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Engineering and Technical Teaching Equipment

Wind Energy Unit

EEE

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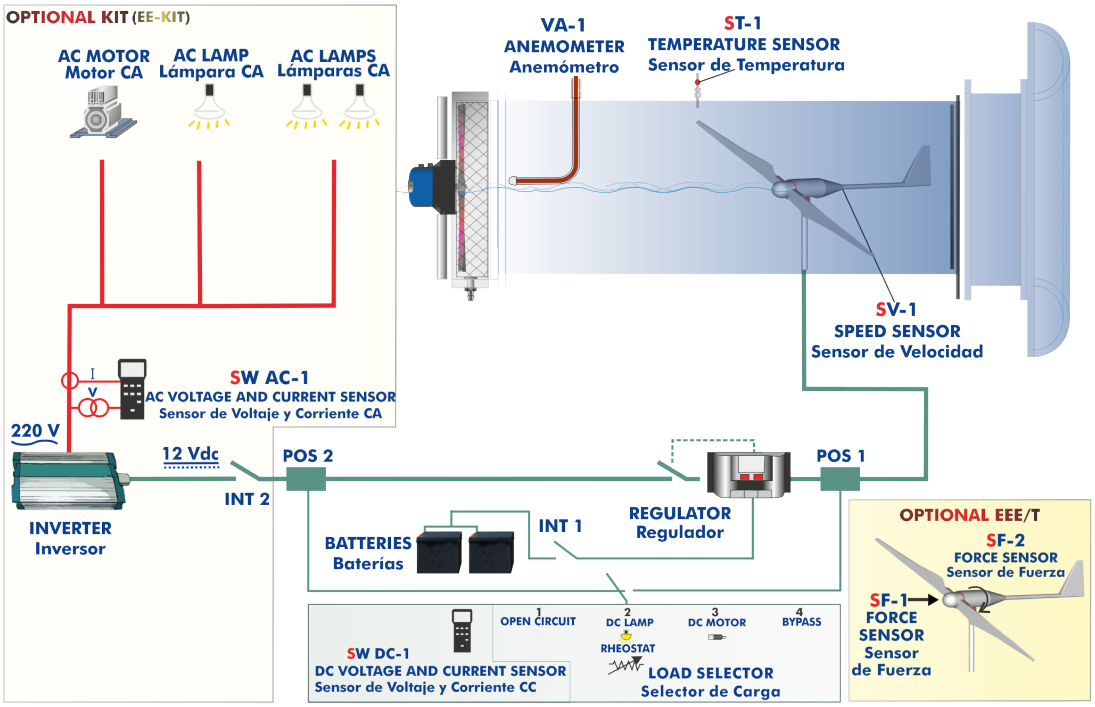
↳PRODUCTS
↳5.- ENERGY AND 8.- FLUID MECHANICS

Electronic console

PROCESS DIAGRAM AND UNIT ELEMENTS ALLOCATION



Certificate of Approval of the Quality Management System

European Union Certificate (total safety)

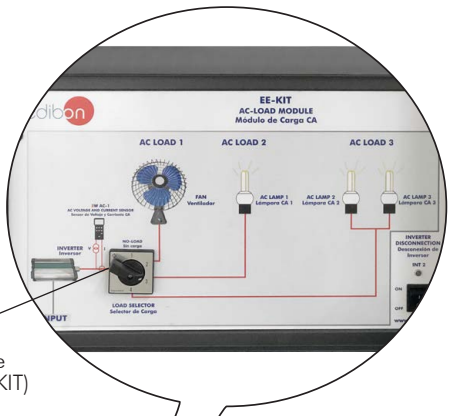
UL and CSA Regulations (All our products are manufactured according to current UL and CSA regulations)

Certificate of Approval of the Environmental Management System

Worlddidac Association Certificate of Membership

Process diagram and unit elements allocation

Aerogenerator



AC loads module
(recommended EE-KIT)

Tunnel

Axial fan for wind
simulator

Force and Torque Meter
for the Wind Turbine
(recommended EEE/T)

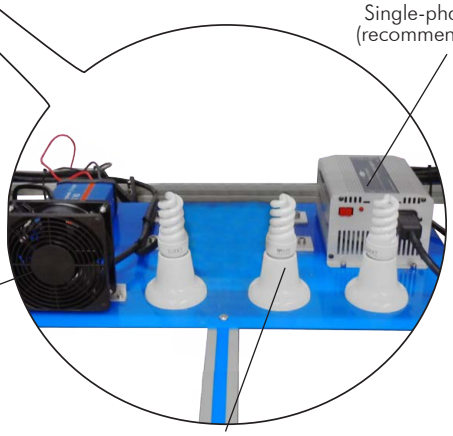
DC load
regulator

Battery

Auxiliary battery
charger

DC loads module

Single-phase inverter
(recommended EE-KIT)



Axial fan
(recommended EE-KIT)

Lamps (recommended EE-KIT)

Aerogenerator configurations

Aerogenerator with six blades

Aerogenerator with three blades

Aerogenerator with two blades

INTRODUCTION

Wind energy is a renewable source of energy that occurs in the nature spontaneously and can be harnessed to meet the necessity of power. It is being used from a very early age and the technology of using this energy efficiently is being improved with time.

Wind power is the conversion of wind energy into a useful form of energy, it is done using wind turbines to make electricity, wind mills for mechanical power, wind pumps for pumping water or drainage, or sails to propel ships.

GENERAL DESCRIPTION

The Wind Energy Unit, "EEE", contains an aerogenerator, in laboratory-scale, and is used to study the conversion of kinetic wind energy into electrical energy and to study the influence of some factors on this generation.

The unit consists of a stainless steel tunnel, an aerogenerator and an axial fan with variable speed. A rotor (or turbine) to place up to blades and a generator are the core elements of the aerogenerator.

The air speed is varied by changing the rotational speed of the axial fan. This fan generates the air flow required to set the rotor of the wind energy unit. The generator converts the rotor's kinetic energy into electrical energy.

The aerogenerator incidence angle and the angle of every blade can be modified. The blades can be removable and it's possible to set different blade configurations.

This unit includes a DC load regulator, an auxiliary battery charger, a battery and a DC loads module. The DC loads module contains DC lamps, rheostat, DC motor, load selector and switches to select the type of load:

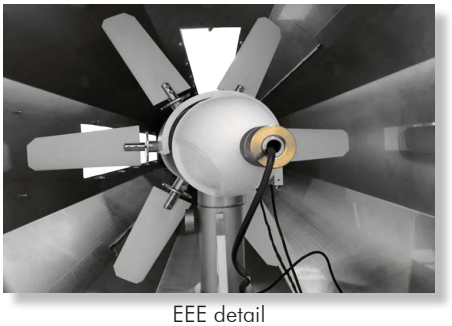
- Position 1: The aerogenerator or regulator operates at open circuit voltage.
- Position 2: The DC lamps and the rheostat are directly connected to the aerogenerator or regulator. These loads can be connected independently or in parallel with the help of manual switches.
- Position 3: The DC motor is directly connected to the aerogenerator or regulator.
- Position 4: Bypass mode, there are no DC loads.

The following parameters are measured: air temperature, air speed, speed of the rotor and voltage and current. There is a temperature sensor before the rotor of the aerogenerator. The air speed is measured with an anemometer placed in the tunnel and also is determined the rotational speed of the aerogenerator (rpm). A voltage and current sensor allows to measure the voltage and current to determine the power.

It is possible to know, in real time, the value of the DC voltage and the current given by aerogenerator, measured before and after the regulator.

SPECIFICATIONS

Anodized aluminum frame and panels made of painted steel.
The unit includes wheels to facilitate its mobility.
Main metallic elements made of stainless steel.
Diagram in the front panel with distribution of the elements similar to the real one.
The unit includes:


EEE detail

- Stainless steel tunnel of 2000 x 550 x 550 mm approx. (78.74 x 21.65 x 21.65 inches approx.), which includes two transparent windows of 1000 x 130 mm approx. (39.37 x 5.11 inches approx.).
- Aerogenerator:
  - Diameter: 510 mm. Starting air speed: 2.0 m/s.
  - Maximum power output: 60 W. Voltage: 12 V. Maximum charging current: 5 A.
  - It includes a set of six blades.
  - The aerogenerator incidence angle can be modified to simulate different weather conditions and it is possible to set different blade configurations (aerogenerator with six, three or two blades).
  - This unit allows to change the angle of every blade, as each one embeds its own calibrated protractor. The blades can be adjusted in a 360° range.
  - Low friction alternator, which provides a smooth and silent output.
  - Friction less alternator and fixed shaft.
- Axial fan with variable speed for wind simulation:
  - Maximum flow: 10650 m^3/h. Maximum power: 1.5 kW.
  - It includes a finger guard.
- DC load regulator:
  - It regulates how power generated in the aerogenerator is distributed to and from the auxiliary battery and to the load. A display informs about the state of the charge, operating parameters and fault messages. The functions of the electronic protection are:
    - Overvoltage disconnection, short circuit protection of load and module, overvoltage protection at module input, over-temperature and overload protection, and battery overvoltage shutdown.
- Auxiliary battery charger:
  - It carefully assesses the battery and then delivers the optimum charge required.
- Battery: Nominal voltage: 12 V. Nominal capacity (20 hours rate): 24 Ah.
- DC loads module:
  - Metallic box with diagram on the front panel.
  - Two 12 V lamps.
  - DC motor: Voltage: 24 V, power: 5 W.
  - Rheostat of 500 W.
  - Two manual switches.
  - Independent connection for every load with the help of the four position load selector:
    - Position 1: The aerogenerator or regulator operates at open circuit voltage.
    - Position 2: The DC lamps and the rheostat are directly connected to the aerogenerator or regulator. These loads can be connected independently or in parallel with the help of manual switches.
    - Position 3: The DC motor is directly connected to the aerogenerator or regulator.
    - Position 4: Bypass mode, there are no DC loads.
- Sensors/meters:
  - "J" type temperature sensor to measure the air temperature inside of the tunnel.
  - The air speed is measured with an anemometer placed in the tunnel; anemometer range: 0.20 – 20 m/s.
  - Sensor measures the rotational speed of the aerogenerator (rpm).
  - DC voltage and current sensor. It is possible to know, in real time, the value of the DC voltage and the current given by aerogenerator, measured before and after the regulator.
- Electronic console:
  - Metallic box.
  - Connector for the temperature sensor. Digital display for the temperature sensor.
  - Connector for the speed sensor. Digital display for the speed sensor.
  - Connector for the DC current and voltage sensor. Digital display for the current (DC) and Digital display for the voltage (DC).
  - Fan regulator for the axial fan. Switch for the axial fan.
  - Connectors for the force sensors. Digital displays for the force sensor.
  - Main switch.

Cables and accessories, for normal operation.
Manuals: This unit is supplied with the following manuals: Required services, Assembly and Installation, Starting-up, Safety, Maintenance & Practices manuals.

<u>Additional recommended elements</u> (at least one) (Not included):

- EE-KIT. Kit of Conversion and Consumption Simulation (AC):
  - Single-phase inverter.
  - AC loads module:
    - Three lamps, an axial compact fan with plastic guards and four positions selector.
  - AC voltage and current sensor.
- EE-HYB-KIT. Hybrid Grid Inverter Kit with Self-Energy Management:
  - Hybrid inverter.
  - Gel battery.
- EEE/T. Force and Torque Meter for the Wind Turbine.

Additional recommended elements (at least one) (Not included)

EE-KIT. **Kit of Conversion and Consumption Simulation (AC):**

- Single-phase inverter:
  Single-phase.
  25 kHz switch mode technology.
  Start-up power of 200 %.
  Short-circuit protection.
  High temperature protection.
  Overcharge protection.
  Operation state indicating LED.
  Rear connection/disconnection switch.

- AC loads module:
  Metallic box.
  Diagram in the front panel.
  Axial compact fan of 230 V with plastic guards.
  Three lamps of 220 V – 240 V, power: 11 W.
  Independent connection for every load with the help of the four positions selector:
  - Inverter operation with no load.
  - Fan motor connected.
  - One AC lamp connected.
  - Two AC lamps connected in parallel.

- AC voltage and current sensor. The value of AC power can be visualized with the software.

EE-KIT. Kit of Conversion and Consumption Simulation (AC)

EE-HYB-KIT. **Hybrid Grid Inverter Kit with Self-Energy Management:**

This inverter can take electrical energy either from the laboratory power grid (50/60 Hz) or from a photovoltaic panel (not included) to supply power to a local load (included) or to store such energy in a battery (included). This criteria will depend on the amount of stored energy in the battery at any given time and whether or not sufficient solar energy is available to supply the energy demand at that time.

In order to study the different modes of operation of the hybrid inverter, this kit consists of a battery, a variable resistive load and several analog DC and AC current and voltage meters.

Depending on the energy stored in the battery and the energy demanded by the variable load, it will be possible to observe the inverter behavior by means of the analog meters located at different points of the electrical circuit. For example, it will be possible to measure the current flows in and out of the battery, the current consumed by the resistive load and also, the current flows coming from the grid in case there is not enough energy in the battery to supply the demand of the resistive load.

EE-HYB-KIT. Hybrid Grid Inverter Kit with Self-Energy Management

Supply voltage: 230 VAC.
Frequency: 50/60 Hz.
Nominal power: 1000 W.
Power switch.
Bidirectional DC ammeter: -50 A – 0 – 50 A.
DC voltmeter: 0 – 15 VDC.
AC ammeter for load consumption measurement: 0 – 5 A.
AC voltmeter for measuring the voltage at the load: 0 – 250 VAC.
AC ammeter for measuring input current of the network: 0 – 5 A.
AC voltmeter for mains voltage measurement: 0 – 250 VAC.
Mains disconnecting switch.
Load disconnecting switch.
Battery disconnecting switch.
Battery circuit breaker: 40 A.
Differential circuit breaker: 230 VAC, 10 A, 30 mA.
Fuses: 2 x 16 A.
Variable resistor: 0 – 1000 Ohm, 1000 W.
Hybrid inverter:
  Battery voltage: 12 VDC.
  MPPT regulator: 17 – 80 VDC.
Gel battery:
  Nominal voltage: 12 VDC.
  Capacity: 60 Ah.

EEE/T. **Force and Torque Meter for the Wind Turbine.**

Force sensor to measure the mechanical torque of the wind turbine, range: 0 – 600 g.
Force sensor to measure the thrust force on the wind turbine, range: 0 – 3000 g.

EEE/T. Force and Torque Meter for the Wind Turbine

EXERCISES AND PRACTICAL POSSIBILITIES

1.- Identification and familiarization with all components of the unit and how they are associated with its operation.
2.- Familiarization with the regulator parameters and the wind energy measurements.
3.- Study of the conversion of kinetic wind energy into electrical energy.
4.- Study of the power generated by the aerogenerator depending on the wind speed.
5.- Determination of the typical parameters of the aerogenerator (short circuit current, open-circuit voltage, maximum power).
6.- Determination of the I-V curve.
7.- Study of voltage, current and power in function of different loads.
8.- Study of the influence of the load variation on the aerogenerator.
9.- Determination of the maximum power output of the aerogenerator.
10.- Determination of the P-air speed curve.
11.- Study of the power generated by the aerogenerator depending on the incident angle of the air.
12.- Study of the characteristic curve of the rotor.
13.- Study of the connection of loads to direct voltage.

Additional practical possibilities:

14.- Study of the power coefficient.
15.- Study of the aerogenerator operation in function of the blade configuration (aerogenerator with six, three or two blades).
16.- Study of the optimum number of blades.
17.- Study of the aerogenerator operation in function of the angle of the blades.
18.- Study of the efficiency of a wind power unit.
19.- Determination of the efficiency of a wind power unit in function of the number of blades, angle of the blades and angle of the generator.

Practices to be done with the additional recommended element "EE-KIT":

20.- Study of the connection of loads to alternating voltage of 220 V.

Practices to be done with the additional recommended element "EE-HYB-KIT":

21.- Study of the hybrid inverter's grid connection procedure: correct sequence of battery and grid switches.
22.- Study of the hybrid inverter configuration.
23.- Study of the hybrid inverter in grid connection mode.
24.- Study of the hybrid inverter in island mode.
25.- Study of the behavior of the hybrid inverter in the event of a blackout.
26.- Study of the charging process of the battery from the laboratory grid through the hybrid inverter.
27.- Study of the battery charging process from a renewable energy source.
28.- Study of the power flows of the battery and the grid under variations of the energy demand with the variable resistive load.
29.- Study of the response of the hybrid inverter when the critical discharge point of the battery is reached.
30.- Study of the energy balance between the battery-charge-grid by means of the analog ammeters and voltmeters incorporated in the kit.

Practices to be done with the additional recommended element "EEE/T":

31.- Determination and study of the thrust force on the wind turbine.
32.- Determination and study of the mechanical torque of the wind turbine.

REQUIRED SERVICES

- Electrical supply: single-phase 200 VAC – 240 VAC/50 Hz or 110 VAC – 127 VAC/60 Hz.

* At maximum power the unit can exceed 80 dB.

DIMENSIONS AND WEIGHTS

EEE:

Unit:

- Dimensions: 2300 x 630 x 1080 mm approx. (90.55 x 24.80 x 42.52 inches approx.).
- Weight: 120 Kg approx. (264.55 pounds approx.).

Electronic console:

- Dimensions: 490 x 330 x 310 mm approx. (19.29 x 12.99 x 12.20 inches approx.).
- Weight: 15 Kg approx. (33 pounds approx.).

ADDITIONAL RECOMMENDED ELEMENTS (Not included)

Recommended (at least one):

- EE-KIT. Kit of Conversion and Consumption Simulation (AC).
- EE-HYB-KIT. Hybrid Grid Inverter Kit with Self-Energy Management.
- EEE/T. Force and Torque Meter for the Wind Turbine.

SIMILAR UNITS AVAILABLE

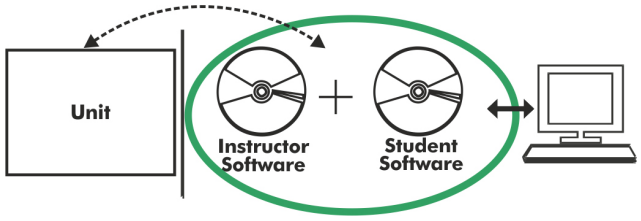
Offered in this catalog:

- EEE. Wind Energy Unit.

Offered in other catalogs:

- EEEC. Computer Controlled Wind Energy Unit.
- MINI-EEEC. Computer Controlled Wind Energy Basic Unit.
- MINI-EEE. Wind Energy Basic Unit.

EEE/ICAI. Interactive Computer Aided Instruction Software:



With no physical connection between unit and computer, **this complete software package consists of an Instructor Software (EDIBON Classroom Manager -ECM-SOF) totally integrated with the Student Software (EDIBON Student Labsoft -ESL-SOF)**. Both are interconnected so that the teacher knows at any moment what is the theoretical and practical knowledge of the students.

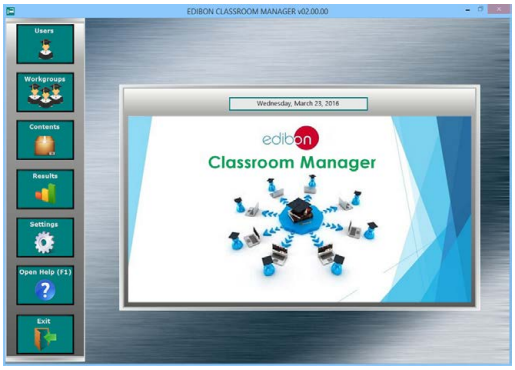
Instructor Software

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).

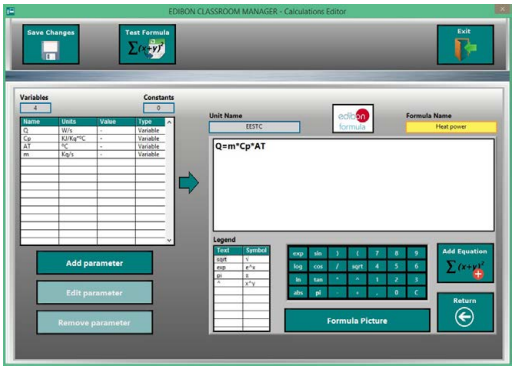
ECM-SOF is the application that allows the Instructor to register students, manage and assign tasks for workgroups, create own content to carry out Practical Exercises, choose one of the evaluation methods to check the Student knowledge and monitor the progression related to the planned tasks for individual students, workgroups, units, etc... so the teacher can know in real time the level of understanding of any student in the classroom.

Innovative features:

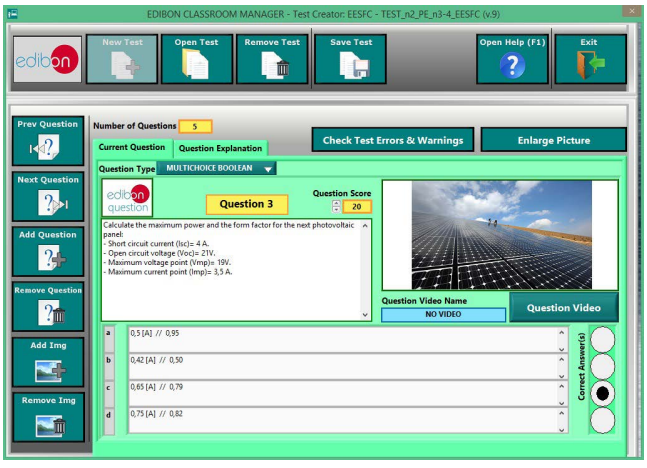
- **User Data Base Management.**
- **Administration and assignment of Workgroup, Task and Training sessions.**
- **Creation and Integration of Practical Exercises and Multimedia Resources.**
- **Custom Design of Evaluation Methods.**
- **Creation and assignment of Formulas & Equations.**
- **Equation System Solver Engine.**
- **Updatable Contents.**
- **Report generation, User Progression Monitoring and Statistics.**



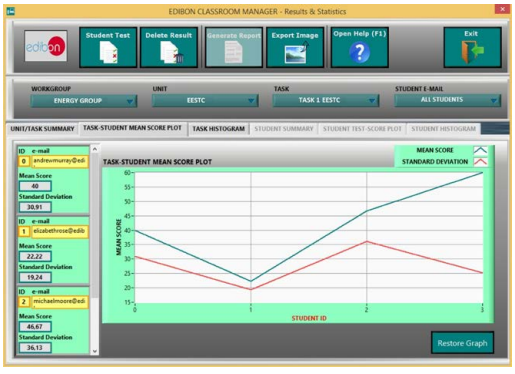
ECM-SOF. EDIBON Classroom Manager (Instructor Software) Application Main Screen



ECAL. EDIBON Calculations Program Package - Formula Editor Screen



ETTE. EDIBON Training Test & Exam Program Package - Main Screen with Numeric Result Question



ERS. EDIBON Results & Statistics Program Package - Student Scores Histogram

Optional

Student Software

- ESL-SOF. EDIBON Student Labsoft (Student Software).

ESL-SOF is the application addressed to the Students that helps them to understand theoretical concepts by means of practical exercises and to prove their knowledge and progression by performing tests and calculations in addition to Multimedia Resources. Default planned tasks and an Open workgroup are provided by EDIBON to allow the students start working from the first session. Reports and statistics are available to know their progression at any time, as well as explanations for every exercise to reinforce the theoretically acquired technical knowledge.

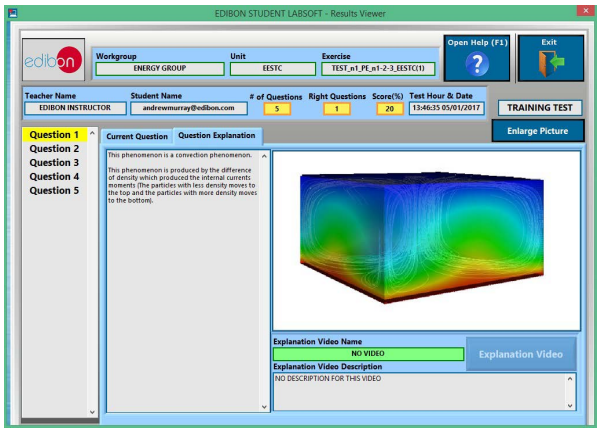
Innovative features:

- **Student Log-In & Self-Registration.**
- **Existing Tasks checking & Monitoring.**
- **Default contents & scheduled tasks available to be used from the first session.**
- **Practical Exercises accomplishment by following the Manual provided by EDIBON.**
- **Evaluation Methods to prove your knowledge and progression.**
- **Test self-correction.**
- **Calculations computing and plotting.**
- **Equation System Solver Engine.**
- **User Monitoring Learning & Printable Reports.**
- **Multimedia-Supported auxiliary resources.**

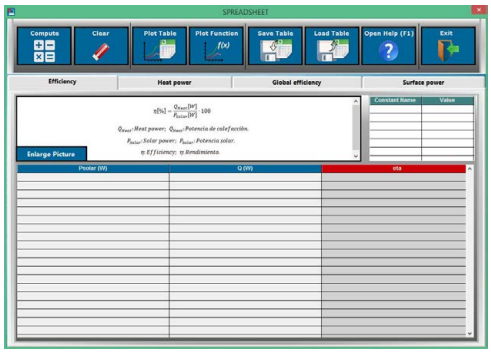
For more information see **ICAI** catalogue. Click on the following link:
www.edibon.com/en/interactive-computer-aided-instruction-software

ESL-SOF. EDIBON Student LabSoft (Student Software) Application Main Screen

EPE. EDIBON Practical Exercise Program Package Main Screen



ERS. EDIBON Results & Statistics Program Package - Question Explanation



ECAL. EDIBON Calculations Program Package Main Screen

✱ Specifications subject to change without previous notice, due to the convenience of improvement of the product.

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REPRESENTATIVE: