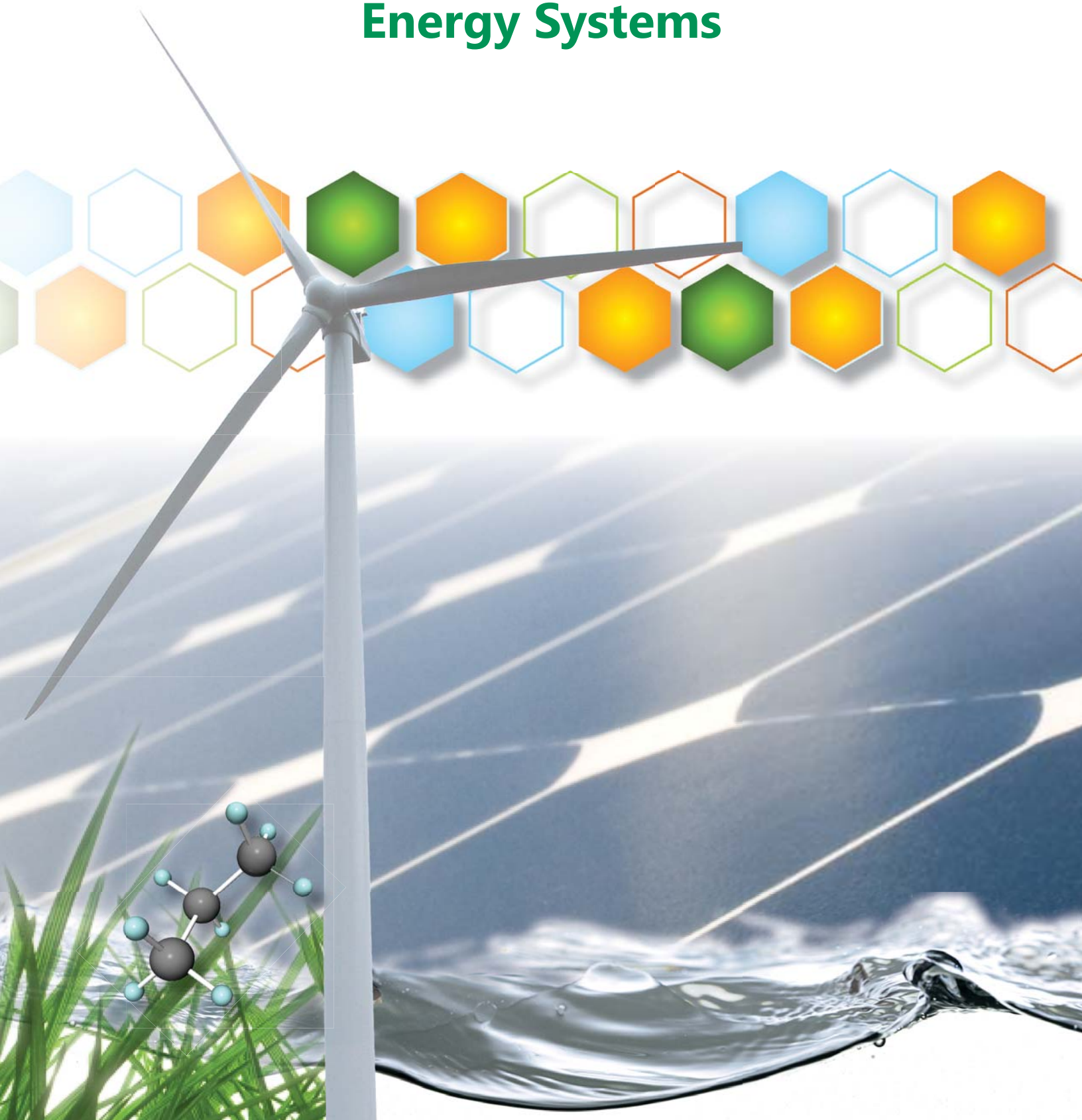
Lab-Volt®

Alternative and Renewable Energy Systems



Lab-Volt's Alternative Energy Training Program was developed as a three-tiered program. It begins at the secondary education level with 40 hours of Graymark's GREENtech program and continues with hands-on training on our comprehensive training systems: Solar/Wind Energy, Solar Thermal Energy, Wind Turbine Nacelle, Electric Pitch Hub, Hydraulic Pitch Hub, Geothermal, and Grid Tie.

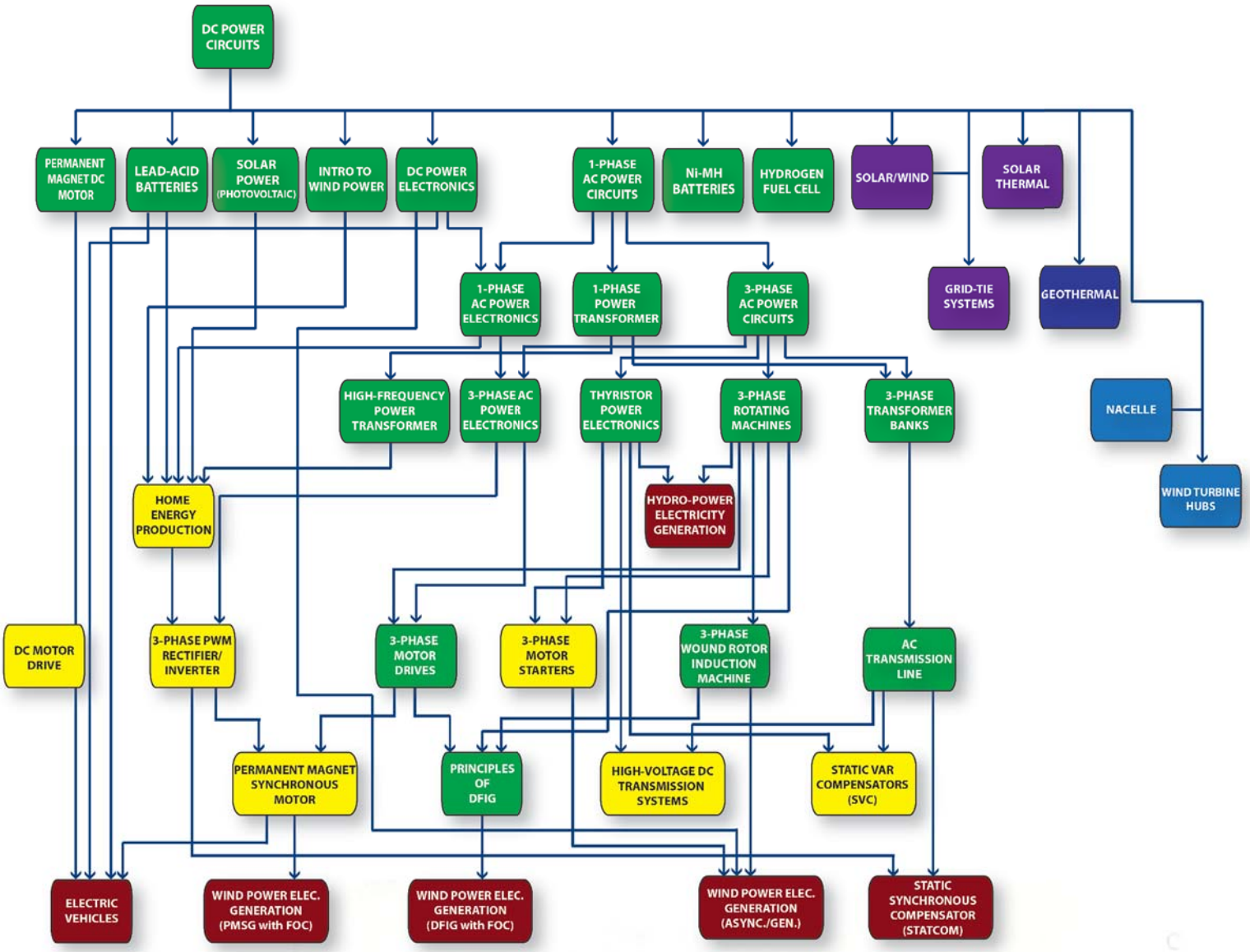
These secondary education programs focus on installation and operation, including electrical skills, maintenance and support, and an understanding of the set-up and use of stand-alone (a small renewable energy system that is not connected to the electricity grid) and grid-tied (a small renewable energy system that *is* connected to the electricity grid) renewable energy systems.

The college and university two-year program is based on Lab-Volt's Electromechanical Systems trainer and focuses on power generation, transmission, and distribution and voltage/frequency power synchronization, as well as control of the many different types of generators used in wind and hydro power. Also included in this program are the power electronics behind alternative and renewable energy systems, battery chargers and small electric vehicles, hydrogen fuel cells, and energy storage.

Lab-Volt also offers comprehensive simulation training with our Wind Farm Simulator and Grid-Tie Systems simulation software.

Table of Contents

RENEWABLE ENERGY TRAINING PROGRAM



Graymark® GREENtech

GREENtech is a low-cost turnkey Energy Efficiency & Renewable Energy Training Lab that includes all the courseware, hardware, software, tools and accessories needed to provide the basic knowledge and the hands-on skills required to enter the green collar job market.

Topic coverage includes:

- Introduction to the Trainer
- Energy Overview
- Solar Energy
- Wind Energy
- Fuel Cell Energy
- Electrical Energy Distribution
- Career Opportunities
- Introduction to Electricity
- Electrical Circuits
- Solar Panels
- Fuel Cell Computer Interface
- Fuel Cells and Zero Emissions Car
- Wind Turbines

Training Lab Components

- Reversible Fuel Cell
- Wind Turbine with different blade sizes
- 1-w Solar Panel
- Data Acquisition Board
- Graphic Software
- Hydro Car
- DC Motor with propeller
- 2 AA Battery Holder
- Student Theory and Lab Manual
- Student Accessories
- Student Tools

Solar/Wind Energy Training System
Model 46120-00

Lab-Volt Systems, Inc. is proud to lead the way in offering new hands-on training systems in Alternative, Renewable, and Sustainable Energy Technology. The Solar/Wind Energy Trainer is our initial offering in this series and includes state-of-the-art components and curriculum. Lab-Volt's Alternative Energy training programs are not only for those who can make a difference today, but also for those who will shape the future of these technologies.

The Solar/Wind Energy Trainer forms a complete hybrid energy training system. This program demonstrates how wind turbines and solar cells are being used in the consumer and industrial markets to supplement the world's power needs. The program explores solar and wind as energy sources that can be used to help reduce dependence on non-renewable fuel sources. Students gain a global perspective when they understand the economics, efficiency, and low environmental impact of producing energy from non-polluting, renewable sources.

Topic Coverage

- Energy Fundamentals
- Trainer Familiarization and Safety
- Solar Module
- Wind Turbine
- Solar/Wind Systems
- Going Green

Shown with AC Flood Lamp (Sun Simulator)

Solar Thermal Energy Training System
Model 46121

The Lab-Volt 46121 Solar Thermal Energy Training System is a solar hot water heating system. Students will be able to install system components, observe pressures, temperatures, and flow rates. Students will set up various realistic operating environments, such as radiant floor heating, passive and active solar water heating, space heating, and hot water heat exchangers.

This system provides a small-scale hot water supply, radiator, and hydronic floor heating system to teach students how solar radiant energy can be harnessed from the sun and converted to solar thermal energy in order to elevate air, water, and surface temperatures within a residential home or commercial business.

Topic Coverage

Introduction to Solar Thermal Energy
- Thermal Energy Fundamentals
- Trainer Familiarization and Safety
- Site Analysis
- System Sizing

Solar Thermal Energy Systems
- Solar Heating and Cooling Systems
- Collecting Thermal Energy
- Storing/Exchanging Thermal Energy
- Supplying/Controlling Thermal Energy

Multi-Loop Systems
- Closed-Loop Water Heating
- Closed-Loop Surface Heating
- Closed-Loop Air Heating
- Closed-Loop Drainback Systems
- Closed-Loop Combination Systems

Grid-Tie Training System
Model 46125

Alternative energy systems that convert solar or wind power to electricity can supply electric power to the utility grid. Grid-tied systems generate electricity and send this energy back to the utility company's power grid.

The energy produced counts against the energy a home or business uses, thereby offsetting utility usage. Lab-Volt's Grid-Tied Training System provides hands-on training in developing the skills required for installing a grid-tied system and meets NEC Code Compliance requirements.

Model 46120-A0 shown. Add-on to the Solar/Wind Energy Training System, Model 46120

Topic Coverage

Grid Connected Equipment
- Commercial String Inverters
- Installing a Grid-Tied System
- Wiring and Configuring

Utility Grid
- Smart-Grid Technology
- Remote Data Acquisition
- Power Management Techniques

The NEC
- The NEC Code as it Applies to Alternative Energy Installation in the U.S.
- Installation Requirements for Solar and Wind Power Systems in the Continental U.S. and its Territories

Geothermal Training System
Model 46126

The Lab-Volt Geothermal Training Systems, Models 46126-0 and 46126-A, are designed to teach the fundamentals of heat transfer, refrigeration, and air conditioning applied to geothermal energy HVAC projects. The operation of each system faithfully reproduces that of a typical geothermal residential system and includes all real-world components. The advanced system, Model 46126-A, features a second heat pump which is used to control the temperature in the ground loop heat exchanger to simulate various ground conditions.

Topic coverage*:

- Introduction and Overview
- The Ground Loop
- Heat Pump Connections and Interior Piping
- The Refrigeration Cycle
- Psychrometrics
- Geothermal Heat Pumps
- Heat Exchangers
- Heat Pump Control and Safety Devices
- System Characterization
- Maintenance and Troubleshooting
- Geothermal Software Design Tools

INTERNATIONAL GROUND SOURCE HEAT PUMP ASSOCIATION

*Topics covered will assist in completing the IGSHPA Accredited Installer exam.

Wind Turbine Nacelle Training System
Models 46122 and 46122-A0

Lab-Volt's Model 46122 Wind Turbine Nacelle Trainer is a complete scaled-down version of commercial wind turbine nacelles. The trainer consists of a complete drive train including the main shaft, a gearbox with a transparent side cover, speed sensors, a hydraulic brake, and an asynchronous generator.

Lab-Volt has recently created the Model 46122-A0, a new version of the Wind Turbine Nacelle Training System that features a Grid Connection option. This new model differs from the existing Model 46122 in that it has the additional capability of connecting to a three-phase network to transmit to the grid the power produced with the generator.

Topic Coverage

- Introduction to Energy Production with Wind Power
- Machine Safety
- Introduction to SCADA
- Hydraulic Braking System
- Wind Turbine Operation
- Electrical System
- Heating/Cooling Systems
- Troubleshooting

Electrical Pitch Hub Training System
Model 46123

Lab-Volt's Electrical Pitch Hub Trainer features all the components typically found in the hub of a commercial wind turbine and a representation of the wind turbine blade. The Electrical Pitch Hub Trainer addresses blade pitch control and emergency back-up systems using the appropriate technologies typical to electrical pitch control systems. A SIEMENS PLC controls the different functions of the hub and is located in a transparent electrical enclosure, with all the other electrical components.

The Electrical Pitch Hub Training System can be linked to the Nacelle Training System, Model 46122 through a fiber-optic connector to demonstrate the pitch adjustment with wind conditions.

Topic Coverage

- Introduction to Energy Production with Wind Power
- Machine Safety
- Introduction to SCADA
- Rotor
- Electric Pitch Control Operation
- Electrical System
- Back-Up Power
- Troubleshooting

Hydraulic Pitch Hub Training System
Model 46124

Lab-Volt's Hydraulic Pitch Hub Trainer features a representation of the wind turbine blade and all the components typically found in the hub of a commercial wind turbine. The Hydraulic Pitch Hub Trainer addresses blade pitch control and emergency back-up systems using the appropriate technologies typical to hydraulic pitch control systems. A SIEMENS PLC controls the different functions of the hub and is located in a transparent electrical enclosure, with all the other electrical components.

The Hydraulic Pitch Hub Training System can be linked to the Nacelle Training System, Model 46122 through a fiber-optic connector to demonstrate the pitch adjustment with wind conditions.

Topic Coverage

- Introduction to Energy Production with Wind Power
- Machine Safety
- Introduction to SCADA
- Rotor
- Hydraulic System
- Hydraulic Pitch Control Operation
- Electrical System
- Back-Up Power
- Troubleshooting

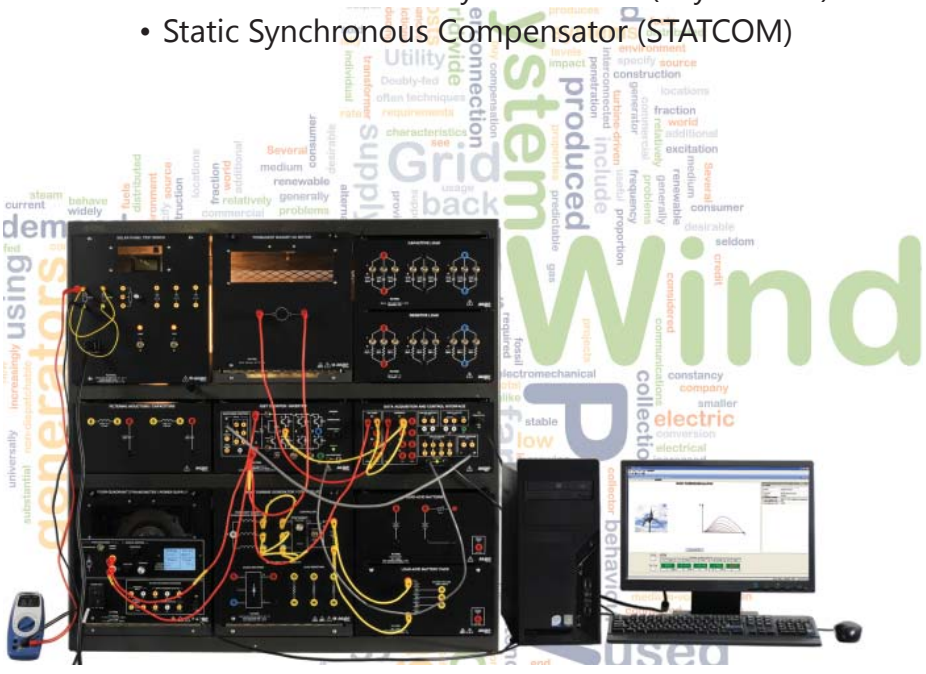
Renewable Energy Training Program

Renewable Energy Training Systems, Series 8010

Lab-Volt's Renewable Energy Training Systems, based on the proven Lab-Volt Electromechanical System (EMS) as well as newly-developed, state-of-the-art training equipment, provide a turn-key solution dealing with different aspects of the wide field of renewable energy. This program provides in-depth coverage of a wide variety of topics related to the field of renewable energy, such as the large-scale production of electrical energy from hydro power, solar power, and wind power (doubly-fed induction generator [DFIG], synchronous generator, and asynchronous generator technologies), small-scale production of electrical energy from wind power and solar power, storage of energy in batteries, home energy production, and drive systems for small electric vehicles (e.g., bicycles, scooters, golf carts, fork lifts, etc.) and electric cars. The program also covers power electronics as well as the fundamentals of electricity required to understand the numerous technical aspects related to the production and use of renewable energy.

Courses in the Renewable Energy Training Program

- DC Power Circuits
- Permanent Magnet DC Motor
- Lead-Acid Batteries
- Solar Power (Photovoltaic)
- Introduction to Wind Power
- DC Power Electronics
- Single-Phase AC Power Circuits
- Ni-MH Batteries
- Hydrogen Fuel Cell
- Single-Phase AC Power Electronics
- Single-Phase Power Transformers
- Three-Phase AC Power Circuits
- DC Motor Drives
- High-Frequency Power Transformer
- Three-Phase AC Power Electronics
- Thyristor Power Electronics
- Three-Phase Rotating Machines
- Three-Phase Transformer Banks
- Home Energy Production
- Hydro-Power Electricity Generation
- Three-Phase PWM Rectifier/Inverter
- Three-Phase Motor Drives
- Three-Phase Motor Starters
- Three-Phase Wound-Rotor Induction Machine
- AC Transmission Line
- Permanent Magnet Synchronous Motor
- Principles of DFIG
- High-Voltage DC Transmission Line
- Static VAR Compensators (SVC)
- Electric Vehicles
- Wind Power Electricity Generation (PMSG with FOC)
- Wind Power Electricity Generation (DFIG with FOC)
- Wind Power Electricity Generation (Async. Gen.)
- Static Synchronous Compensator (STATCOM)



Renewable Energy Training Program

DC Power Circuits

The DC Power Circuits course introduces students to the fundamentals of electricity, such as the direct current (DC), DC voltage, resistance, and Ohm's Law.

Topic coverage includes:

- Voltage, Current, and Ohm's Law
- Equivalent Resistance
- Power in DC Circuits
- Series and Parallel Circuits

Permanent Magnet DC Motors

This course introduces students to permanent magnet DC motors used as either generators or motors. The course covers the construction, operating principles, and characteristic curves of permanent magnet DC motors related to each of these two operating modes.

Topic coverage includes:

- Operation as a Generator
- Operation as a Motor

Lead-Acid Batteries

The Lead-Acid Batteries course explains how a lead-acid battery produces electricity from a chemical reaction. The course familiarizes students with the charge and discharge characteristics of lead-acid batteries. Students also learn the various methods of charging lead-acid batteries.

Topic coverage includes:

- Battery Fundamentals
- Discharge Characteristics
- Battery Charging Fundamentals
- Battery Charging Methods

Renewable Energy Training Program

Solar Power (Photovoltaic)

Solar Panel Test Bench (with Solar Panel installed)

Lead-Acid Batteries

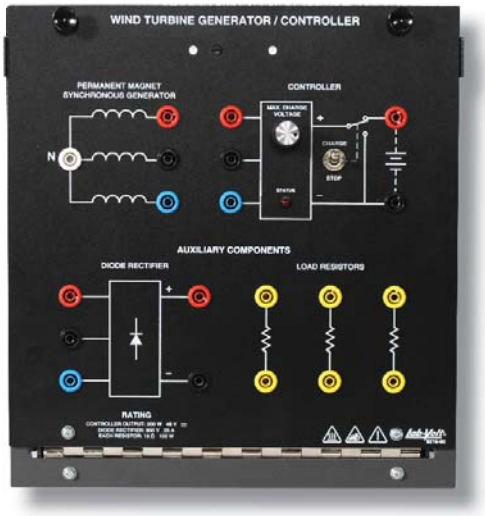
Monocrystalline Silicon Solar Panel (front and back)

The Solar Power course features the production of electricity using photovoltaic (PV) solar panels. The course introduces the diode, the basic semiconductor component in PV solar panels. Producing electricity from solar power as well as storing the electric energy in batteries is also covered, as are connecting PV panels in series and in parallel to increase the voltage and current produced, respectively, and setting the orientation of solar panels so the maximum amount of energy is produced.

Topic coverage includes:

- The Diode
- The Solar Panel (Photovoltaic Panel)
- Effect of Temperature on Solar Panel Performance
- Storing Energy from Solar Panels into Batteries
- Effect of Shading on Solar Panel Operation
- Solar Panel Orientation
- Solar Panel Performance vs. Insolation

Introduction to Wind Power



The Introduction to Wind Power course familiarizes students with the small-scale production of electricity using a fixed-pitch, direct-drive wind turbine. Students learn how a wind turbine produces electricity from wind power as well as how to store this electric energy in batteries to ensure the availability of electric power when there is no wind or during low wind periods. A realistic wind turbine rotor emulator and an actual wind turbine generator are used in the hands-on exercises to reproduce the behavior of a small wind turbine operating under various conditions of wind, in the laboratory classroom.

Topic coverage includes:

- Voltage-Speed Characteristic of a Wind Turbine Generator
- Torque-Current Characteristic of a Wind Turbine Generator
- Power vs. Wind Speed
- Storing Energy from a Wind Turbine into Batteries

Renewable Energy Training Program

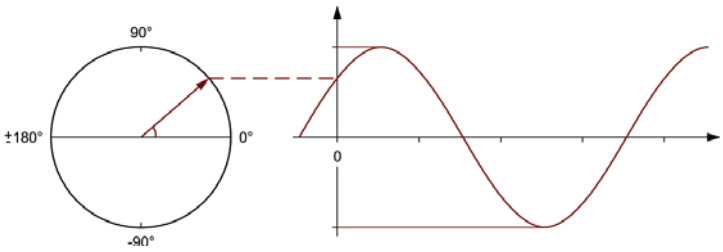
DC Power Electronics: Diodes, IGBTs, and Choppers

The DC Power Electronics course introduces the student to power electronic components and circuits (choppers) required to manage DC power, such as the DC power stored in batteries or produced from wind power or solar power. The course first presents the diode and the switching transistor, the two main semiconductor components used in power electronics. The remainder of the course covers the main types of choppers, high-speed power switching (voltage-type and current-type circuits, free-wheeling diodes, etc.), controlling ripple in choppers, and building a battery charger using a buck chopper.

Topic coverage includes:

- The Diode and the Switching Transistor
- The Buck Chopper
- Introduction to High-Speed Power Switching
- Ripple in Choppers
- The Lead-Acid Battery Charger
- The Boost Chopper
- The Buck/Boost Chopper
- The Four-Quadrant Chopper

Single-Phase AC Power Circuits



The Single-Phase AC Power Circuits course first introduces the student to the fundamentals of alternating current (AC) such as the sine wave, period and frequency, phase angle and phase shift, instantaneous and average power, etc. The student then becomes familiar with the inductor and capacitor. The course continues with more advanced topics such as the impedance, active power, reactive power, apparent power, and power triangle. The course concludes by teaching the student how to solve AC power circuits using the impedance calculation method or the power triangle method.

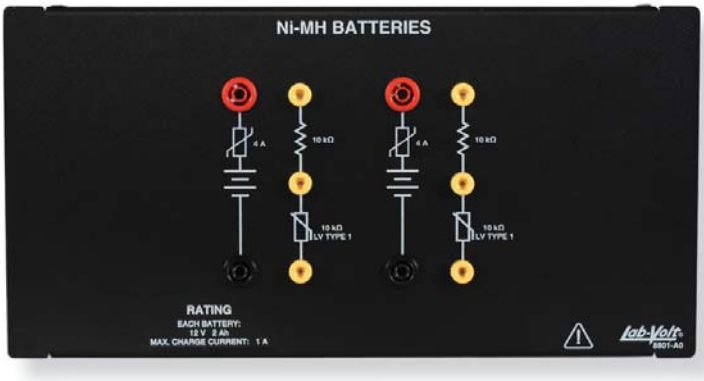
Topic coverage includes:

- The Sine Wave
- Phase Angle and Phase Shift
- Instantaneous Power and Average Power
- Inductive Reactance
- Capacitive Reactance
- Impedance
- Active and Reactive Power
- Apparent Power and the Power Triangle
- Solving Simple AC Circuits using Circuit Impedance Calculation
- Solving AC Circuits Using the Power Triangle Method

Renewable Energy Training Program

Ni-MH Batteries

The Ni-MH Batteries course explains how a nickel-metal hydride (Ni-MH) battery produces electricity from a chemical reaction. The course familiarizes the student with the charge and discharge characteristics of Ni-MH batteries as well as the various methods of charging Ni-MH batteries, with emphasis on the various methods of terminating the charge (temperature cutoff, voltage drop, and rate of temperature increase).



Topic coverage includes:

- Battery Fundamentals
- Battery Charging Fundamentals
- Battery Charging Methods

Hydrogen Fuel Cells

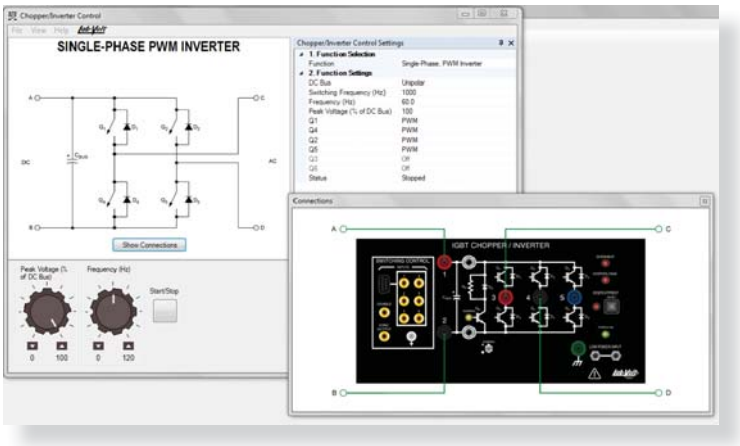
The Hydrogen Fuel Cell course teaches foundational engineering principles of fuel cell systems. The course covers the structure and functioning principles, the thermodynamics theory, and the different characteristics of a real 50 W fuel cell system. Through numerous experiments, the students will also learn about the safety aspects of this type of technology.

Topic coverage includes:

- The Basic Functions of the Fuel Cell System
- The Characteristic Curve of a Fuel Cell
- Parameters Influencing the Characteristic Curve
- Determination of the Hydrogen Current Curve
- Efficiency of the Fuel Cell Stack
- Set-up of a Fuel Cell Power Supply
- Efficiency of a Fuel Cell Power Supply
- Fuel Cell Application I: Remote Traffic Light
- Fuel Cell Application II: Fuel Cell Car

Renewable Energy Training Program

Single-Phase AC Power Electronics



The Single-Phase AC Power Electronics course introduces the student to power electronic circuits (rectifiers and inverters) used to perform AC/DC power conversion in single-phase circuits. The course begins with the study of single-phase diode rectifiers. The student then becomes familiar with the operation of the single-phase inverter and the single-phase PWM rectifier. The course concludes with the study of power flow in a single-phase PWM rectifier.

Topic coverage includes:

- Power Diode Single-Phase Rectifiers
- The Single-Phase Inverter
- The Single-Phase PWM Rectifier
- Power Flow in a Single-Phase PWM Rectifier

Single-Phase Power Transformer

The Single-Phase Power Transformers course covers, through theory and demonstrations, the operating characteristics of single-phase power transformers. Through measurements, students will learn the important characteristics of a power transformer, such as the turns ratio, voltage and current ratios, winding polarity, voltage regulation, power losses, and transformer ratings.

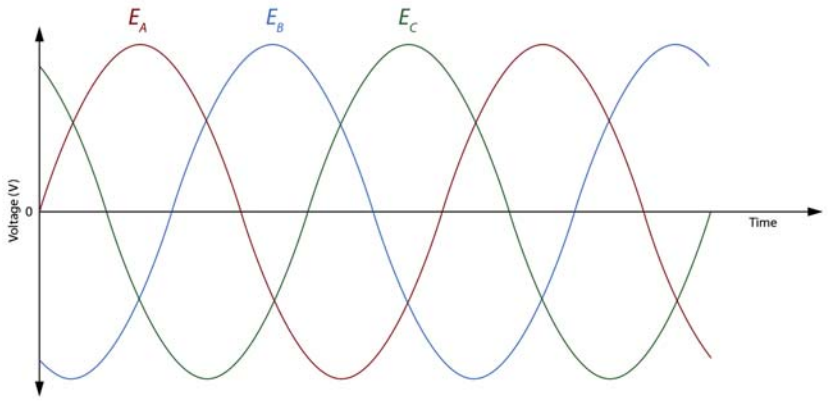
Topic coverage includes:

- Voltage and Current Ratios
- Transformer Polarity
- Transformer Regulation
- The Autotransformer

Renewable Energy Training Program

Three-Phase AC Power Circuits

The Three-Phase AC Power Circuit course familiarizes the student with three-phase power systems. The course first introduces the student to the fundamentals of three-phase power systems such as the wye (star) and delta configurations, phase and line voltages, phase and line currents, phase balance, etc. The student then learns how to measure power in three-phase circuits using the two-wattmeter method as well as how to determine the power factor. Finally, the student learns what the phase sequence is and how to determine the phase sequence of a three-phase power system.

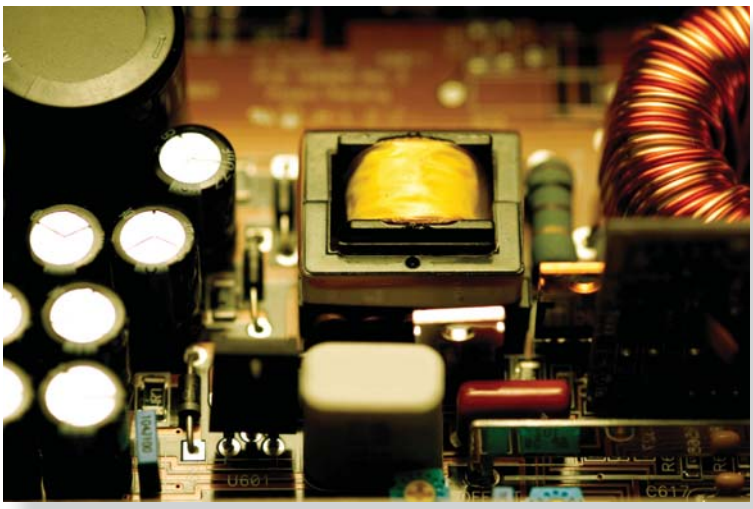


Topic coverage includes:

- Balanced Three-Phase Circuits
- Three-Phase Power Measurement
- Phase Sequence

High-Frequency Power Transformer

The High-Frequency Power Transformer course demonstrates how high-frequency switching can be used to increase the power handling capability of power transformers. This type of power transformer is commonly used to perform DC-to-DC conversion in grid-tied inverters used for home energy production.



Topic coverage includes:

- High-Frequency Power Transformer

Renewable Energy Training Program

Three-Phase AC Power Electronics

The Three-Phase Power Electronics course introduces the student to power electronic circuits (rectifiers and inverters) used to perform AC/DC power conversion in three-phase circuits. The course begins with the study of three-phase diode rectifiers. The student then becomes familiar with the operation of the single-phase inverter built with a dual-polarity DC bus. The course continues with the operation of the three-phase inverter built with a single-polarity or dual-polarity DC bus. The course concludes with the study of the three-phase PWM rectifier. The 180° modulation and pulse-width modulation (PWM) techniques are introduced during the study of the inverters and PWM rectifier.

Topic coverage includes:

- Power Diode Three-Phase Rectifiers
- The Single-Phase Inverter with Dual-Polarity DC Bus
- The Three-Phase Inverter

Three-Phase Rotating Machines

The Three-Phase Rotating Machines course familiarizes students with the various three-phase machines used for large-scale production of electricity from wind power and hydro power. The course begins with fundamentals of rotating machines such as the torque, rotation speed, direction of rotation, motor power, power losses in motor, motor efficiency, etc. Students then study the operation of the following three-phase machines: squirrel-cage induction machine and synchronous machine.

Topic coverage includes:

- Prime Mover and Brake Operation
- The Three-Phase Squirrel Cage Induction Motor
- Eddy-Current Brake and Asynchronous Generator
- The Three-Phase Synchronous Motor
- Synchronous Motor Pull-Out Torque
- The Three-Phase Synchronous Generator No-Load Operation
- The Three-Phase Synchronous Generator Voltage-Regulation Characteristics

Renewable Energy Training Program

Thyristor Power Electronics

The Thyristor Power Electronics course introduces students to the power electronic component (thyristor) and circuits (rectifiers) used to control very large amounts of DC power, as in the excitation circuit of synchronous generators in a hydro-power electricity plant. The course first presents the thyristor, the main semiconductor component used to control large amounts of DC power. The student is then introduced to AC phase control. Through the remainder of the course, the student becomes familiar with the single-phase and three-phase thyristor bridges, in both the rectifier and inverter modes.

Topic coverage includes:

- Power Diode Three-Phase Rectifiers
- The Power Thyristors
- The Solid State Relay
- Single-Phase AC Power Control
- Three-Phase AC Power Control
- Thyristor Three-Phase Rectifier/Inverter

Three-Phase Transformer Banks

The Three-Phase Transformer Banks course covers the operating characteristics of three-phase transformer banks. The course covers the winding connection (wye and delta configurations) and shows how to ensure proper phase relationships between the phase windings.

Topic coverage includes:

- Three-Phase Transformer Connections
- Voltage and Current Relationships

Renewable Energy Training Program

Home Energy Production

The Home Energy production Course explains how to produce AC power from the DC power produced using renewable natural resources (e.g., wind, sunlight, etc.) and stored in batteries. The course first shows how to produce AC power for local use (typically at remote sites) from DC power produced using solar panels or a wind turbine. The course then explains how the AC power produced can be supplied to the local AC power network via a single-phase grid-tied inverter using either the LF or HF power transformer technology. The course also deals with the use of MPP trackers for optimizing energy production.

Topic coverage includes:

- Home Energy Production using a Stand-Alone Inverter
- The Single-Phase Grid-Tied Inverter (Single-Phase PWM Rectifier/Inverter)
- Home Energy Production using a Grid-Tied Inverter
- Home Energy Production with a Grid-Tied Inverter and an LF Power Transformer
- Home Energy Production with a Grid-Tied Inverter and an Insulated DC-to-DC Converter

Hydropower Electricity Generation

The Hydropower Electricity Generation course examines the large-scale production of electricity from hydropower using a synchronous generator, a proven technology long used worldwide by power utilities. The course first introduces the student to the configuration of a typical hydropower plant. The student then learns how to adjust the voltage and frequency of the synchronous generator in a hydropower plant. The course concludes with a study of the automatic voltage and frequency regulation systems used in a hydropower plant.

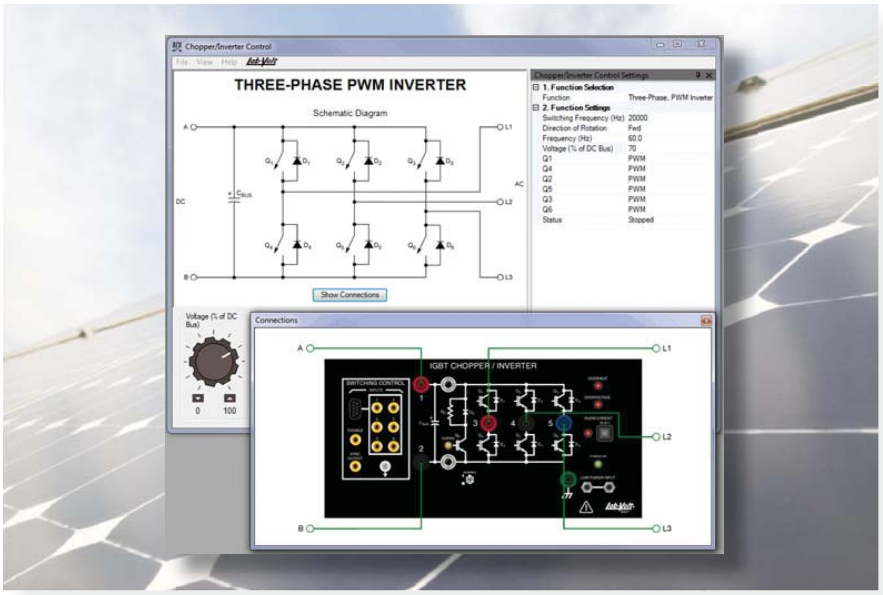
Topic coverage includes:

- Generator Synchronization (Manual and Automatic)
- Principles of Speed and Voltage Regulation
- Automatic Voltage and Power Regulation

Renewable Energy Training Program

Three-Phase PWM Rectifier/Inverter

The Three-Phase PWM Rectifier/Inverter course teaches the operation and characteristics of a Three-Phase Pulse Width Modulation (PWM) system with a rectifier section and an inverter section. Using Three-Phase Power Electronics knowledge previously learned, students will go further in using power electronics devices to transfer power back and forth at different voltage levels (AC or DC).



Three-Phase Motor Drives

The Three-Phase Motor Drives course teaches the fundamentals principles and operating characteristics of three-phase motor drives. The induction motor is a rugged, low maintenance, and low cost type of motor, making it attractive for industrial applications. To control the rotational speed of an induction motor, a motor drive using variable frequency and voltage is necessary.

Topic coverage includes:

- Saturation and Effect of Frequency in Magnetic Circuits
- Three-Phase Voltage-Source Inverter Induction-Motor Drive

Renewable Energy Training Program

Three-Phase Motor Starters

The Three-Phase Motor Starters course demonstrates how using a three-phase motor starter to help start a motor allows the motor to start smoothly by avoiding inrush currents and is a better option than connecting a motor directly to a three-phase power source.

Topic coverage includes:

- Direct On-Line Starters
- Soft Starters

Three-Phase Wound Rotor Induction Machine

The Three-Phase Wound-Rotor Induction Machine course describes the operation of three-phase wound-rotor induction machines. The students will learn the effects of varying the rotor resistor to reduce starting current and increase the machine starting torque. They will also learn how to vary the operating speed of this type of motor.

Topic coverage includes:

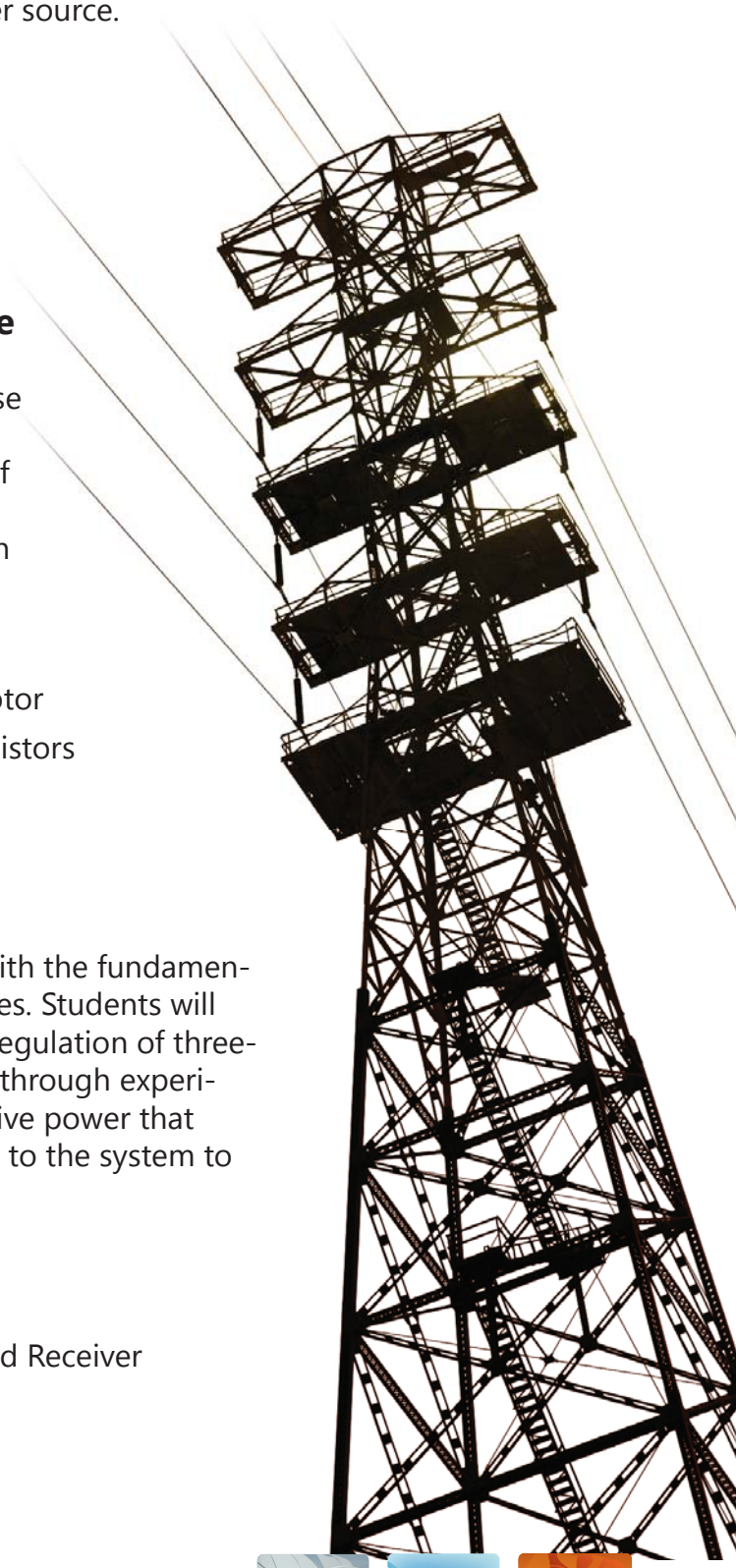
- Wound-Rotor Induction Motor with Short-Circuited Rotor
- Wound-Rotor Induction Motor with Variable Rotor Resistors

AC Transmission Lines

The AC Transmission Line course familiarizes students with the fundamentals principles of three-phase AC power transmission lines. Students will learn about the power handling capability and voltage regulation of three-phase AC power transmission lines. They will also learn, through experiments, which parameters can affect the active and reactive power that goes through the line and corrections that can be made to the system to increase its efficiency.

Topic coverage includes:

- Voltage Regulation and Power Transmission Capability
- Shunt Capacitors and Phase Angle between Sender and Receiver
- Parameters Affecting Active and Reactive Power Flow



Renewable Energy Training Program

Principles of DFIG

The Principles of DFIG course deals with the large-scale production of electricity from wind power using a doubly-fed induction generator (DFIG). This technology allows the generator to operate at different rotation speeds while keeping the frequency of the generated voltage and current fixed; a very useful feature when the generator is used in a wind turbine.

Topic coverage includes:

- Three-Phase Wound-Rotor Induction Machine used as a Synchronous Machine
- Doubly-Fed Induction Motor
- Doubly-Fed Induction Generator

Static VAR Compensators

The Static Var Compensators (SVC) course deals with the automatic control of the voltage or the power factor in three-phase power networks. As part of the FACTS (Flexible AC Transmission Systems), this technology is used by power utilities to maintain voltage quality for the distribution system as well as by industrial plants for power factor regulation at the plant electric power entrance.

Topic coverage includes:

- Main Components of a Static VAR Compensator
- Voltage Compensation of AC Transmission Lines using SVCs
- Power Factor Correction using SVCs (Arc Furnaces)

High-Voltage DC Transmission Systems

The High-Voltage Direct-Current (HVDC) Transmission Systems course describes the operating characteristics of this type of power transmission systems and the technology involved. HVDC transmission systems are used at several points in a power network for several reasons like: long-distance power transmission, submarine link, back-to-back link for easy interconnection with another network.

Topic coverage includes:

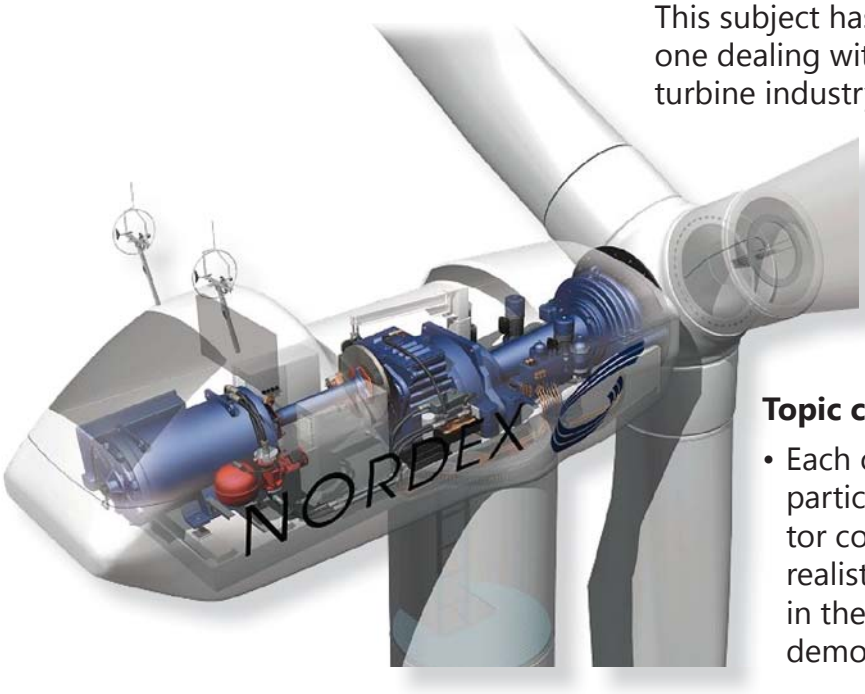
- Voltage Regulation and Power Factor in Thyristor Three-Phase Bridges
- Basic Operation of HVDC Transmission Systems
- Automatic Power Flow Control in HVDC Transmission Systems
- Commutation Failure at the Inverter End
- Harmonic Reduction using Thyristor 12-Pulse Converter

Renewable Energy Training Program

Electric Vehicles

The Electric Vehicles course introduces the student to the operation of the drive system in modern electric vehicles (cars, light truck, etc.), which are considered an essential step toward a larger use of renewable energy. The course then deals with the control of the DC brushless motor when used in an electric vehicle application.

Wind Power Electricity Generation



This subject has been divided in three separate courses, each one dealing with one type of generator used in today's wind turbine industry. The three generator types are:

- Asynchronous Generator
- Permanent Magnet Synchronous Generator (PMSG) using Field-Oriented Control (FOC)
- Doubly-Fed Induction Generator (DFIG) using Field-Oriented Control (FOC)

Topic coverage includes:

- Each course recalls the main characteristics of a particular type of generator and discusses generator control when it is used in a large wind turbine. A realistic wind emulator allows generator operation in the context of a large wind turbine to be clearly demonstrated.

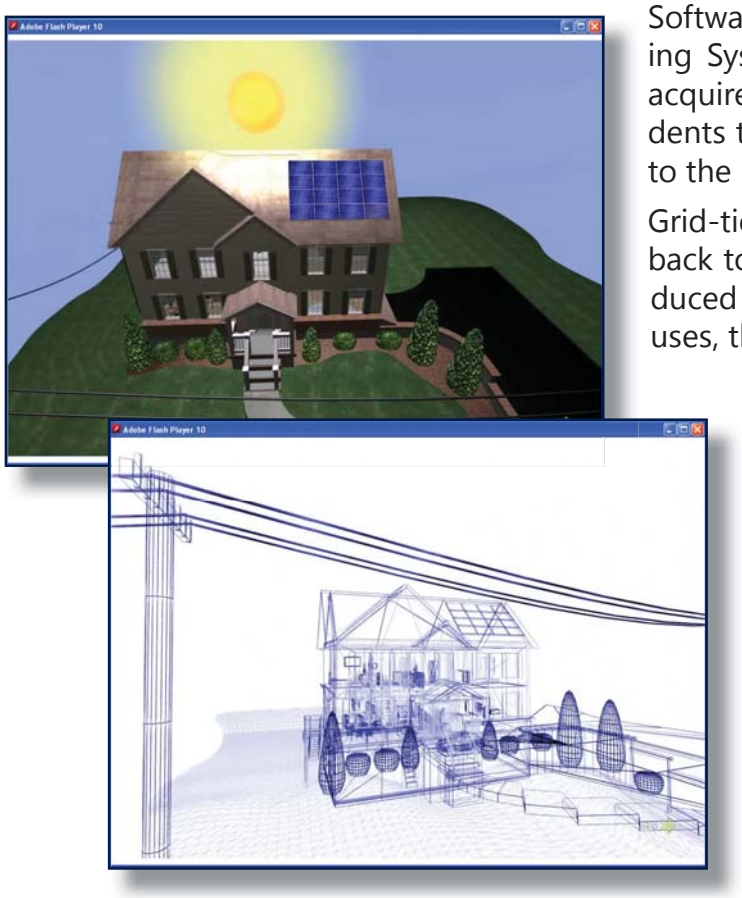
Static Synchronous Compensators (STATCOM)

This course deals with static synchronous compensators (STATCOM). This type of compensator, which is part of the FACTS (Flexible AC Transmission Systems), provides fast and accurate reactive power compensation in a power transmission system. A STATCOM is a power electronics based device that is basically a voltage-source converter that can transfer reactive power, and even active power, to and from the network.

Topic coverage includes:

- Reactive Power Compensation
- Energy Storage

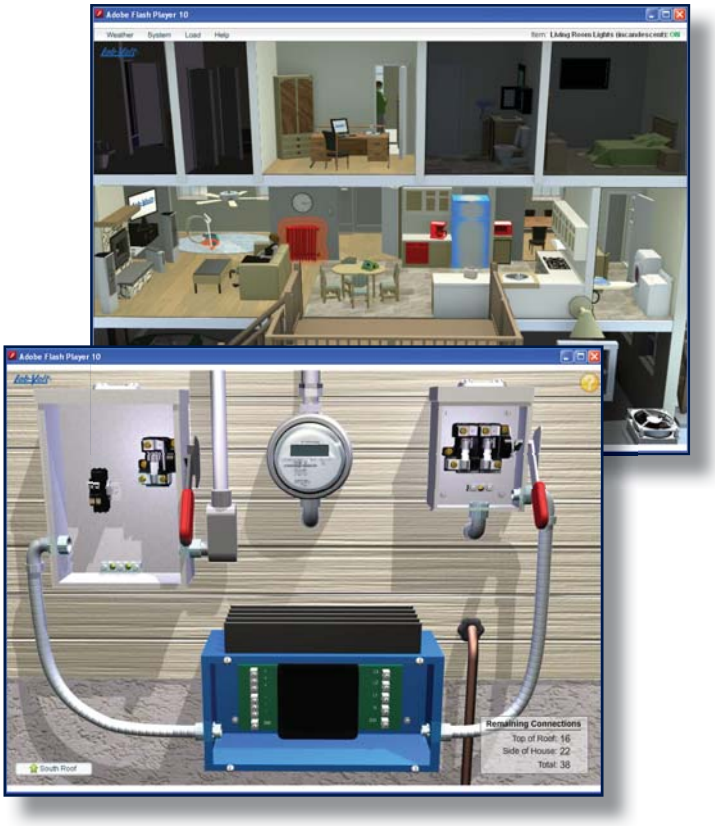
Grid-Tied Systems Simulation Software
Model 46120-A0



Lab-Volt's comprehensive Grid-Tied Systems Simulation Software is an add-on to our Solar/Wind Energy Training System, Model 46120. The software expands on the acquired Solar/Wind Energy knowledge and enables students to simulate the connection of the converted energy to the public utility grid.

Grid-tied systems generate electricity and send this energy back to the utility company's power grid. The energy produced counts against the energy your home or business uses, thereby offsetting your utility usage.

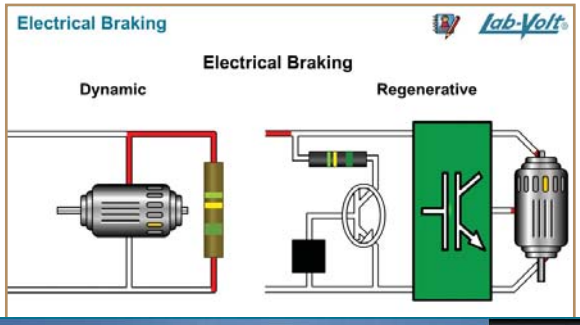
Lab-Volt's Grid-Tied Systems uses computer software to simulate the installation and operation of a utility-interactive photovoltaic (PV) solar energy system in a residential home. The software is comprised of an Electrical Wiring Simulator and a Home Energy Simulator and includes Student and Instructor Manuals.



Topic Coverage includes:

- Commercial String Inverters
- Installing a Grid-Tied Photovoltaic Solar Power System
- Wiring and Configuring Alternative Energy Systems
- Smart-Grid Technology
- Remote Data Acquisition
- Power Management Techniques
- The NEC Code as it Applies to Alternative Energy Installation in the U.S.
- Installation Requirements for Solar and Wind Power Systems in the Continental U.S. and its Territories

Wind Power Systems
Model 46127



The Wind Power Systems course is an interactive program for technicians in the systems of wind power generation. The program, which runs in the Mind-Sight LMS, consists of seven components, with the Wind Turbine Virtual Tour as the cornerstone of the program. Using 360° panoramic film techniques, the Virtual Tour explores all sectors of a wind turbine from the perspective of standing at the entry door to standing strapped to the top of the nacelle, overlooking the countryside. Each sector contains turbine icon call-outs that are accessed as needed for in-depth concepts related to wind-power-specific technologies.

Topic coverage includes:

- Wind Turbine Virtual Tour
- AC/DC Motors and Drives
- Mobile Electrical
- Mobile Hydraulics
- Industrial Safety
- Industrial Mechanical
- PLC Fundamentals

Wind Farm Simulation Software, Model 46128

A Wind Farm is a set of Wind Turbines, located near each other, sharing a common point of connection to the electrical distribution grid called a Common Connection Point. Generally, a Wind Farm has a SCADA (Supervisory Control and Data Acquisition) system used to control individual wind turbines and monitor the entire wind farm. The Wind Farm Simulation Software is a software-only solution: no special hardware is required, only a PC with adequate performance capabilities. The HMI (Human Machine Interface) is designed to be user-friendly and intuitive. It presents every parameter as well as the values of the signals, both internal to the wind turbine and published to the SCADA system.

Topic coverage includes:

- What is a Wind Farm?
- What is a Wind Turbine?
- Structure of the Wind Farm Simulator
- Physics of a Wind Turbine
- Wind Farm Operations
- Teaching Sessions
- Technical Data used in the WFS WT and WFS SCADA

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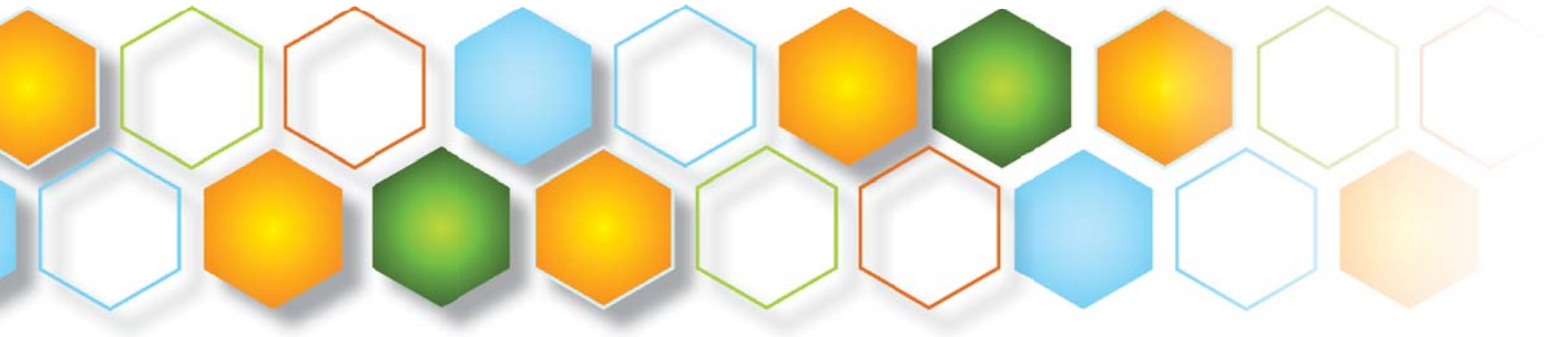

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