

# Catalog 2019 Professional



understanding new energies  
comprendre les énergies renouvelables  
Изучаем альтернативную энергию

neue energien verstehen  
entendiendo las energías renovables  
领会新能源

capire le nuove energie  
entendiendo las energías renovables  
فهم الطاقات المتجددة

# Greeting Contact

Why does leXsolar-understanding new energies exist?

We are convinced that renewable energies are the only solution to satisfy mankind's massive energy demands. With our products, we lay the foundation of an energy supply, relying 100% on renewable energies.

Everybody is talking about renewable energies. Let yourselves get bitten by the bug and learn to understand renewable energies!



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General Managers:  
Dr. Ronny Timmreck  
Michael Dietrich  
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- ▲ leXsolar headquarters
- x leXsolar local office
- leXsolar partner



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# Together with you we will ...

- ... explain renewable energy and environmental technologies– from the scientific principles to their applications – to let students and adults understand new energies.
- ... develop professionals for job market worldwide.
- ... change the world to a non-carbon based economy
- ... and save the future of earth for our children



Scan and watch the video:



# What we stand for:

- Our products and our service are oriented towards you! You, as customer, are our focus.
- We are innovative! Each of our training equipment solutions has special product innovations for the best impact of results for your trainings and lessons.
- We provide quality „made in Germany“: optimized and long lasting products for many generations of users.



„I work for renewable energy 100%. With leXsolar I am able to provide the education system with the necessary knowledge.“

**Dr. RONNY TIMMRECK**

Founder and General Manager



„New energy means to me: new technologies, new education, new jobs, new perspectives! leXsolar makes your perspectives possible!“

**MICHAEL DIETRICH**

Founder and General Manager



„My job is to ensure that our products are always on the cutting edge of technology“

**DMITRY KUSHNIKOVSKIY**

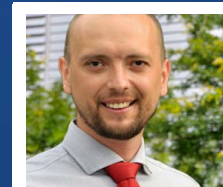
Chief Technology Officer



„‘understanding new energies’ means to me strengthen the synergy between education and economy. To reach this purpose, I develop tailor-made and creative strategies with and for you.“

**SEBASTIAN KABOTH**

Marketing and Sales Manager



„I check the quality of our products and look forward to your suggestions for further improvements.“

**KRZYSZTOF SZYNAL**

Quality and Production Manager



„As your first point of contact I am pleased to support you in all your concerns. Furthermore I am responsible for the processing as well as the dispatch of your order.“

**NICOLE SCHERZER**

Management Assistant



„My goals are vivid products, a comprehensible portrayal of reality as well as didactically valuable training exercises. This is how you understand renewable energies.“

**ANITA RASCHE**

Product Developer



„In order to meet your expectations and our quality standards I am constantly on the lookout for high-grade material attaching importance to innovative resources and manufacturing technologies“

**KRISTIN MAAß**

Quality Management Assistant

# The leXsolar areas of expertise

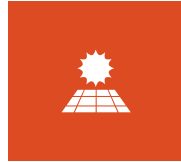
The leXsolar areas of expertise reflect the wide spectrum of renewable energies. You can find specialized educational products for nearly all the practical relevant technologies.

Even for related technologies that will play a decisive role in the future of our energy supply, like energy storage and energy efficiency, leXsolar offers suitable products.




# Training systems for the technical education

Specialized learning systems for the technical education in universities and vocational schools are available for the areas of expertise leXsolar-PV, leXsolar-Wind, leXsolar-EMobility and leXsolar- SmartGrid. These products are fully described in this catalog.



**leXsolar-PV**  
Photovoltaic (PV) is the direct conversion of light into electricity through solar cells.



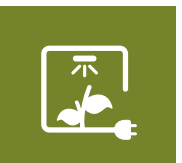
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**leXsolar-Wind**  
Wind power currently has the largest share of the renewable energy production.




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**leXsolar-BioEnergy**  
Discover how biomass can be grown and the energetic use of different degradation processes. Experience the whole biomass cycle!




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**leXsolar-SmartGrid**  
The term SmartGrid stands for the connection and control of energy producers, stores and consumers into an „intelligent power grid“.



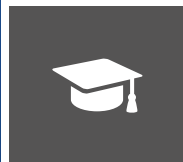
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**leXsolar-EMobility**  
The use of storage technologies is the requirement for a sustainable energy revolution. With leXsolar-EMobility students can discover the features and fields of application of different battery and storage technologies.




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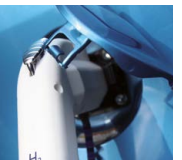
**leXsolar-Academy**  
The leXsolar Academy provides you with the necessary knowledge to all renewable energy technologies and makes you a competent contact person on this topic for their students and colleagues.




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**leXsolar-H<sub>2</sub>**  
Fuel cells can convert hydrogen (H<sub>2</sub>) into electricity – one possible solution to the storage problem of renewable energies.



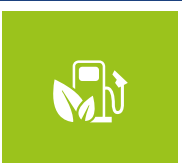
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**leXsolar-ThermalEnergy**  
Solar thermal technologies can not only be used to heat energy. Concentrated solar thermal energy can also generate electricity!




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**leXsolar-BioFuel**  
Bio fuels can easily be stored and replace fossil fuels in transportation.



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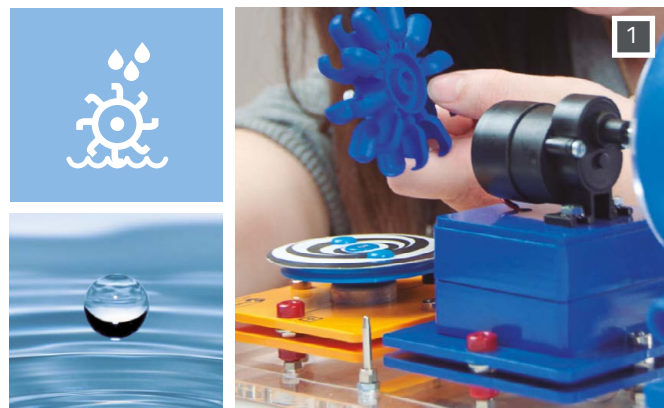


**leXsolar-Hydropower**  
Hydropower was the first renewable energy source that was used by man and is subject to few fluctuations.



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## New area of expertise: leXsolar-Hydropower



## New product: EMobility Instructor



## New area of expertise: leXsolar-BioEnergy



## Expansions of the leXsolar-Academy: Events and Technical education

# leXsolar novelties

### 1 leXsolar-Hydropower

Hydropower was the first renewable energy source that was used by man to produce electrical energy. Even if its potential is limited in many countries, it plays an important role in the energy mix, as it is less prone to fluctuations like other renewable energy sources. With the new products from the Hydropower topic area you can build different hydroelectric turbines and compare their properties. With this, students can learn about different turbine designs – from a simple water wheel to a highly efficient Pelton-Turbine – as well as their fields of use.

*Please find further information starting on page 38.*

### 2 leXsolar-EMobility Instructor

The world is turning to electric transportation to curb greenhouse gas emissions. The trend toward electric mobility forces changes along the automotive sector's entire value chain. The new vehicles on the one hand require a number of technically innovative components and systems to operate and on the other hand new infrastructure, business models and services. The only way to achieve this, is high-quality training and education at colleges, vocational schools and universities.

*Please find further information starting on page 10.*

### 3 leXsolar-BioEnergy

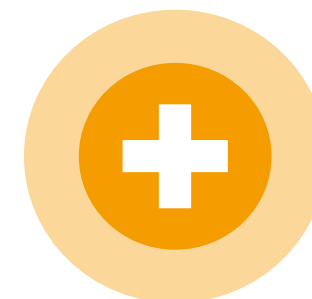
In addition to produce bioethanol and FAME with our BioFuel system, our newest product BioEnergy Ready-to-go allows you to understand the whole biomass cycle. From the sprouting and growth of the plants to the aerobic and anaerobic degradation and the use of produced biogases – all of these steps can be performed and understood with our new system. For that you won't need any additional equipment, everything from seeds, fertilizer and hydroculture boxes to compost container, Erlenmeyer flask, tubings and measuring instruments is ready-to-go in the leXsolar-BioEnergy system.

*Please find further information starting on page 46.*

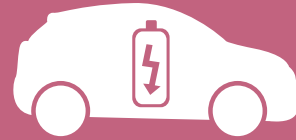
### 4 Add-on for leXsolar-Academy

One further innovation is the expansion of our leXsolar-Academy. To enhance the synergies between business partners and educational institutions, leXsolar offers two new services – leXsolar-Events and teacher training courses.

*Please find further information starting on page 54.*







leXsolar-EMobility is dealing with storage technologies for renewable energy. Electricity from wind and solar energy needs to be stored in the future. That is why basic knowledge of storage technology is necessary for a sustainable energy transition. With the products of the leXsolar-EMobility, students can discover the features and fields of application of different battery and storage technologies.

## Topic Electromobility

### 1 5 kW BLDC Motor

- Setup and functional principle of BLDC motors
- Voltage Current (IV) Characteristics of BLDC motors
- Torque-Speed / Torque-Power characteristics of BLDC motors
- Efficiency of BLDC motors

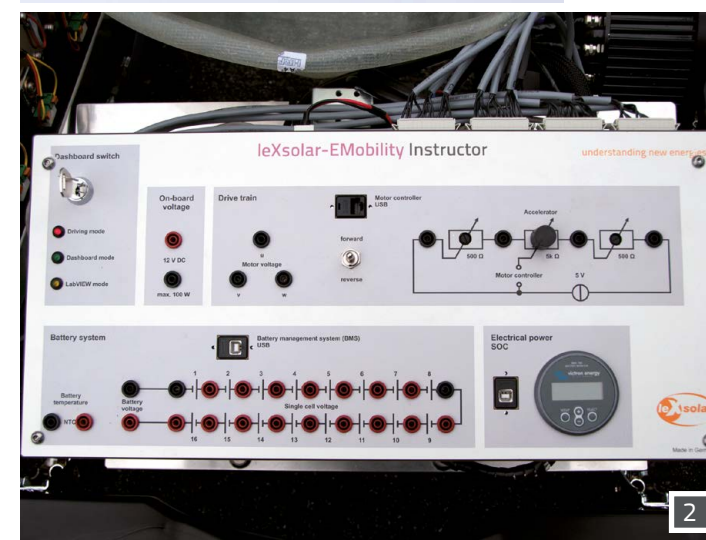
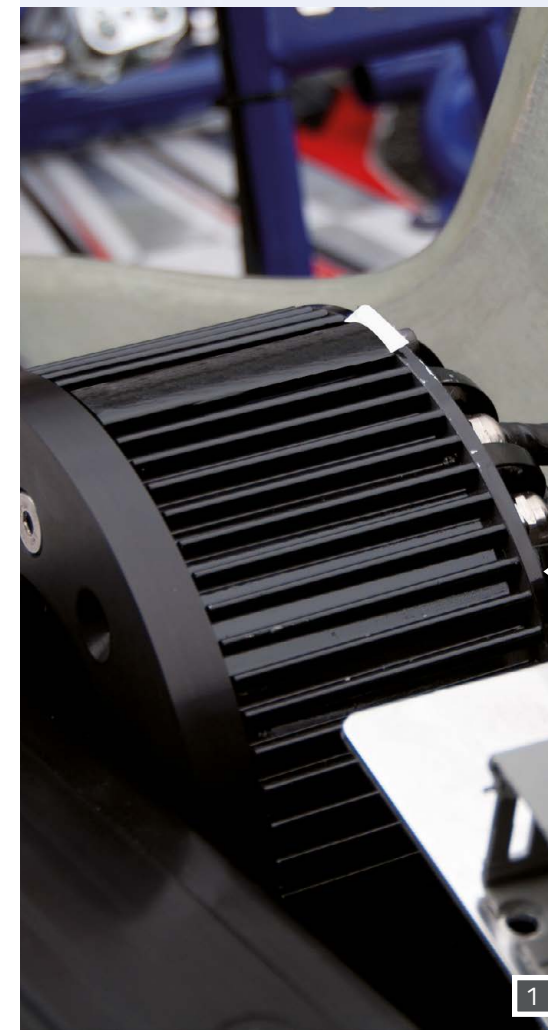
### 2 leXsolar-Dashboard

A pilot has a cockpit. Our users have the leXsolar Dashboard for a full access to control and measurement on stall for the leXsolar-EMobility Instructor.

The display with „System on Chip“ SoC technology, CAN connectivity, USB port connection and Bluetooth are making this the brain unit of the leXsolar-EMobility Instructor.

### 3 Battery pack

- Battery and Battery Management system
- Characteristics of Lithium-Batteries
- Safety measures when charging batteries
- Typical charging methods
- Determination of the main battery parameters
- Analyze the Battery Management System (BMS) function by discharging the battery pack





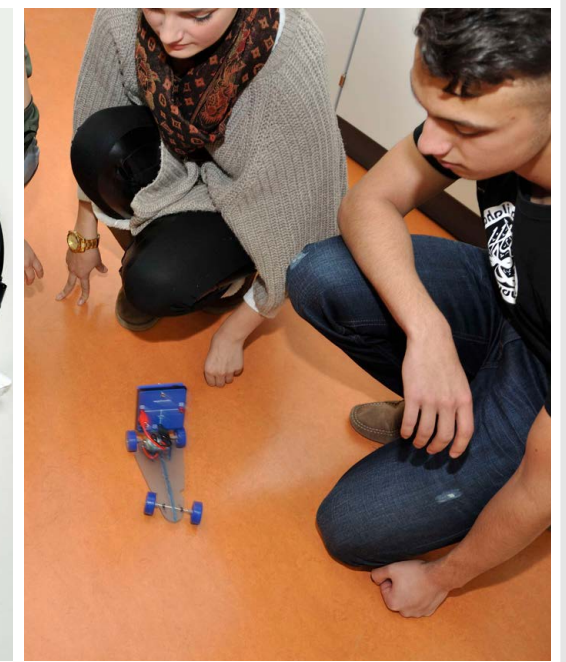
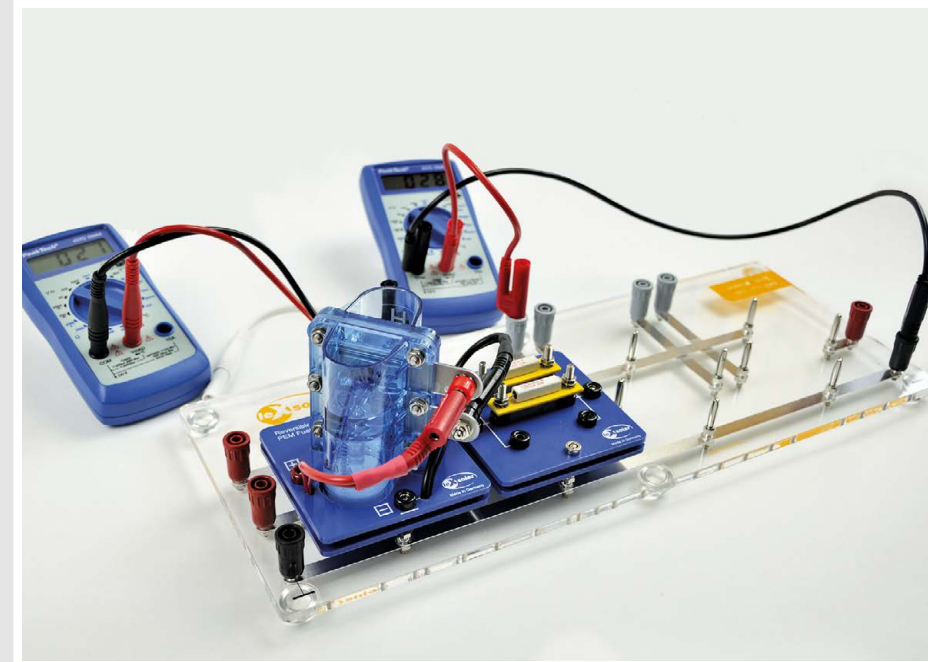
## leXsolar-EMobility Professional ▶

Item-No. 1801

To store electrical energy several different types of battery technologies are already on the market. But which battery type is required for every application, what capacity does the battery need and which is the best loading performance to ensure a long lifetime?

Due to the hot topic of storing renewable energy, these kind of questions can find an answer during the technical training.

With leXsolar-EMobility Professional, the characteristics of different battery types can be analyzed in detail. In addition, the kit helps students to find out more about the different fields of application. The kit is provided with different battery technologies such as lead, NiMH or Lithium-Polymer(LiPo) as well as a PEM-fuel cell. For the correct determination of the internal resistance, four-terminal sensing are possible. With the electric car several types of batteries can be analyzed qualitatively. Furthermore it deals with the issues of the future E-Mobility topic.



## Experiments

- Relationship between current, resistance and voltage
- Nominal voltage of voltage sources
- Four-terminal sensing
- Internal resistance of voltage sources
- Series connection of voltage sources
- I-V characteristics of a single NiMH battery module
- I-V characteristics of the NiZn battery module
- I-V characteristics of the LiFePo battery module
- I-V characteristics of the lead battery module
- I-V characteristics of the lithium-polymer battery module
- I-V characteristics of the triple NiMH battery module
- I-V characteristics of a hydrogen fuel cell
- The charging behavior of a battery module with resistances
- The charging behavior of a battery module with an MPP tracker
- The discharge process of a battery module
- The charging process of a capacitor
- The discharge process of a capacitor
- Hydrogen production in the reversible hydrogen fuel cell
- Hydrogen usage of the reversible hydrogen fuel cell
- The efficiency of the hydrogen fuel cell
- The capacity of a battery module
- Operation of the electric car with several battery modules
- The Ri efficiency of a single NiMH battery module
- The Ri efficiency of a NiZn battery module
- The Ri efficiency of a LiFePo battery module
- The Ri efficiency of a lead battery module
- The Ri efficiency of a lithium-polymer battery module
- The Ri efficiency of a triple NiMH battery module
- Temperature-dependent behavior of the lithium-polymer cell

## Key data

- Battery trainer for the technical education
- Battery types: NiMH, lead, LiPo, NiZn, LiFePo plus capacitor
- Fuel cell included
- All components prepared for four-terminal sensing
- Topic e-mobility as practical example of fields of application for battery technologies



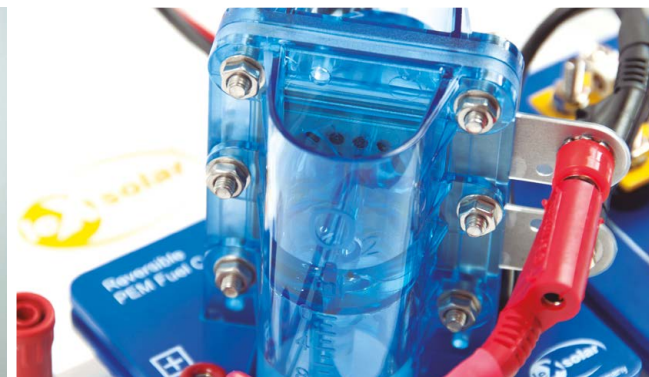
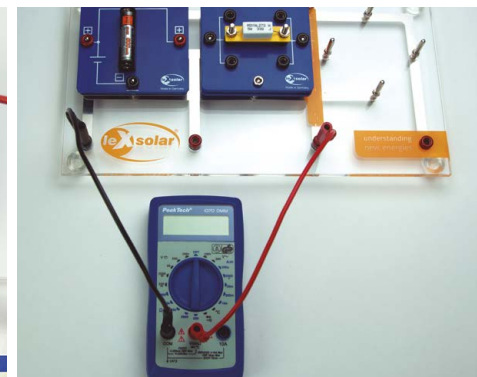
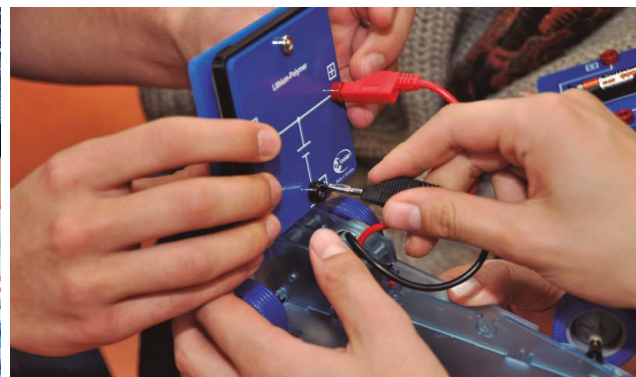
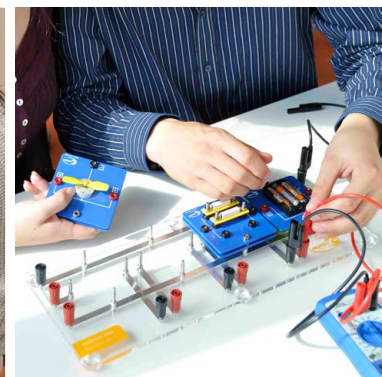
## Components

- 1 x 1118-02 Motor module Pro
- 1 x 1118-09 Battery module NiMH 3xAAA Pro
- 1 x 1118-11 Capacitor module Pro
- 1 x 1400-13 leXsolar-base unit Professional
- 1 x 1800-01 Resistor module (triple) Pro
- 1 x 1800-03 Resistor plug element 1 Ohm
- 1 x 1800-04 Resistor plug element 100 Ohm
- 3 x 1800-05 Resistor plug element 10 Ohm
- 1 x 1800-06 Resistor plug element 33 Ohm
- 1 x 1800-07 Lithium-polymer (LiPo)-battery module
- 1 x 1800-08 Battery module holder 1xAAA Pro
- 1 x 1800-09 Battery adapter cable
- 1 x 1800-12 Fuel cell holder Pro
- 1 x 1800-13 Lead (Pb) -battery module Pro
- 1 x 1801-02 Electric model car
- 1 x 1801-06 LiFePo-battery AAA
- 1 x 9100-13 ChargerModule
- 1 x 9100-03 AV-Module
- 1 x 1100-62 Potentiometer module 110 Ohm Pro
- 1 x L2-02-017 Propeller
- 1 x L2-04-059 Safety test lead, 50cm, red
- 1 x L2-04-060 Safety test lead, 50cm, black
- 1 x L2-04-066 Safety test lead, 25cm, red
- 1 x L2-04-067 Safety test lead, 25cm, black
- 1 x L2-04-102 NiZn-battery AAA
- 3 x L2-05-068 Safety short-circuit plug, with mid socket
- 1 x L2-06-011 Digital multimeter
- 1 x L2-06-067 Reversible Fuel cell
- 1 x L3-01-072 Aluminium case Emobility-Professional
- 1 x L3-01-092 Insert EMobility Professional 1801
- 1 x L3-03-258 Info sheet initial startup
- 1 x L2-04-021 NiMH battery AAA
- 1 x L3-03-165 Layout diagram 1801 leXsolar-EMobility Professional



## extras available

- Manuals available to download
- L2-04-044 Electric grid adapter set
- 1100-63 DC converter 120V - 240V





## leXsolar-EMobility Instructor ▶

Item-No. 1804

The world is turning to electric transportation to curb greenhouse gas emissions. The trend toward electric mobility forces changes along the automotive sector's entire value chain. The new vehicles on the one hand require a number of technically innovative components and systems to operate and on the other hand new infrastructure, business models and services. The only way to achieve this, is high-quality training and education at colleges, vocational schools and universities.

With leXsolar-EMobility Instructor students can gain comprehensive knowledge of state-of-the-art electric mobility systems as well as the underlying technical concepts and components.

Batteries and battery management systems, controllers and CAN bus as well as motor and power train concepts are only a few topics that are addressed with the practical training sessions of leXsolar-EMobility Instructor. To top it all, students can really drive and the combination of a powerful ride and lab experiments guarantees great learning success!



## Experiments

### 1. Battery and Battery Management system

- Characteristics of Lithium-Batteries
- Safety measures when charging batteries
- Typical charging methods
- Determination of the main battery parameters
- Analyze the Battery Management System (BMS) function by discharging the battery pack

### 2. Configuration and communication

- Motor controller configuration
- BMS configuration
- Bluetooth setup

### 3. Performance Tests

- Performance test for different loading conditions
- Analysis of speed-time graphs
- Efficiency vs Input current and power
- Calculating state of charge for different discharge duration and analyze with motor output power (Fuel Efficiency)
- Overall efficiency

### 4. Regenerative Braking

- Concept of regenerative braking
- Efficiency of regenerative braking depending on drive cycle

### 5. BLDC motors

- Setup and functional principle of BLDC motors
- Voltage Current (IV) Characteristics of BLDC motors
- Torque-Speed / Torque-Power characteristics of BLDC motors
- Efficiency of BLDC motors



## Components

- 1 x 1804-02 Dashboard EMobility-Instructor
- 1 x L2-06-193 EMobility Kart
- 1 x L3-03-258 Info sheet initial startup
- 1 x L3-03-282 Einräumplan 1804 EMobility Instructor
- 1 x L2-04-202 Tablet with installed software package

### extras available

- Manuals available to download

## Detailed specifications of the components:

### Interfaces - The system can be accessed by:

- USB for data acquisition (PC)
- Bluetooth (mobile phone, tablet)
- Display (on the dashboard)
- CAN-Bus
- Handheld measurement devices

### Dashboard

The dashboard gives access to all measurement parameters and allows the full control of the complete car:

- Key switch and automatic dashboard mode
- Display with SOC, battery voltage, battery current, power
- Overall battery voltage measurement
- Individual cell voltage measurement
- Battery temperature measurement
- Motor voltage measurement
- Smooth acceleration control using Potentiometer
- LED interface (indicating mode of operation)
- CAN port for motor configuration
- USB port for data acquisition
- USB port for battery management system (BMS)

The data acquisition system with integrated sensors gives access by computer to:

- Battery voltage
- Battery SOC
- Battery current
- Electrical power

### Battery Pack

- LiFePo 30Ah capacity (1,5kWh)
- 2P16S configuration
- Nominal Voltage 51.2 Volts
- Continuous discharge current: 75A
- Max. Peak discharge current: 150A
- Anderson type connector for battery charging
- Emergency stop switch

### Battery Management System (BMS)

- Battery protection from under-voltage, over-voltage, over-current and overheat
- Balancing feature for single cells
- CAN- (internal), USB-, RS-232 (internal), Bluetooth- interface

### Power Train

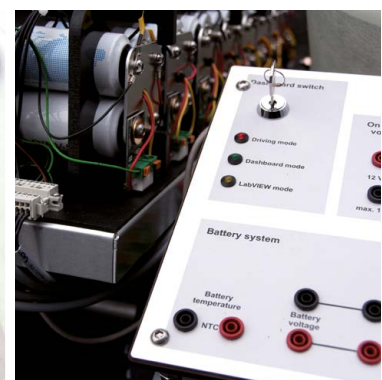
- 5 kW BLDC motor
- Rated voltage: 48V
- Rated speed: 4500 RPM
- Efficiency: 88%
- Belt connected direct drive

### Motor Controller

- Rated operating voltage: 48-96 Volts
- Rated DC bus current: 30 - 200 Amp
- Allows recuperation
- CAN communication
- Includes CAN-to-USB adapter

### Car and Platform

- Max. speed: 75km/h
- Acceleration from 0 to 75 km/h in 5 seconds
- Stainless steel axle with high performance brakes
- High quality frame made in Germany
- Car Axle speed: 2500 RPM
- Delivery is including a stable aluminum platform for working in the lab





# leXsolar-Curriculum Electric Mobility ▶

Within four semesters, this curriculum turns students into experts for electric mobility and battery technology.

In the first semester of this course fundamental knowledge of battery technologies and battery handling as well as concepts for their application especially in electric mobility is addressed. Main focus of the second and third semester is on e-mobility components and their interaction in electric vehicles.

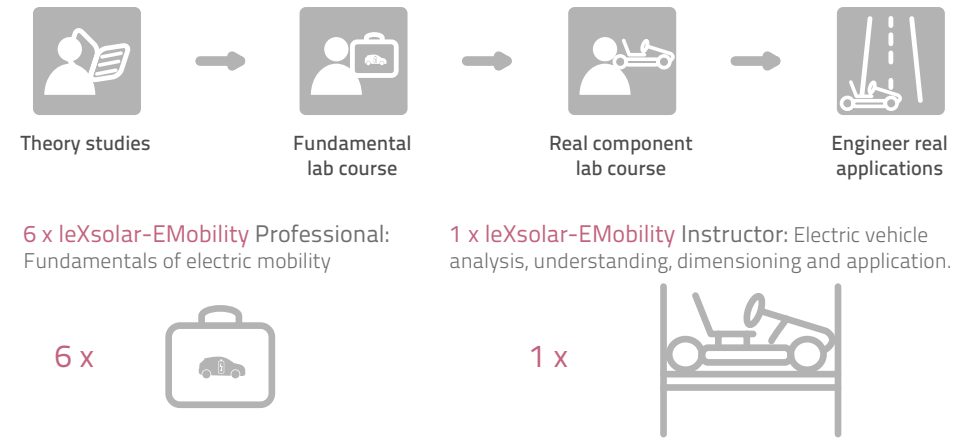
In the last semester the gained knowledge is applied to set up and optimize an electric vehicle to win the EMobility Championship.

The course comes with a technical manual containing didactically high-quality student's instructions for 90 hours of lab experiments and the theory and solutions for the lecturer.



# How to accomplish the EMobility Curriculum?

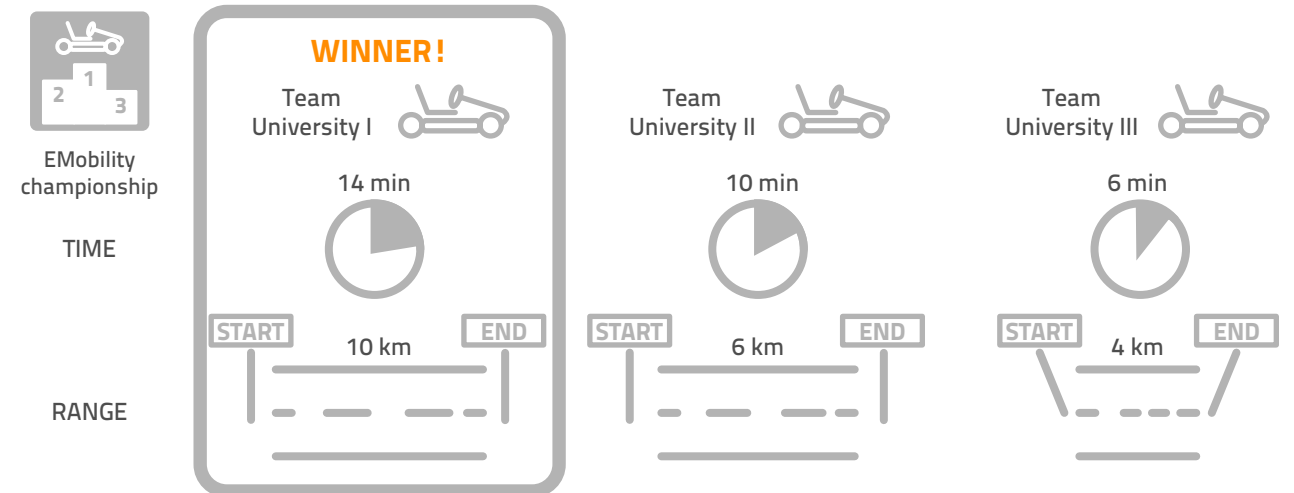
**Approach 1:** The traditional way of technical training and education



**Approach 2:** The new way of training: Create your EMobility championship



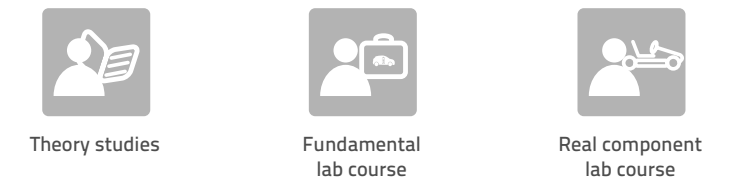
Based on their knowledge and skills from the lab courses students have to optimize the EMobility Instructor to achieve highest speed but also maximum range!



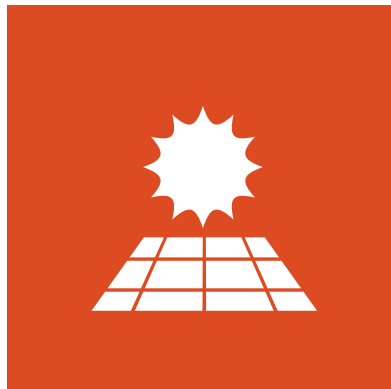
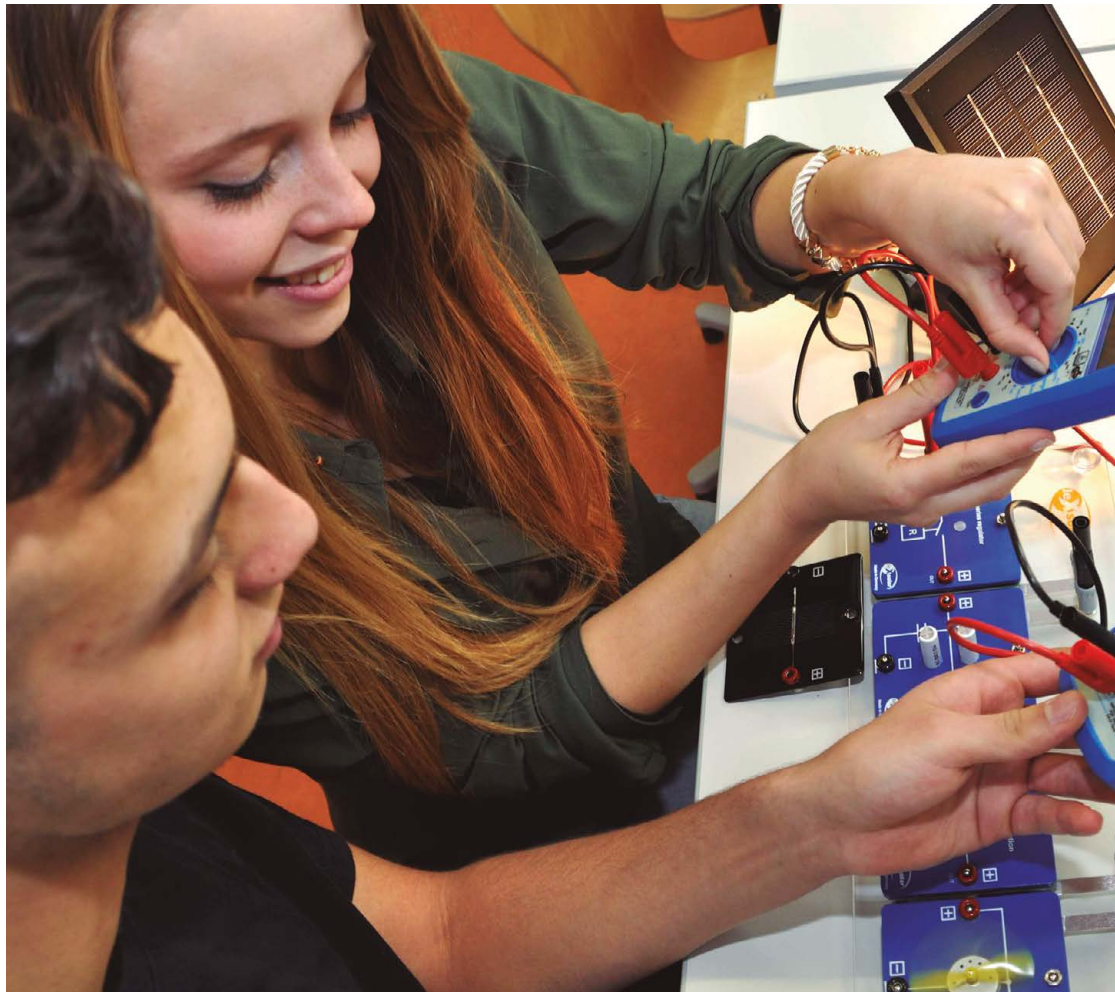
	<b>Fundamentals of Energy Storage Technologies</b>	<ul style="list-style-type: none"> <li>Lab course hours: 15</li> <li>Topics: Battery types and its characteristics; Internal resistance; Efficiency; Fuel Cell characteristics</li> <li>Objectives: Determining basic properties of batteries; Analyzing electrical characteristics of batteries; Determining state of charge (SOC)</li> <li>Product used: leXsolar-EMobility Professional</li> </ul>
	<b>Applications and Handling of Batteries and Fuel Cells</b>	<ul style="list-style-type: none"> <li>Lab course hours: 10</li> <li>Topics: Charging methods; Battery packs; Battery life-time</li> <li>Objectives: Knowing charging methods; Dimensioning batteries and battery packs; Learning which battery types are suitable in which application; Knowing battery life-time limiting factors</li> <li>Product used: leXsolar-EMobility Professional</li> </ul>
	<b>Concepts of E-Mobility Systems</b>	<ul style="list-style-type: none"> <li>Lab course hours: 15</li> <li>Topics: Typical concepts of e-mobility systems and its simulation; Components of e-mobility systems; Faults in e-mobility systems</li> <li>Objectives: Gaining conceptual knowledge of different e-mobility systems; Knowing the necessary components for e-mobility systems and their functional principles; Being able to find and evaluate faults in e-mobility systems</li> <li>Product used: leXsolar-EMobility Instructor</li> </ul>
	<b>E-Mobility Components</b>	<ul style="list-style-type: none"> <li>Lab course hours: 25</li> <li>Topics: Detailed characterization of the components of an e-mobility system; Battery, BMS, motor controller, power train, BLDC motor; Characteristics, specifications and efficiencies of the components</li> <li>Objectives: Detailed knowledge of E-Mobility Components; Knowing how to measure their characteristics, especially: Electrical characteristics (IV), torque, temperature, RPM, SOC, speed</li> <li>Product used: leXsolar-EMobility Instructor</li> </ul>
	<b>Electric vehicle system implementation</b>	<ul style="list-style-type: none"> <li>Lab course hours: 25</li> <li>Topics: Dimensioning and setup of e-mobility systems; Instrumentation, control and automation of e-mobility systems (using CAN-bus); Characterization of e-mobility systems in real operation</li> <li>Objectives: Being able to characterize and control electric vehicles; Knowledge of dimensioning, constructing and programming e-mobility systems</li> <li>Product used: leXsolar-EMobility Instructor</li> </ul>

We offer fundamental lessons of theory, lab courses and real component courses and you can also practice skill activities.

Bring all together in 1-2 semester courses and decide between our classic semester lab course approach 1 or make a semester lab course with the highest impact of technical knowledge with approach 2 to create champions.







The area of expertise leXsolar-PV connects the technical and physical basics as well as the required knowledge to understand PV-systems and their components.

## Topic photovoltaic

### 1 leXsolar-plug-in/plug-out security system

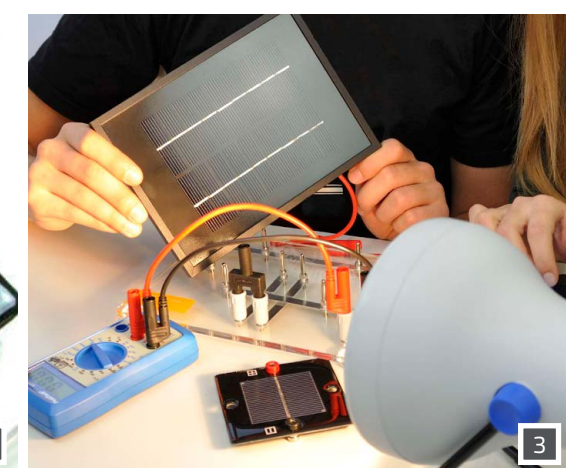
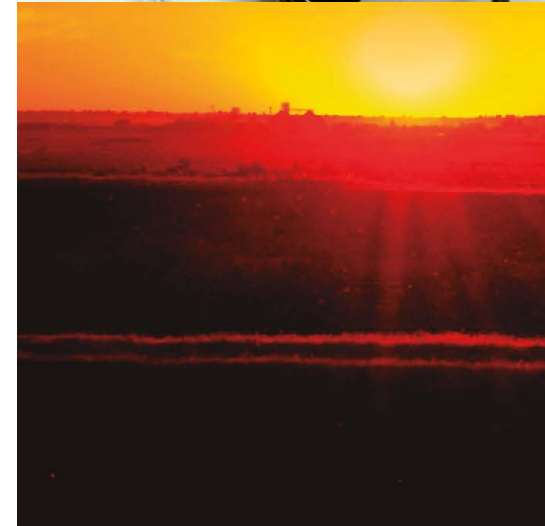
PWM regulator, MPP tracker, deep-charge protection, shunt and series regulator, DC/AC inverter are important parts of each professional photovoltaic system. With these components we have created the fastest and easiest handling training system worldwide. With our high innovative leXsolar-plug-in/plug-out security system your students can execute more than 30 experiments – everywhere!

### 2 leXsolar-Illumination module

The leXsolar-Illumination module allows reproducible illumination conditions in experiments with solar cells. The module supersedes the use of energy intensive and heat producing halogen lamps, so that there is no danger of burns and furthermore you create much less energy losses. But more importantly, it does not create the impression that solar cells have to be illuminated with hundreds of watts. This system allows research experiments in basic level and provides a high cost value solution instead of trainer systems with cost intensive PV simulators.

### 3 leXsolar-Solar modules

leXsolar exclusively uses highly efficient solar cells with excellent low light behavior. Especially in the classroom it is important that all experiments work reproducibly, even under bad lighting conditions. leXsolar therefore only uses high-class brands of solar cells and checks the low light behavior for each cell. Different modules for the plug-in- plug-out security system and one industrial standard module for PV PICO Systems build a perfect bridge to the next level trainer systems.

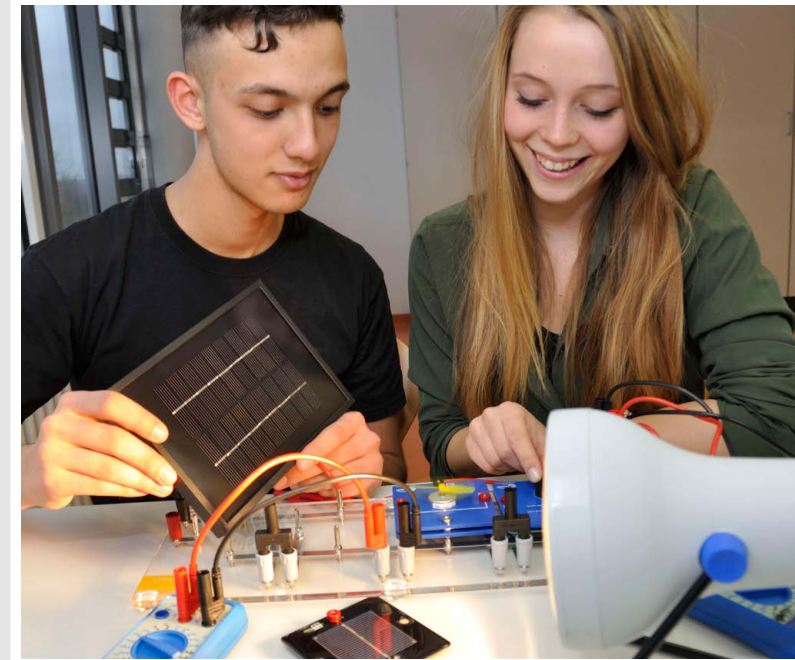




## leXsolar-PV Professional ▶

Item-No. 1118

Nowadays, a wider understanding of photovoltaic is necessary to pursue a profession in the field of renewable energy. For the relating studies and courses of education, leXsolar-PV Professional offers the optimal tools for practical courses. The wide range of experiments goes from the physical fundamentals of photovoltaic, until the analysis of the components of PV-Systems and the design of complex PV-Systems on a laboratory scale. The experiments are designed to be equally employed for the training of sales representatives, for industrial and in-service training of technicians and PV-installers, as well as for the basic training of engineers.



## Experiments

### Electrical engineering – basic experiments

- Measurement of voltage, current and power
- Ohm's law
- Series connection of resistors (voltage divider)
- Parallel connection of resistors (current divider)

### Photovoltaic – basic experiments

- Series and parallel connection of solar cells
- Power dependence on the surface area of the solar cell
- Power dependence on the angle of incidence
- Power dependence on level of illumination
- Power dependence on level of illumination under load
- Internal resistance dependence on level of illumination
- Shading effect on solar cells
- Dark characteristic curve of solar cells
- I-V-characteristics, MPP and fill factor of solar cells
- Dependence of the I-V-characteristics of solar cells on level of illumination
- Dependence of the I-V-characteristics of solar cells on temperature
- Characteristic curve of solar modules
- I-V-characteristics of partial shaded solar modules
- Temperature coefficient of solar Cells

### Photovoltaic system experiments

- Components of an off-grid system
- Possible operating conditions of off-grid systems
- Working principle of shunt and series regulators
- Comparison of PWM- and series regulator
- Load characteristic of PWM regulators
- Working principle of a MPP tracker
- Characteristics of a MPP tracker
- Working principle of deep discharge protection
- Working principle of an inverter
- Determination of the output voltage progression at an inverter

Scan!



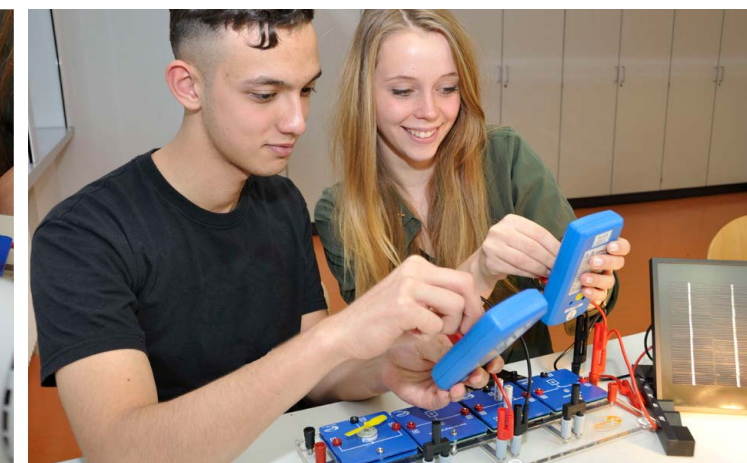
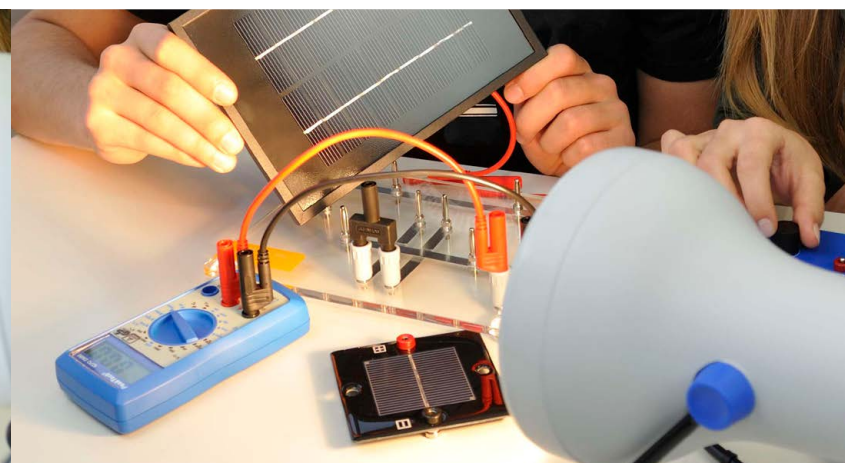
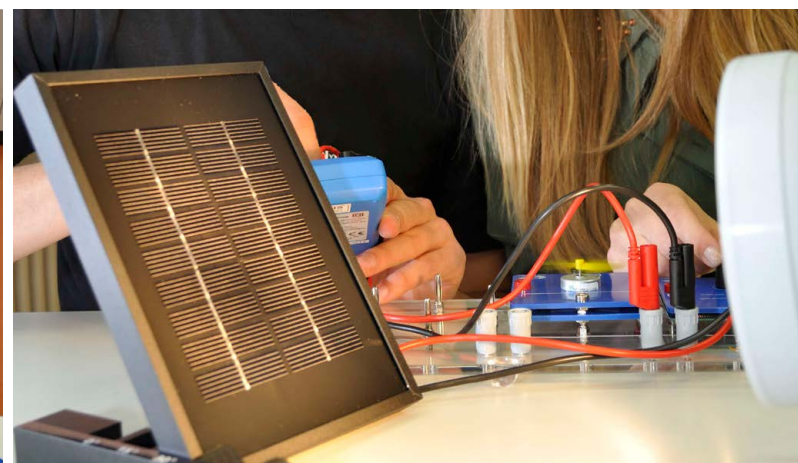
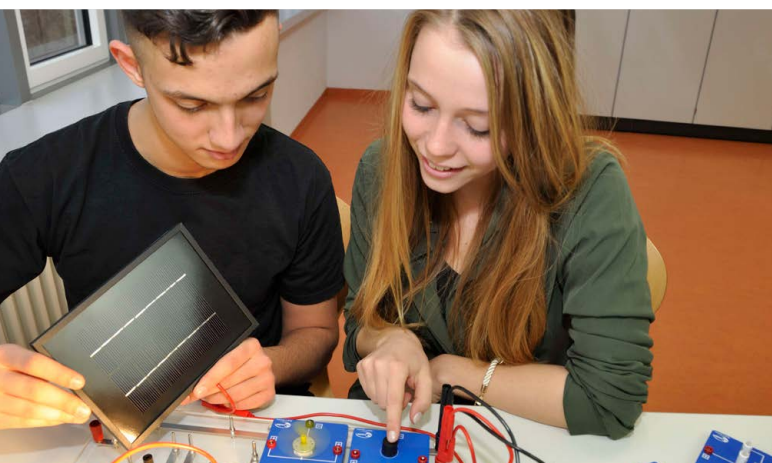
## Components

- 3 x 1100-01 Solar module 0.5 V, 420 mA
- 1 x 1100-04 Solar module 5.22 V, 380 mA
- 1 x 1118-05 Diode module Pro
- 1 x 1118-04 Potentiometer module Pro
- 1 x 1118-06 Shunt regulator module Pro
- 1 x 1118-02 Motor module Pro
- 1 x 1118-01 Light bulb module Pro
- 1 x 1400-13 leXsolar-base unit Professional
- 1 x 1118-08 LED module (high brightness) Pro
- 1 x 1118-07 Deep discharge protection module Pro
- 1 x 1118-10 Series regulator module Pro
- 1 x 1118-11 Capacitor module Pro
- 1 x 1118-16 Radio module Pro
- 1 x 1118-12 DC/ AC-Inverter Pro
- 1 x 1118-13 MPP-Tracker Pro
- 1 x 1118-15 PWM regulator Pro
- 1 x 1800-06 Resistor plug element 33 Ohm
- 3 x 1800-04 Resistor plug element 100 Ohm
- 2 x 1800-05 Resistor plug element 10 Ohm
- 3 x 1100-02 Solar module 0.5 V, 840 mA
- 2 x 1800-01 Resistor module (triple) Pro
- 3 x 1100-59 Lighting module (with safety sockets)
- 1 x 1118-17 Base for solar panel
- 2 x 9100-03 AV-Module
- 1 x 9100-05 PowerModule
- 1 x 1100-29 Solar cell cover set (4 pieces)

- 1 x L2-02-017 Propeller
- 1 x L3-01-074 Aluminium case PV Professional 1118
- 4 x L2-04-066 Safety test lead, 25cm, red
- 3 x L2-04-067 Safety test lead, 25cm, black
- 2 x L2-04-059 Safety test lead, 50cm, red
- 1 x L2-04-060 Safety test lead, 50cm, black
- 3 x L2-05-068 Safety short-circuit plug, with mid socket
- 1 x L3-01-090 Insert PV Professional 1118
- 1 x L3-03-258 Info sheet initial startup
- 1 x L2-04-080 Lamp housing
- 1 x L2-04-093 Illuminant 80W
- 1 x L3-03-181 Layout diagram 1118 PV Professional

### extras available

- Manuals available to download
- L2-04-044 Electric grid adapter set
- 1100-63 DC converter 120V - 240V





## leXsolar-Curriculum PV-Professional ▶

The new leXsolar-Curricula are the perfect guideline to teach your students how photovoltaic works, from the basic concepts until its commercial application. In less than one semester or half a year, transform your participants into high-qualified experts on photovoltaic.

### Key data

- Pre-made practical course for one semester
- No preparation needed
- From PV-basics to PV-systems
- Included in the Instructions manual PV-Professional



The leXsolar-Curricula are especially designed to help you, as a professional. For this purpose the approved experiments from the leXsolar PV Professional kit were sorted by content and educational aspects, and the learning goals were subdivided into different structure levels.

As a result, you get a free access to a set of 15 predefined units, incorporated in four thematic sections. The 90 minutes lasting units can be integrated perfectly into the classical lab course/ theory-concept. The structure is adapted to the deep structure of the topic, from the

features of single cells to well-designed power supply systems. Therefore, it ensures the optimal learning background.

The elaborated structure and selection of topics can also be a big help to plan and support the theoretical lectures. For a further support, we also offer the leXsolar-Academy (see p. 32), which we recommend for the training of your future tutors.

## Abstract of the leXsolar-Curriculum PV-Professional:

### Fundamental Basics (optional)

- 1,5 hours
- Topics: electric basic knowledge
- Objectives: describing and explain the behavior of basic electrical circuits; calculate and measure systems of resistors

### Basic Solar Cell Properties

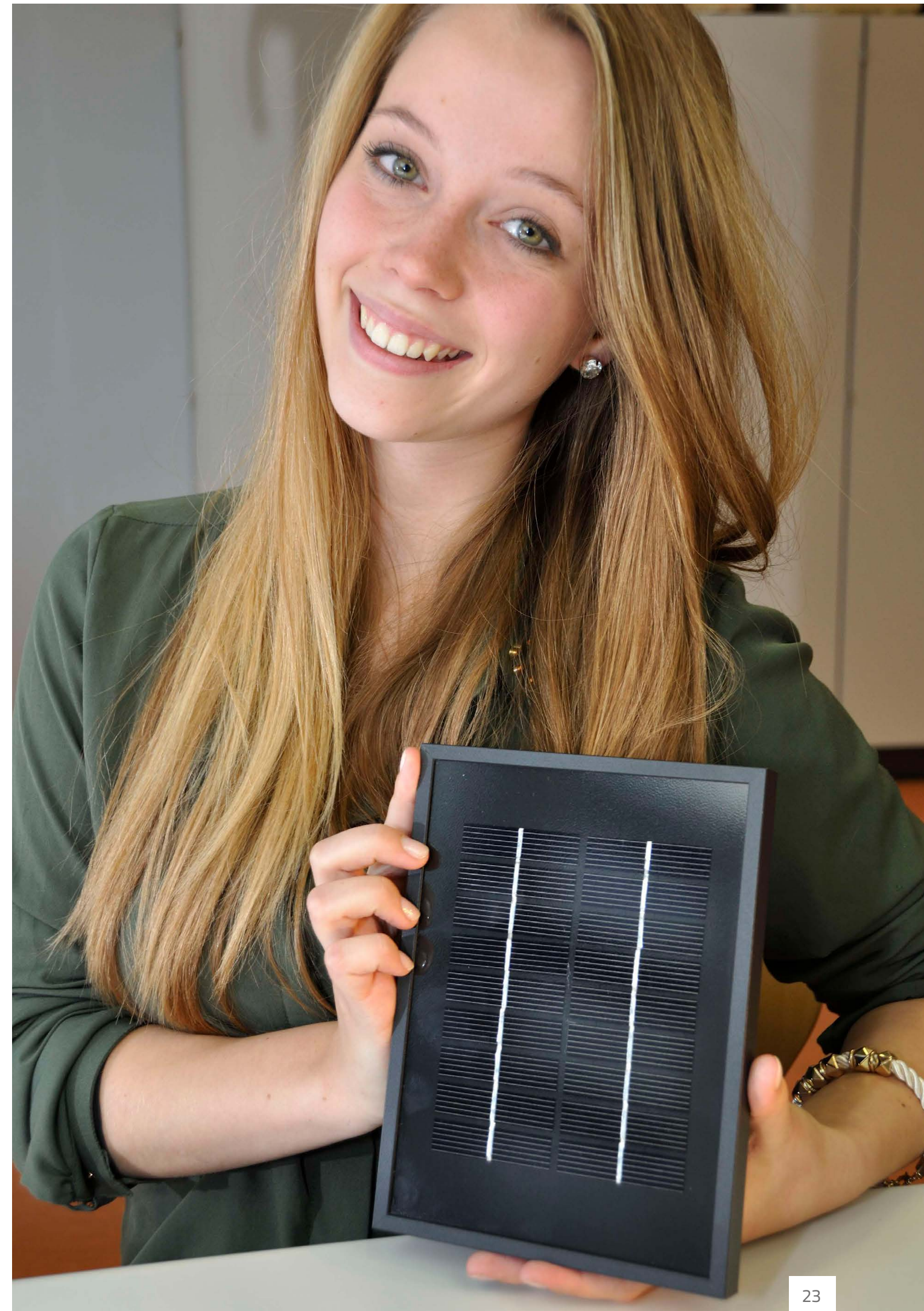
- 7,5 hours
- Topics: solar cells and environmental conditions; characteristics of solar cells
- Objectives: determining basic properties of solar cells; analyzing electrical characteristics of solar cells; measuring and describing the influence of environmental conditions on solar cell parameters

### Solar Cells in use

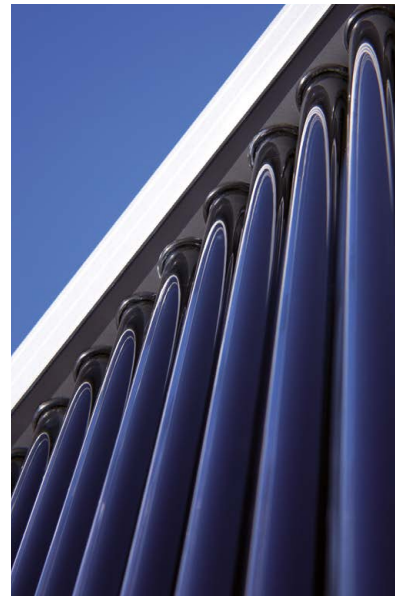
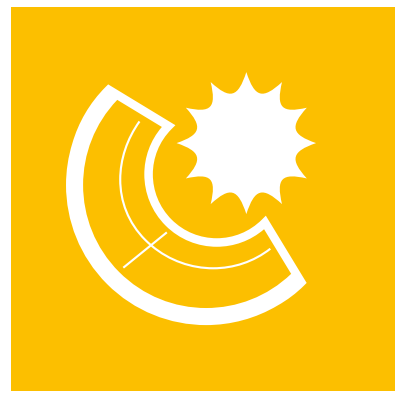
- 6 hours
- Topics: connecting solar cells to modules; solar cells as supply
- Objectives: building up solar modules; dimensioning and power supply tuning reasonable parts of solar cell modules

### Off-Grid systems: Parts and Properties

- 7,5 hours
- Topics: Off-grid systems; charge regulators; electrical storage, deep discharge regulators, DC/DC and DC/AC inverter
- Objectives: problems and tasks concerning the design of photovoltaic power supply systems; different peripheral parts of off-grid systems; reasonable choosing from different standard solutions when building up a system







The area of expertise leXsolar-ThermalEnergy summarizes all the technologies for renewable heat production. This includes solar collectors as well as the CSP-technology (Concentrated Solar Power) for the production of electricity from solar heat.

## Topic ThermalEnergy

### 1 Parabolic collector Item-No. 1300-04

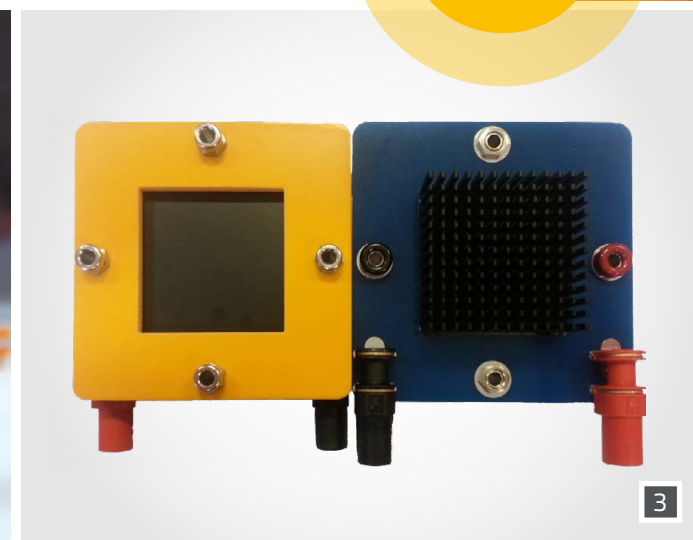
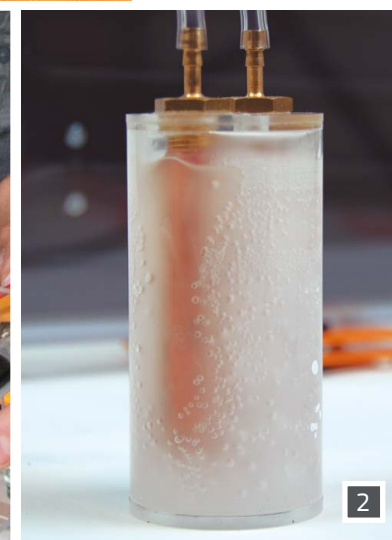
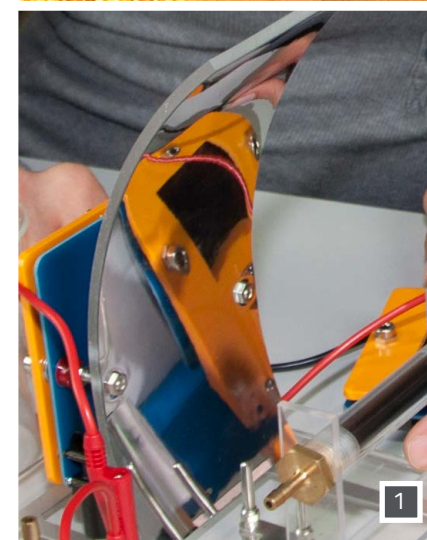
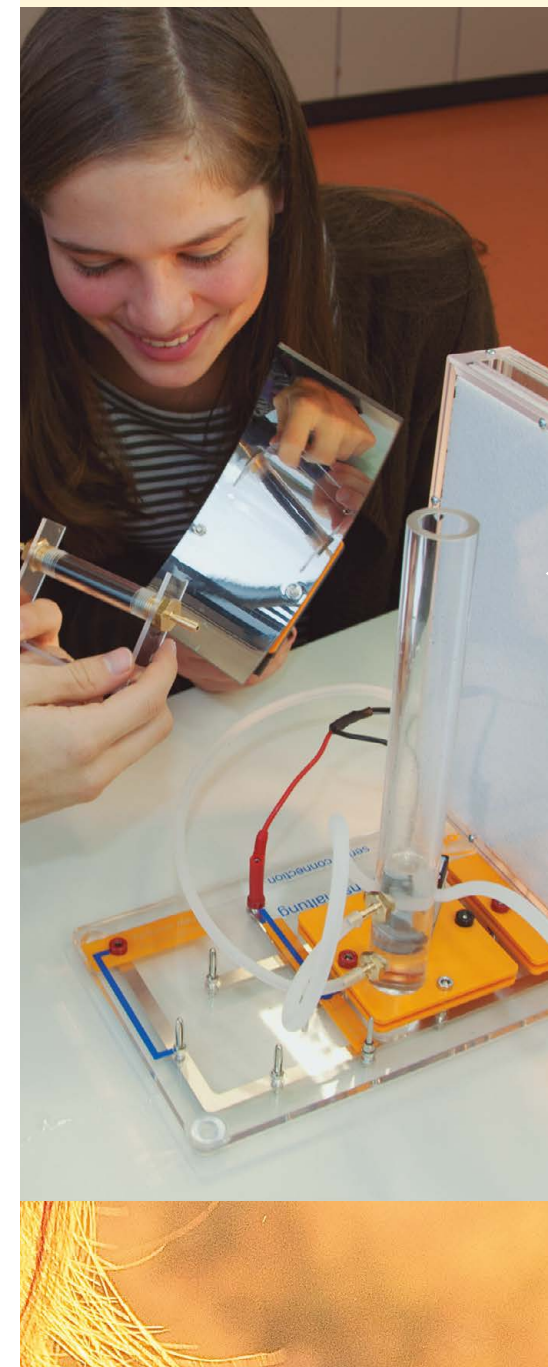
The leXsolar-parabolic collector enables the representation of a parabolic trough power plant on a laboratory scale. The realistic depiction of the basic processes gives students well-grounded information about the application of solar thermal power plants.

### 2 Paraffin heat exchanger Item-No.1300-12

The paraffin heat exchanger represents a latent heat storage. The physical effect of the phase change of a storage medium is used here to store heat. With the leXsolar-Paraffin heat exchanger, this can be impressively demonstrated with simple experiments.

### 3 leXsolar- Peltier module Item-No.1300-10

The PLUG-IN leXsolar-Peltier module is a simple and easy to handle thermoelectric cooler. With compact measuring size of the system it gives students a fast impression of the operating principle of a Peltier element. With this component we complete our leXsolar-ThermalEnergy trainer system.



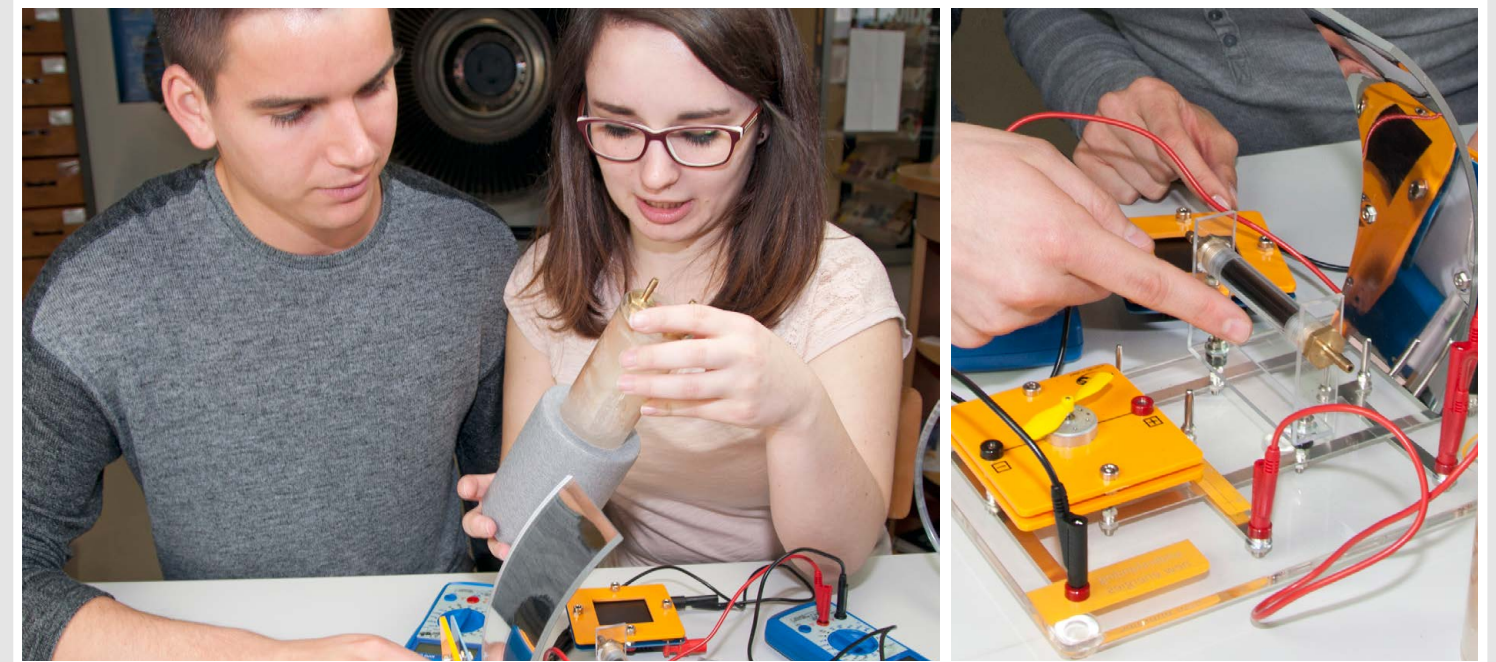


## leXsolar-ThermalEnergy Professional ▶ Item-No. 1306

This experimentation system allows for the application of different technologies of solar thermal energy transformation in technical education. The product does not only contain various solar collector systems, which can be operated with or without pumps, but also CSP-technology (Concentrated Solar Power) and a Peltier element for the direct transformation into electric energy.

Another main feature are the experiments regarding the basics of thermodynamics, like absorption of heat radiation and the convective flow of heat, that provide a comprehensive understanding of the applied physical effects.

Like the other products of the Professional line, the leXsolar-ThermalEnergy Professional amazes with its flexible and location-independent usability that does not require any additional equipment.



## Experiments

- Absorptivity and reflectivity of different materials
- Focusing of light by a Fresnel lens
- Thermal convection and layering
- Thermal conduction
- Thermal insulation
- Solar thermal collector with pump circulation
- Solar thermal collector with thermosiphon circulation
- Variation of the flow speed
- Collector circuit with heat exchanger
- Collector circuit with paraffin heat reservoir
- Parabolic trough collector with pump cycle
- Defocussing
- Qualitative demonstration of the functional principle
- Investigating the thermoelectric generator
- Quantitative determination of the electrical power

## Key data

- Experimentation system for solar thermal energy conversion
- Quantitative experiments for different collector systems
- Flexible and location-independent usage

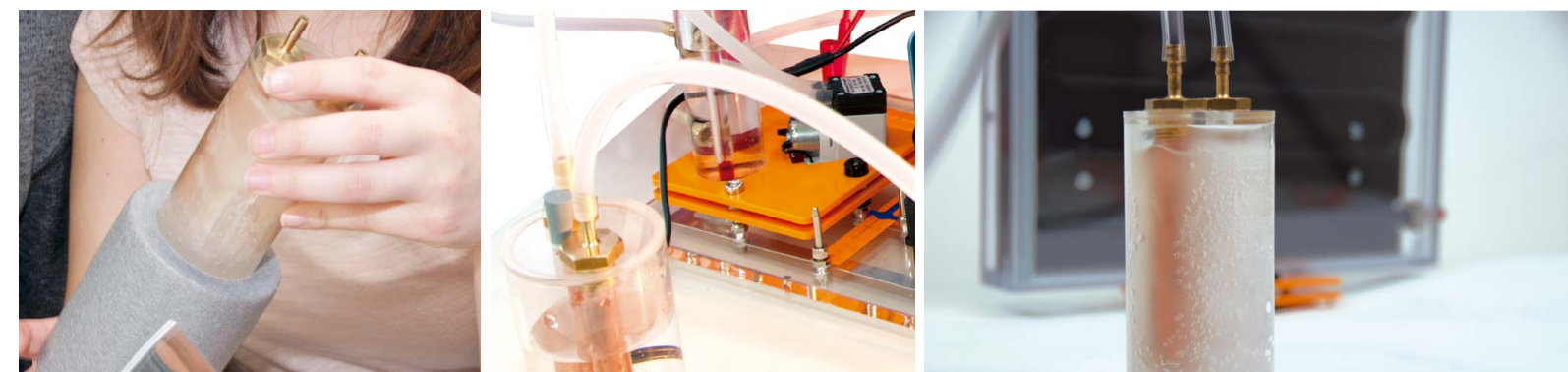
## Components

- 1 x 1100-19 leXsolar-Base unit Large
- 1 x 1100-27 Motor module without gear
- 1 x 1300-03 Solar collector
- 1 x 1300-04 Parabolic reflector
- 1 x 1300-05 Absorber tube
- 1 x 1300-06 Lens module
- 1 x 1300-07 Absorber module for lens
- 1 x 1300-08 Absorber B/W
- 1 x 1300-09 Pump module
- 1 x 1300-10 Peltier module
- 1 x 1300-11 Heat exchanger water
- 1 x 1300-12 Heat exchanger paraffin
- 1 x 1300-13 Hose-set
- 1 x 9100-05 PowerModule
- 1 x L3-03-258 Info sheet initial startup
- 2 x L2-02-007 Sorting rubber d=65, mark P
- 1 x L2-02-017 Propeller
- 2 x L2-04-059 Safety test lead, 50cm, red
- 2 x L2-04-060 Safety test lead, 50cm, black
- 1 x L2-04-080 Lamp housing
- 1 x L2-04-200 Illuminant infrared 230V
- 1 x L2-04-138 Safety plug, black
- 1 x L2-04-139 Safety plug, red
- 6 x L2-05-035 safety socket adapter SA 4000 red
- 4 x L2-05-036 safety socket adapter SA 4000 black
- 2 x L2-06-011 Digital multimeter
- 1 x L2-06-016 Laboratory thermometer
- 1 x L2-06-082 Beaker 250 ml
- 1 x L2-06-123 Temperature measuring sensor
- 1 x L2-06-125 Cooling pad
- 1 x L3-01-171 Aluminium case ThermalEnergy Professional 1306
- 1 x L3-03-190 Layout diagram 1306 ThermalEnergy Professional
- 1 x L3-01-109 Insert „ThermalEnergy Ready-to-go„

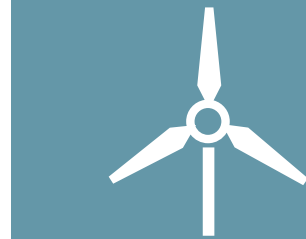


## extras available

- Manuals available to download
- L2-04-044 Electric grid adapter set
- 1100-63 DC converter 120V - 240V

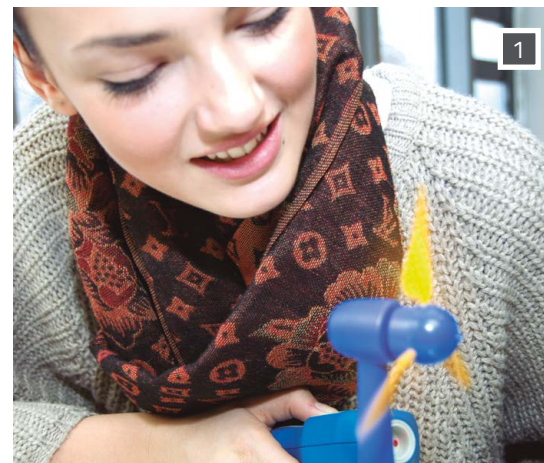






With the leXsolar – Wind area of expertise you develop an understanding of the physical basics of wind energy utilization and the practical application of this technology.

## Topic Wind



### 1 leXsolar-Wind rotor set Item-No. 1400-12

The leXsolar-Rotor blades have a realistic profile and a twisted shape, based on real rotors. Thus, they are the only ones on the educational market that allow realistic experiments. The innovative and easy system of rotor blades and different hubs allows a multitude of rotors.

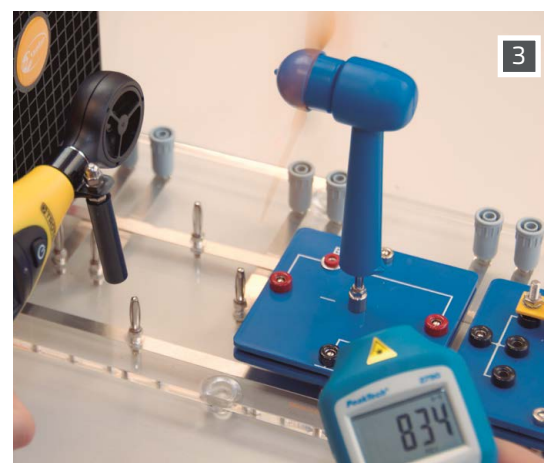
The following parameters can be varied:

- Blade profile : optimized profile or „wind-mill“-style
- Number of blades : 1-,2-,3- or 4-bladed rotors
- Blade angle (the so called pitch) : 20°, 25°, 30°, 50° and 90°



### 2 leXsolar-Wind machine Item-No. 1400-19

To ensure reproducible experiments with wind energy, a laminar flow field is necessary. Until now, this was only possible with big and expensive wind tunnels. The innovative design of the leXsolar-Wind machine achieves this in a compact, competitive device that reaches a wind velocity up to 7m/s. It is powered with 4...12 V DC.



### 3 leXsolar-Wind turbine module Pro Item-No. 1118-03

It is essential for technical training experiments to be as realistic as possible and related to practice in order to keep the students' motivation high. This is why the leXsolar- Wind turbine follows the model of a real wind energy plants and, thus, allows to make the connection to the real model.





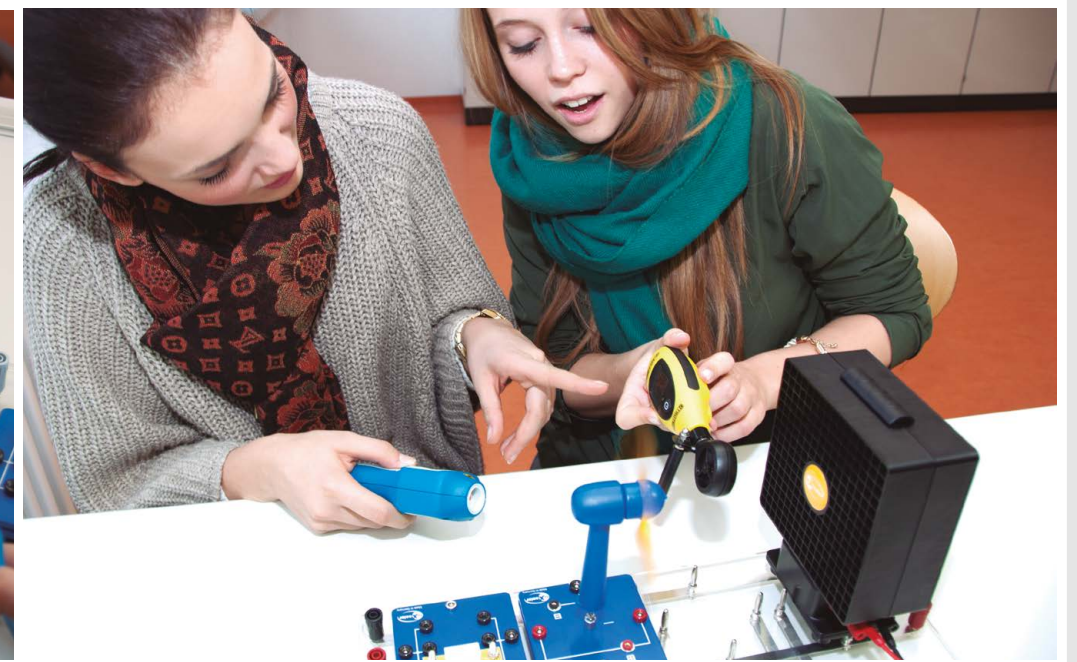
## leXsolar-Wind Professional ▶

Item-No. 1406

Nowadays Wind energy supplies the highest percentage of renewable energy production. Based on the growing construction of new wind power plants, the demand for specialist personnel is really high.

leXsolar-Wind Professional offers you practical oriented experiments for technical training, including interesting basic experiments at the same time. The fields of applications are wide-ranging: from vocational school to university level.

With help of the innovative leXsolar-rotor blades (see page 21), students can determine several parameters like rotational speed, power or efficiency, according to the different settings of the wind plants like pitch angle or number of blades.



## Experiments

- Examine the wind speed behind the rotor
- Energy balance sheet and efficiency of a wind turbine
- Rotational speed and speed ratio of a wind turbine.
- Change the turbine voltage by connecting a consumer
- Characteristic curves and rotational speed of a wind turbine
- Voltage of a wind turbine in dependence of the wind speed
- Rotational speed and output in dependence of the wind speed
- Voltage in dependence of the wind direction
- Rotational speed and output in dependence of the wind direction
- Comparison of the start-up wind speed of a Savonius and a three-blade rotor
- Comparison of a Savonius rotor and a three-blade rotor
- Voltage in dependence of the rotor blade shape
- Rotational speed and output in dependence of the rotor blade shape
- Voltage in dependence of the number of blades
- Rotational speed and output in dependence of the number of blades
- Voltage in dependence of the rotor blade pitch
- Start up speed of a wind turbine in dependence of the rotor blade pitch
- Rotational speed and output in dependence of the rotor blade pitch

Scan!

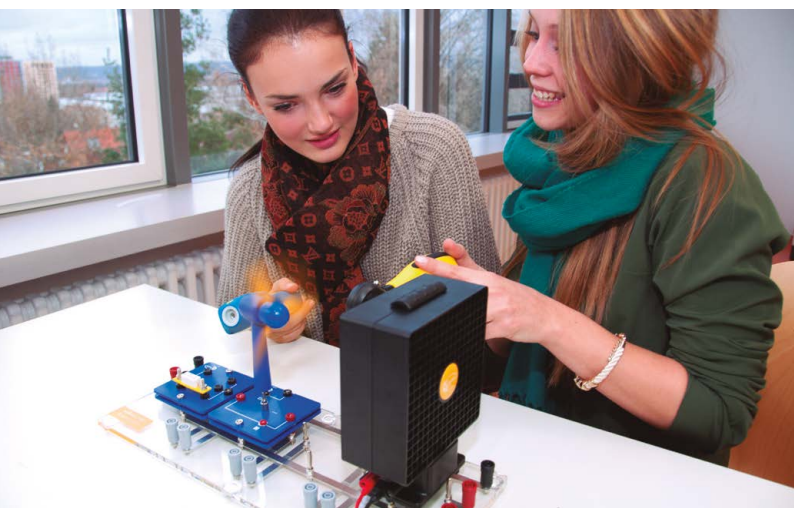


## Components

- 1 x 1118-02 Motor module Pro
- 1 x 1118-03 leXsolar-Wind turbine module Pro
- 1 x 1118-04 Potentiometer module Pro
- 1 x 1118-14 Savonius rotor module Pro
- 1 x 1400-12 leXsolar-Wind rotor set
- 1 x 1400-13 leXsolar-base unit Professional
- 1 x 1400-19 Wind machine
- 1 x 1400-20 Anemometer Pro
- 2 x 1800-01 Resistor module (triple) Pro
- 3 x 1800-04 Resistor plug element 100 Ohm
- 2 x 1800-05 Resistor plug element 10 Ohm
- 1 x 1800-06 Resistor plug element 33 Ohm
- 1 x 9100-03 AV-Module
- 1 x 9100-05 PowerModule
- 1 x L2-02-017 Propeller
- 1 x L2-04-059 Safety test lead, 50cm, red
- 1 x L2-04-060 Safety test lead, 50cm, black
- 1 x L2-04-066 Safety test lead, 25cm, red
- 1 x L2-04-067 Safety test lead, 25cm, black
- 3 x L2-05-068 Safety short-circuit plug, with mid socket
- 1 x L2-06-062 Rotational-speed sensor
- 1 x L3-01-073 Aluminium case „Wind-Professional“
- 1 x L3-01-091 Insert „Wind-Professional“
- 1 x L3-03-258 Info sheet initial startup
- 1 x L3-03-180 Layout diagram 1406 leXsolar-Wind Professional

## extras available

- Manuals available to download
- L2-04-044 Electric grid adapter set
- 1100-63 DC converter 120V - 240V





## leXsolar-Curriculum Wind-Professional

The new **leXsolar-Curricula** are the perfect guideline to teach your students wind power technology from the basic knowledge until the commercial application. In less than one semester, transform your participants into high-qualified experts on wind energy.

### Key data

- Pre-made practical course for one semester
- No preparation needed
- From physical basics to technical applications
- Included in the experimentation manual Wind-Professional



The leXsolar-Curricula are especially designed to help you, as a professional. For this purpose the tested experiments from the leXsolar Wind-Professional kit were sorted by content and educational aspects, and the learning goals were subdivided into different structure levels. As a result you get a free access to a set of 10 predefined units, incorporated in four thematic sections. The 90 minutes lasting units can be perfectly integrated into the classical lab course/ theory-concept.

The structure of the curriculum goes from the basic examinations of wind power plants targeted until the physical details of wind turbines, leaving no doubts behind.

The elaborated structure and selection of topics can also be a big help to plan and support the theoretical lectures. For a further support, we offer also the leXsolar-Academy (see p. 32), which we recommend for the training of your future tutors.

### Fundamental Basics (optional)

- 1,5 hours
- Topics: electrical Basics
- Objectives: describing and reasoning the behavior of basic electrical circuits; calculate and measure systems of resistors

### Wind power basics

- 6 hours
- Topics: Wind turbine characteristics; turbine performance under load; turbine performance at different wind conditions
- Objectives: analyzing the power conversion processes at a wind turbine; characterizing and rating of a typical wind turbine; investigation of the influence of wind conditions and loads on turbine performance; determining optimized working conditions

### Controlling a typical wind turbine

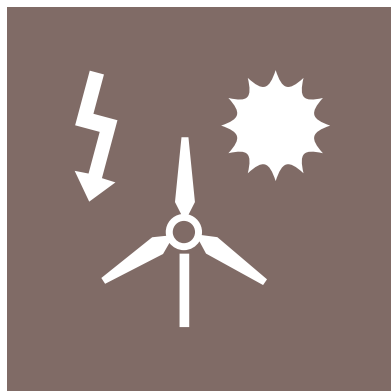
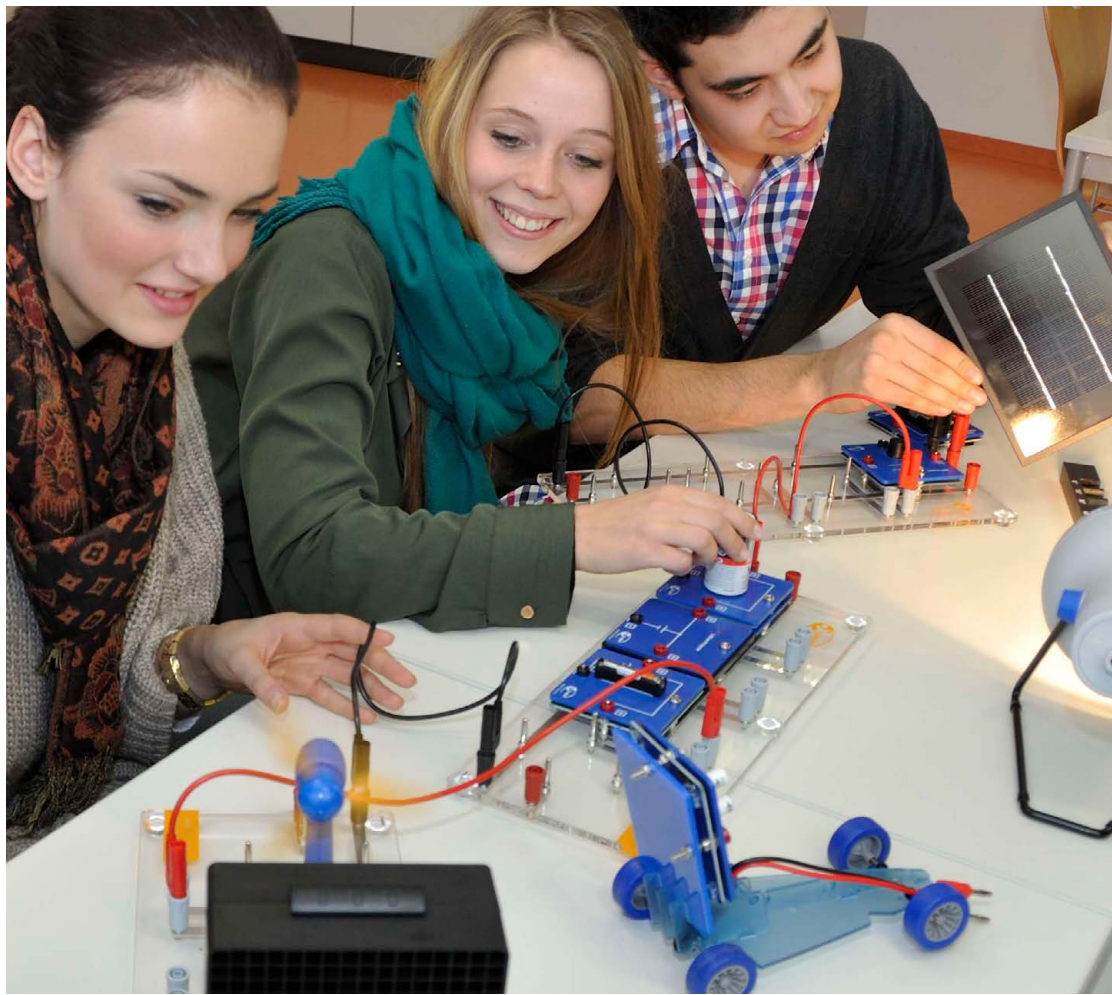
- 4,5 hours
- Topics: controlling of a wind turbine; gondola orientation; pitch regulation
- Objectives: measuring and analyzing the influence of two typical variances on the wind turbine performance; considering different possibilities to use these parameters to control a typical wind turbine

### Different rotor types

- 4,5 hours
- Topics: Savonius rotors; blade shape; blade number; operating conditions
- Objectives: knowing different types of wind rotors; features, advantages and disadvantages of different rotor types; illustrating the line of argument which leads to the three-blade horizontal axis wind turbine



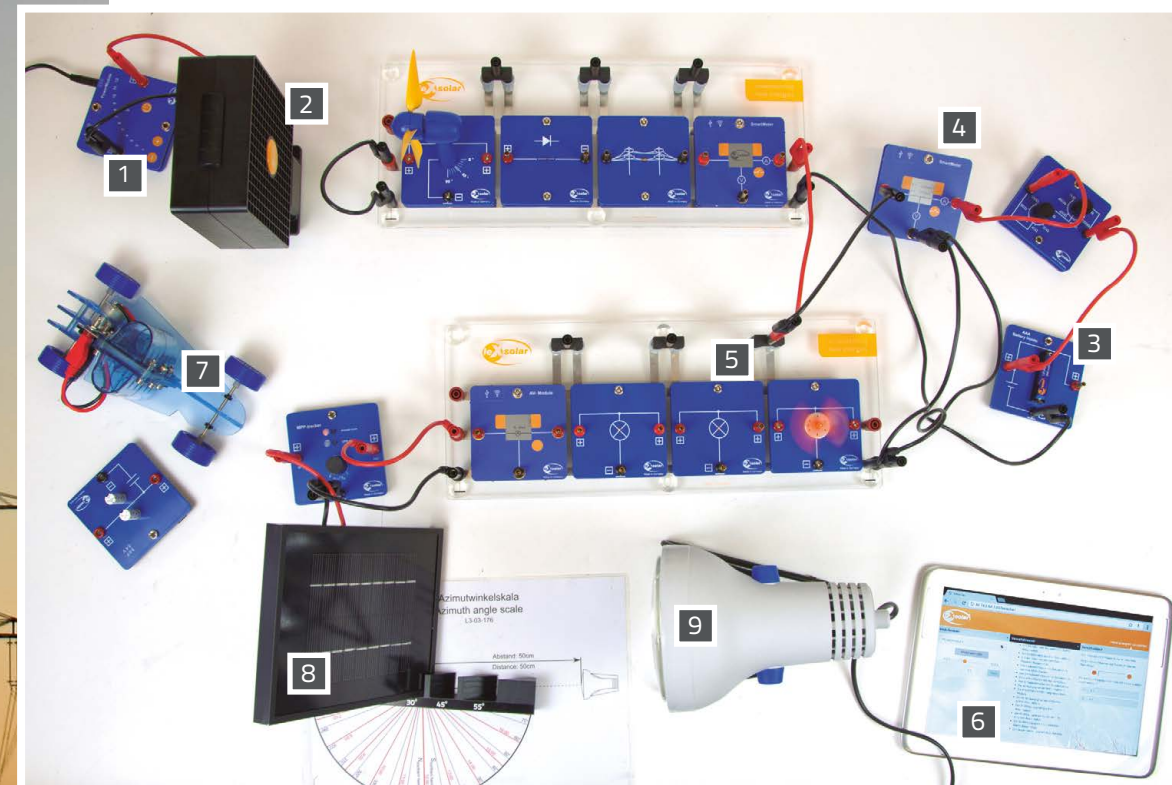




The term SmartGrid stands for Connection and Control of energy sources; its storage and load owe to an "intelligent" power grid. SmartGrids are essential for a successful energy transition.

# Understanding the energy transition with leXsolar-SmartGrid

- 1 Daily profile wind velocity**  
Right now there's a stiff breeze –great conditions for wind power plants! The leXsolar-Power module controls the wind speed according to the daily profile.
- 2 Wind farm**  
The wind farms run at full power! Where should the surplus energy go? Do the storages have enough capacity?
- 3 Pumped storage power plant**  
The storage is almost full! Now, the smart e-mobility fleet needs to be involved to provide sufficient storage capacity!
- 4 Smartmeter**  
The grid reports an ample energy supply–time for the smartmeter to start the pre-programmed washing machine. The leXsolar-Smartmeter works like a real intelligent electricity meter. Depending on the energy supply, it can switch consumers on or off and keeps the grid stable and the electricity not expensive.
- 5 Consumers**  
In a real household, different consumers play different roles different times. Thus, their behavior corresponds to a specific consumption profile.
- 6 Network control center**  
This is where all data come together: current energy production, available storage capabilities and the energy consumption. These kind of information enable students to manage their grid by themselves. The communication works wireless with SmartControl technology (see p.14). The integrated platform-independent software allows the control with any mobile device.
- 7 E-Mobility**  
Electronic vehicles are an important part of the SmartGrid of the future! They work as a decentralized „storage fleet“.
- 8 Solar park in South Europe**  
The conditions are bad and the photovoltaic plants are running only at 20% of their capacity! Luckily, the wind farms in the north are running at full speed.
- 9 Sun**  
It's cloudy and the solar radiation is therefore quite weak. The lighting is controlled by the leXsolar-dimmer module according to a pre-set daily profile.





## leXsolar-SmartGrid Professional ▶

Item-No. 1607

Understanding the complex interactions between renewable energies, energy stores and consumers is an important goal in the vocational and technical education sector. leXsolar-SmartGrid Professional allows the construction of a controllable Smart grid on a laboratory scale. Pre-set or user-created scenarios, let the students gradually develop their knowledge and understand by themselves with their own experiments.

Measuring and Control are accomplished with the help of the leXsolar-SmartControl components. With the SmartControl software, all parts of the Smart Grid can be controlled extensively.

As students set up a real grid and not just a simulation, realistic incidents can happen, like the sudden loss of a wind power plant. Students now need to make sure that all consumers are supplied according to predefined priorities.



## Experiments

### Smart Grid Experiments

- Daily power fluctuations of a photovoltaic (PV) power plant
- Daily power fluctuations of a wind power plant
- Energy supply of a building by conventional power plants
- Energy supply of a building by conventional and PV power plants
- Energy supply of a building by conventional and PV power plants with storage
- Voltage behavior and grid stability in a radial distribution system
- Grid stability with PV power plants
- Grid stability with PV power plants depending on consumer load
- Grid stability with PV power plants depending on wire length
- Grid stability with PV power plants and smart transformer stations
- Grid stability with PV power plants and storages
- Grid integration of E-Mobility
- Conductor rope management

### Fundamental experiments

- Photovoltaics:  
IV-Characteristics of solar panels  
IV-Characteristics depending on illumination  
IV-Characteristics depending on temperature  
MPP-Tracking

- Wind energy  
Turbine power dependent on blade shape and pitch angle  
Turbine power dependent on number of blades  
Turbine power dependent on wind direction
- Fuel Cell and Electrolyzer  
Functionality of an electrolyzer  
IV-characteristics of an electrolyzer  
Functionality of a fuel cell  
IV-characteristics of a fuel cell  
Storage technologies  
Charge and discharge characteristics of a capacitor  
Functionality and charge procedure of a LiFePo battery  
Operation of fuel cells and electrolyzers

## Key facts

- Setup of a complete smart grid on laboratory scale
- Investigating the influence of renewable energies on grid stability
- Additional fundamental experiments on wind, photovoltaics, fuel cells and energy storages

Scan!

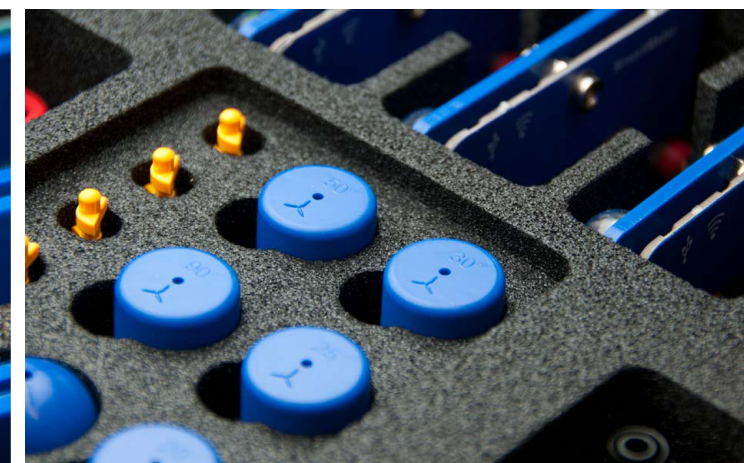
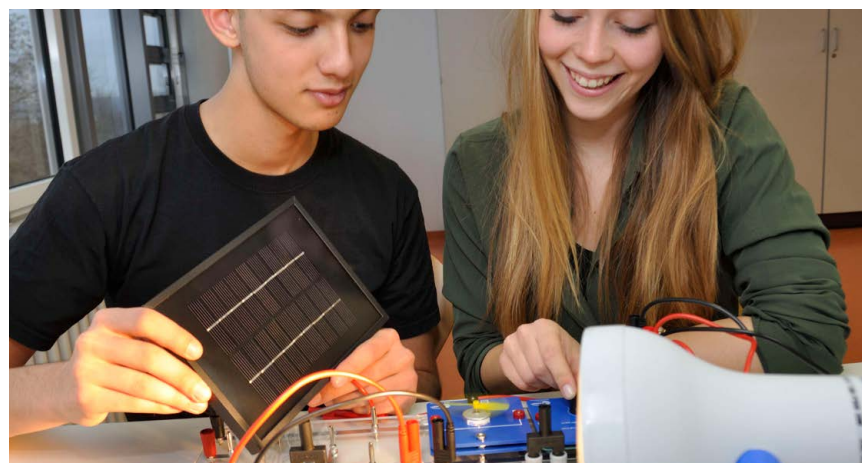


## Components

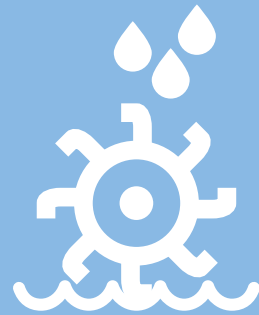
- 2 x 1400-13 leXsolar-base unit Professional
- 2 x 9100-04 SmartMeter
- 1 x 1118-03 leXsolar-Wind turbine module Pro
- 1 x 1100-04 Solar module 5.22 V, 380 mA
- 1 x 1400-19 Wind machine
- 1 x 1118-02 Motor module Pro
- 1 x 1118-17 Base for solar panel
- 2 x 9100-05 PowerModule
- 1 x 1400-12 leXsolar-Wind rotor set
- 2 x 1118-01 Light bulb module Pro
- 1 x 1118-11 Capacitor module Pro
- 1 x 9100-03 AV-Module
- 1 x 1800-08 Battery module holder 1xAAA Pro
- 1 x 1801-06 LiFePo-battery AAA
- 1 x 1800-12 Fuel cell holder Pro
- 1 x 1118-13 MPP-Tracker Pro
- 2 x 1607-01 Grid module Pro
- 1 x 1118-05 Diode module Pro
- 1 x 1100-62 Potentiometer module 110 Ohm Pro
- 1 x L2-04-116 Illuminant 120W, 12°
- 1 x L2-04-080 Lamp housing
- 6 x L2-05-068 Safety short-circuit plug, with mid socket
- 1 x L3-01-137 Koffer SmartGrid Pro 1607
- 1 x L3-01-138 Einlage SmartGrid Pro 1607
- 1 x L3-03-081 leXsolar-DVD Professional
- 5 x L2-04-066 Safety test lead, 25cm, red
- 4 x L2-04-067 Safety test lead, 25cm, black
- 4 x L2-04-059 Safety test lead, 50cm, red
- 4 x L2-04-060 Safety test lead, 50cm, black
- 1 x L2-02-017 Propeller
- 1 x L2-06-067 Reversible Fuel cell
- 1 x L3-03-176 Azimuth angle scale
- 1 x L3-03-171 Einräumplan 1607 SmartGrid Professional
- 1 x L3-03-220 Instruction for use of finger protector

### extras available

- Manuals available to download
- L2-04-044 Electric grid adapter set
- 1100-63 DC converter 120V - 240V







Hydropower was the first renewable energy source that was used by man to produce electrical energy. Even if its potential is limited in many countries, it plays an important role in the energy mix, as it is less prone to fluctuations like other renewable energy sources.

## Topic Hydropower

### 1 Interchangeable Turbines

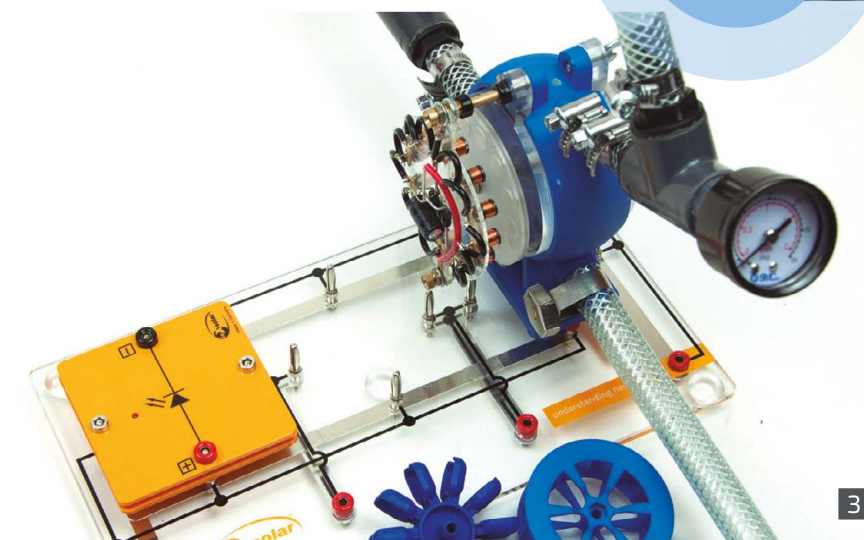
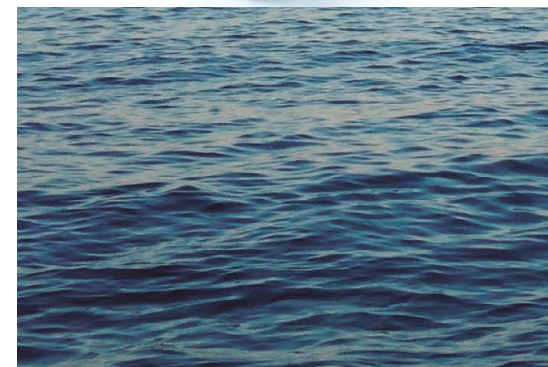
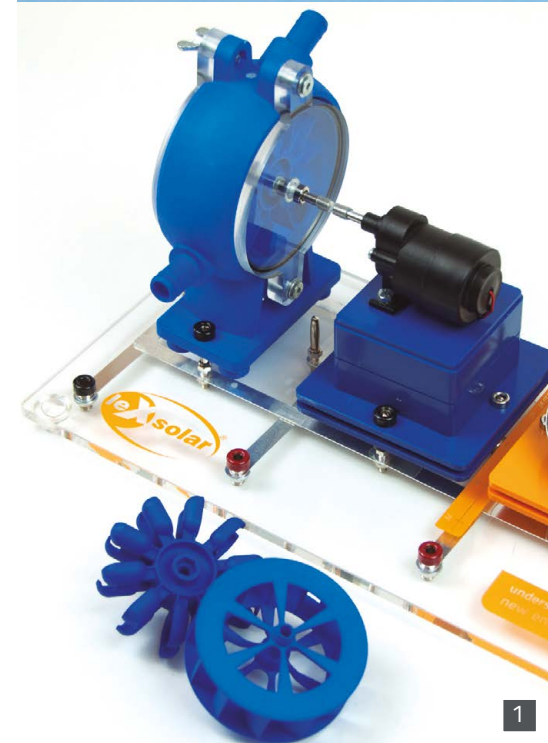
Due to the interchangeable turbines, leXsolar-Hydropower is not only suited for quantitative, demonstrative experiments, but also for numerous praxis-oriented experiments. You can, for instance, compare the efficiency factor for a Pelton- or cross-flow turbine for different rates of flow. This way, students not only learn about the physical principles different types of turbines but also about their respective areas of application.

### 2 The hydropower click-in infrastructure system

leXsolar featuring Gardena and created an easy and simple to use click-in system for necessary elements of the leXsolar hydropower system. With this simple connection the different entrances of the turbine housing can be used easy and fast. An integrated measuring system for water pressure and flow volume makes the system complete and ready to use for everyone.

### 3 leXsolar- Induction generator

The small induction generator used in the hydropower system is a development directly from the leXsolar development team and one of the most efficient systems in the world. With 12 electric coils and magnets the generator makes it very clear and easy to understand the principle of electromagnetic induction of electric power. That allows you to compare the generated power of the three different turbines with the same set-up and without long modification times.







## leXsolar-Hydropower Ready-to-go▶

Item No. 1905

Besides qualitative experiments as introduction into the topic hydropower usage for junior high school students, this experimenting kit offers fundamental quantitative experiments on the physics of water turbines.

A foundation in reality enjoys, as with all leXsolar products, a high priority. leXsolar-Hydropower Ready-to-go is therefore equipped with different types of turbines – from a simple water wheel to a modern, highly efficient Pelton turbine.



## Key facts

- Fast assembly by GARDENA plug system
- Various adapters for water-tap is include
- Observation of the functionality of the electrical generator during the operation
- Three different types of turbines
- Fundamentals of fluid dynamics

## Experiments

- Volume flow, flow velocity and power as a function of the height of fall
- Volume flow, flow velocity and power as a function of the pipe cross-section
- Comparison of the functionality of pelton turbine, crossflow turbine and waterwheel
- Comparison of the performance of the pelton turbine, crossflow turbine and waterwheel in
- Dependence to the volume flow and pressure

## Advantages

Students can open the turbine housing in order to change the turbine; hence different turbines can be compared in the experiments.

As different turbines need different directions of their water supply, the housing is equipped with three tube connectors for ingoing and outgoing water.

Scan!

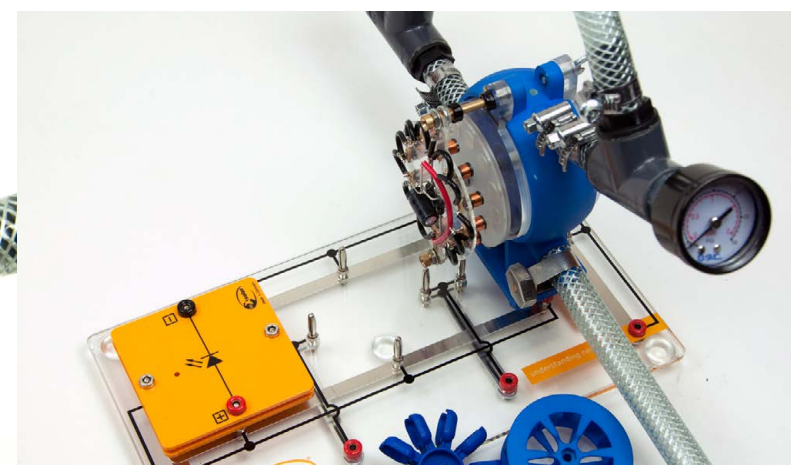
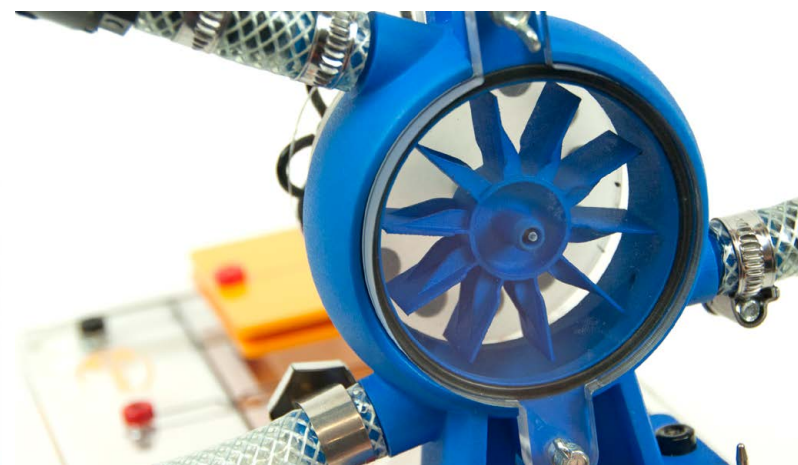
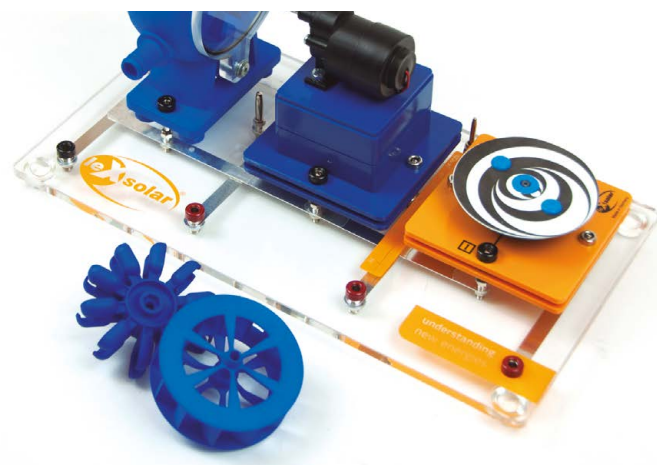


## Components

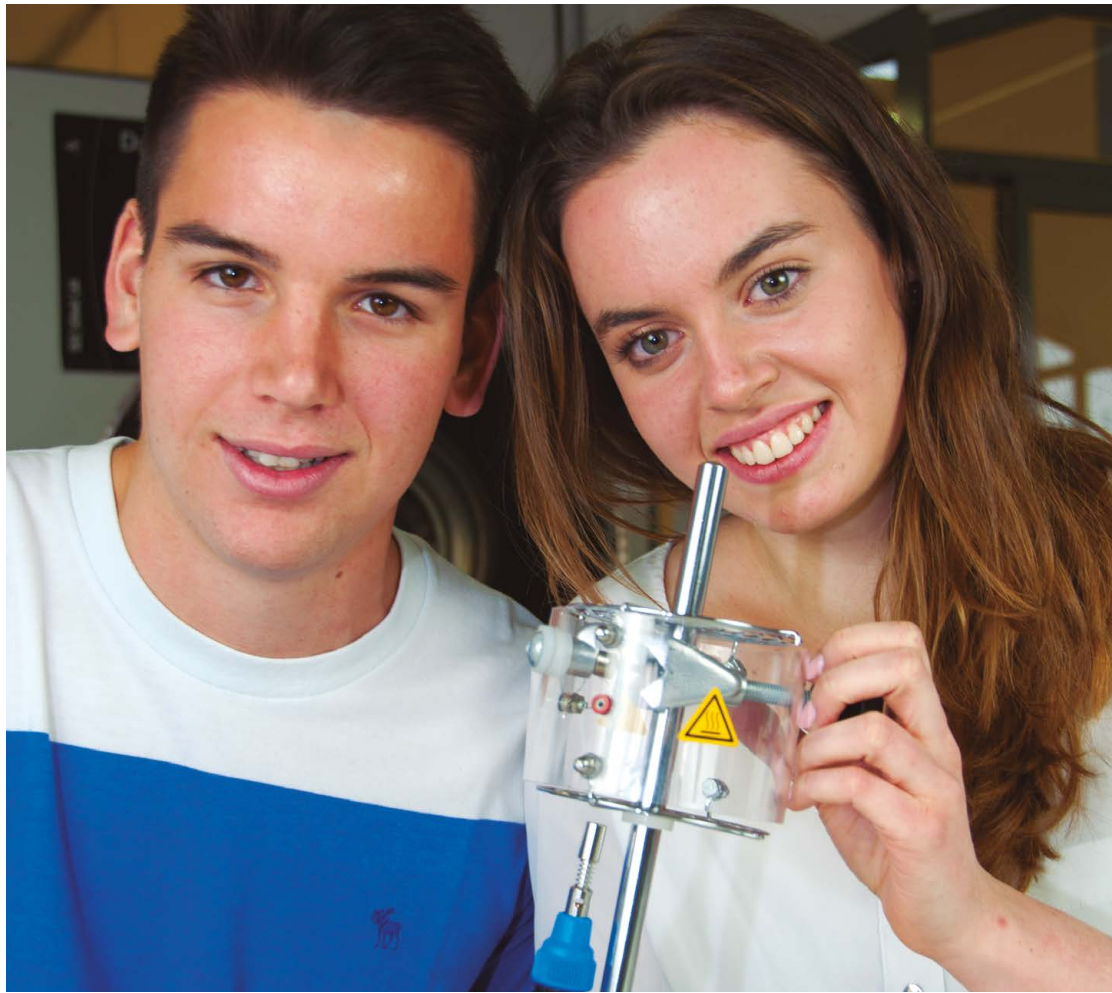
- 1x 1900-02 Water turbine casing
- 1x 1900-03 Turbines set
- 1x 1900-05 Manometer set 2 bar
- 1x 1900-06 Manometer set 4 bar
- 1x 1900-07 Intake connector
- 1x 1900-08 Flow set 4 mm
- 1x 1900-09 Flow set 8 mm
- 1x 1900-10 Flow set 12 mm
- 1x 1905-02 Induction generator 12 fold
- 1x 9100-03 AV-Module
- 1x 1100-26 Light bulb module
- 1x 1400-08 LED-module 2mA, red
- 1x 1100-25 Buzzer module
- 1x 1100-27 Motor module without gear
- 1x 1100-19 leXsolar-Base unit Large
- 1x 1100-22 Resistor module
- 1x 1900-11 Flow box
- 1x 1100-28 Color discs - Set 1
- 1x 1900-12 Connection set
- 1x L3-01-202 Aluminium case PV Professional 1905
- 1x L2-02-066 Water flow meter
- 2x L2-05-131 Schlauchschelle
- 1x L3-03-258 Info sheet initial startup
- 1x L3-03-272 Einräumplan 1905 Hydropower Ready-to-go
- 0,2x L2-02-062 Gewebeslauch 12/18mm
- 1x L2-06-014 Test lead black 50 cm
- 1x L2-06-015 Test lead red 50 cm
- 1x L2-06-012 Test lead black 25 cm
- 1x L2-06-013 Test lead red 25 cm
- 1x L2-05-135 Schlauchschelle mit Drehkopf und Sechskantschraube, Edelstahl
- 1x L3-01-197 Container box 6 L
- 1x L3-01-194 Insert HydroPower RtG 1905
- L2-04-044 Electric grid adapter set
- 1100-63 DC converter 120V - 240V

### extras available

- Manuals available to download
- L2-04-044 Electric grid adapter set
- 1100-63 DC converter 120V - 240V







The hydrogen fuel cell technology is a potential key component to solve the problem of storing renewable energies. That is because renewable energy can be stored as hydrogen (H<sub>2</sub>) and then later transformed into electricity. The leXsolar-H<sub>2</sub> allows for basic and practice-related experiments for physics and chemistry classes.

## Topic H<sub>2</sub>

### 1 leXsolar-PLUG-IN- PLUG-OUT fuel cell stack

Electric mobility is a very present topic in the automotive industry as well as in politics. If you engage with this topic you will also find that fuel cells are very present too. To use fuel cells not just in laboratory but in everyday applications you will need so called stacks of them.

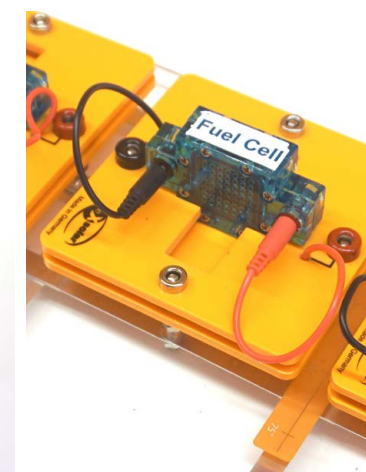
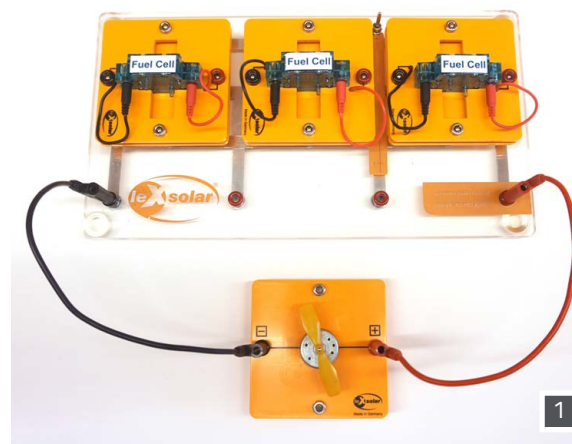
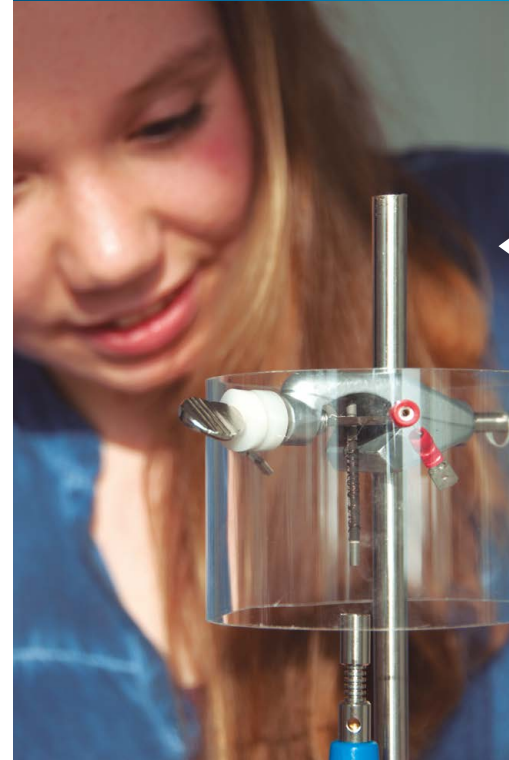
With the leXsolar-PLUG-IN-PLUG-OUT fuel cell stack it is easy to create parallel or serial connection of two or three single fuel cell systems to understand how they work. Together with the innovative H<sub>2</sub> Charge and H<sub>2</sub> Storage solution you can create your hydrogen infrastructure in lab scale size.

### 2 H<sub>2</sub> Charger Item No. 1200 -17

The H<sub>2</sub> Charger allows the easy and safe generation of hydrogen. You only need a power socket and water. The H<sub>2</sub> Charger is instantly ready to use. The hydrogen can then be stored with the H<sub>2</sub> Storage.

### 3 H<sub>2</sub> Storage Item No. 1200 -18

The H<sub>2</sub> Storage allows the easy and safe storage of hydrogen with a metal hydride storage tank and, thus, omits the need for gas containers. The stored hydrogen can also be used for other applications within the leXsolar experimentation systems.



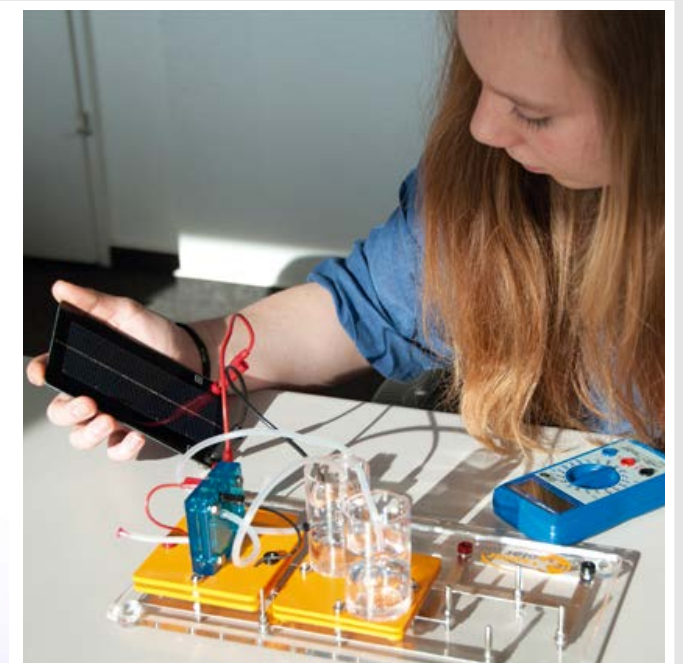
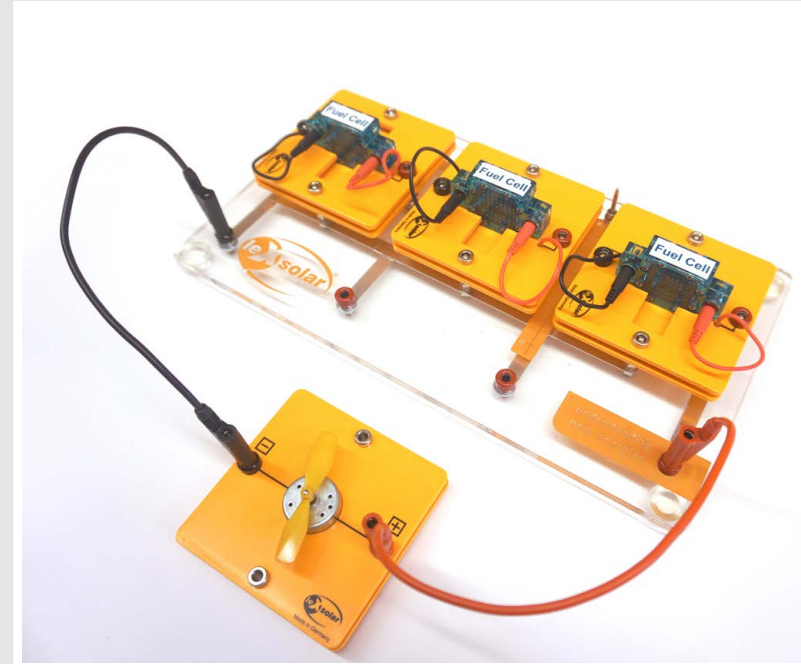


## leXsolar-H<sub>2</sub> Professional ▶

Item-No. 1217

leXsolar-H<sub>2</sub> Professional offers the entire spectrum of current fuel cell technology for the technical education. Solar module, electrolyzer, and fuel cell permit the assembling and examination of a solar-hydrogen cycle. Working principles, efficiency and characteristics curves of electrolyzer and fuel cell are just some of the topics covered. Beside the PEM-fuel cell, it also contains an ethanol-fuel cell in order to compare the different technologies.

H<sub>2</sub> Charger and H<sub>2</sub> Storage allow for the easy generation and storage of hydrogen. True to the traditions of the Professional series all ancillary equipment is already included in the robust aluminum suitcase.



## Experiments

- What does an electrolyzer do?
- Characteristics of an electrolyzer
- Hydrogen production with the H<sub>2</sub> Charger
- Hydrogen storage with the H<sub>2</sub> Storage technology
- Characteristics of a PEM-Fuel cell
- Characteristics of an Ethanol-Fuel cell
- Faraday and energy efficiency of the electrolyzer
- Faraday and energy efficiency of the PEM-fuel cell
- Parallel- and series connection of PEM-fuel cells



## Key data

- Comprehensive experimentation system on fuel cell technology
- Two different fuel cell technologies: PEM-, ethanol fuel cells
- Buildable fuel cell stacks with three PEM-fuel cells
- Easy hydrogen generation and storage with H<sub>2</sub> Charger and H<sub>2</sub> Storage
- Includes all ancillary equipment

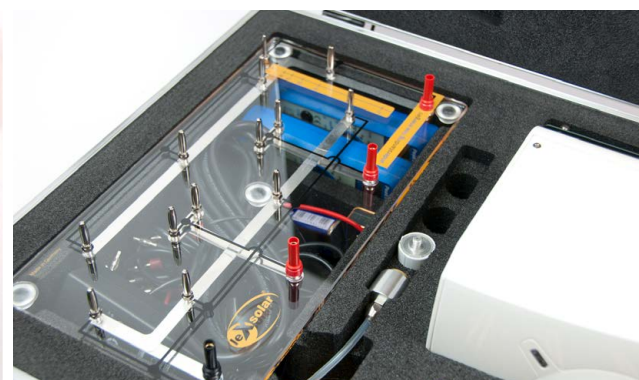
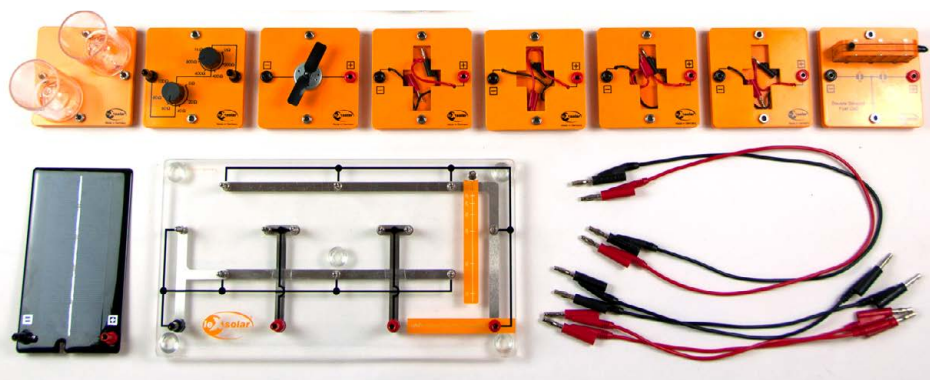
## Components

- 1 x 1100-19 leXsolar-Base unit Large
- 1 x 1100-23 Potentiometer module
- 1 x 1100-27 Motor module without gear
- 1 x 1100-31 Solar module 2.5 V, 420 mA
- 1 x 1200-17 H<sub>2</sub> Charger
- 1 x 1200-18 H<sub>2</sub> Storage
- 1 x 1213-01 Gas storage module
- 1 x 1217-01 Aluminium case 1217
- 3 x 1218-02 PEM-Fuel cell module
- 1 x 1218-03 Electrolyzer module 2.0
- 1 x 1700-01 leXsolar ethanol fuel cell module
- 1 x L2-02-017 Propeller
- 0,15 x L2-02-048 Silicone tube 2 mm
- 1 x L2-04-022 Lamp with table clamp
- 1 x L2-04-059 Safety test lead, 50cm, red
- 1 x L2-04-060 Safety test lead, 50cm, black
- 2 x L2-04-066 Safety test lead, 25cm, red
- 2 x L2-04-067 Safety test lead, 25cm, black
- 2 x L2-05-035 safety socket adapter SA 4000 red
- 4 x L2-05-036 safety socket adapter SA 4000 black
- 2 x L2-06-011 Digital multimeter
- 1 x L2-06-132 Valve for H<sub>2</sub> Storage
- 1 x L3-01-103 Insert H<sub>2</sub> Ready-to-go
- 1 x L3-03-258 Info sheet initial startup
- 1 x L3-03-195 Layout diagram 1217 H<sub>2</sub> Professional



## extras available

- Manuals available to download
- L2-04-044 Electric grid adapter set
- 1100-63 DC converter 120V - 240V







The new area of expertise leXsolar-BioEnergy allows you to understand the whole biomass cycle. From the sprouting and growth of the plants to the aerobic and anaerobic degradation and the use of produced biogases – all of these steps can be performed and understood with our new system.

## Topic BioEnergy

### 1 leXsolar-Hydroculture

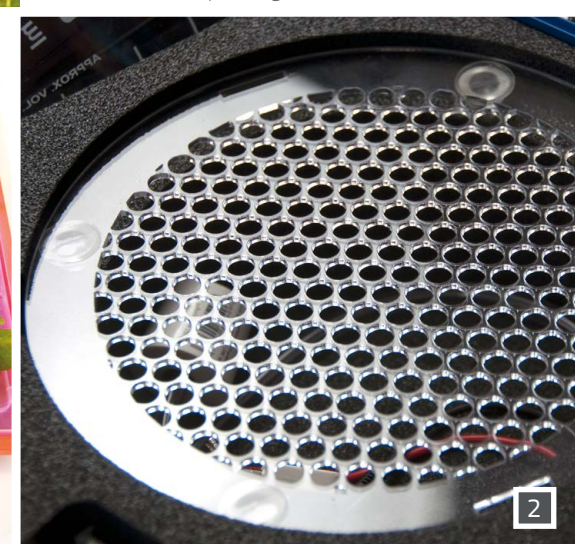
The leXsolar-Hydroculture is a lab scale hydroculture system which allows growing plants with minimal use of space, water and nutrients and no use of soil at all. The plants are placed in individual plant pots with their root tips hanging in a water-fertilizer-dissolution for optimal nutrient and water absorption. Furthermore you'll find plant LED lights with red, blue and white wavelengths to ensure a constant and reproducible light situation and therefore optimal growth of the plants.

### 2 leXsolar- Composter Item No. 1700-08

The leXsolar-Composter is designed to guarantee optimal conditions for the aerobic degradation of biomass. The holes in the bottom plate provide a constant ventilation to transport oxygen into the compost and ensure the drain of redundant water. The whole compost container is made out of transparent material so that the degradation processes can easily be observed.

### 3 leXsolar-Gas collecting container Item No. 1700-09

With the leXsolar-BioEnergy system the anaerobic degradation processes to produce methane and hydrogen out of biomass can be performed in lab scale. To collect the produced gases from these processes, leXsolar developed a gas collecting container. This container allows collecting the gases to use them in a further step. You can also use the scale to monitor the rate of biogas production depending on different conditions like temperature.





## leXsolar-BioEnergy Ready-to-go ▶

Item-No. 1710

The extensive experiment system leXsolar-BioEnergy Ready-to-go enables you to reconstruct and understand the whole biomass cycle without any additional equipment.

A cultivation box and hydroculture allow the observation of the sprouting and growth of plants. Thereby the water and nutrient consumption can be analyzed in the different growth phases.

Different experiments then show the aerobic as well as the anaerobic degradation of the biomass in a compost or biogas processes. Thus allows the exploration of the energetic use of biomass.



## Experiments

- Germination of plant seeds
- Plant growth in a hydroculture
- Consumption of water and nutrients
- Aerobic degradation of biomass in a compost
- Anaerobic degradation of biomass to form hydrogen
- Anaerobic degradation of biomass to form methane

Scan!



## Key data

- An experimental system to experience the whole biomass cycle.
- How biomass can be grown under artificial conditions.
- Energetic use of different degradation processes.

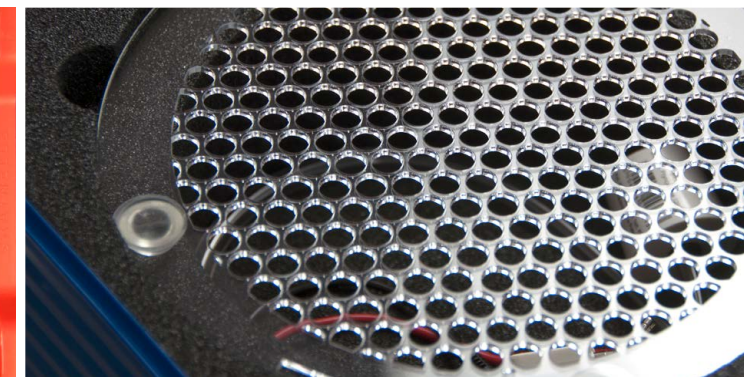
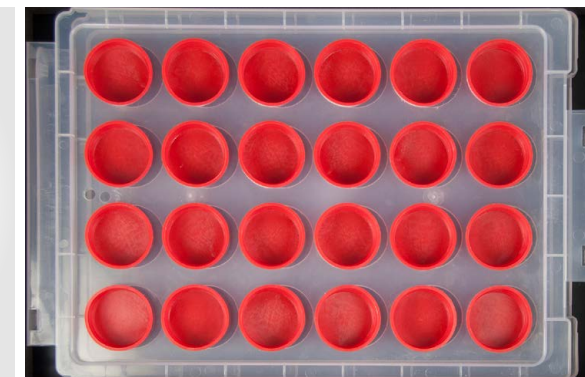
## extras available

- Manuals available to download
- L2-04-044 Electric grid adapter set
- 1100-63 DC converter 120V - 240V



## Components

- 1 x 1100-27 Motor module without gear
- 1 x 1218-02 PEM-Fuel cell module
- 1 x 1602-01 leXsolar-Base unit small
- 2 x 1700-05 Expanded clay pebbles
- 1 x 1700-06 Fertilizer
- 1 x 1700-07 Compost catalyst
- 1 x 1700-08 Composter
- 1 x 1700-09 Gas collecting container
- 1 x 1700-10 Burner
- 1 x 1700-11 Tripod plant lighting
- 1 x 1700-12 Sprout box
- 1 x 1700-13 Box 6 L
- 1 x 1700-14 Tripod
- 1 x 1700-15 Seed set
- 1 x 1700-16 Rubber plug with tube
- 1 x 1700-17 ID tags
- 1 x 1710-01 Aluminum case 1710 silver
- 1 x 1710-02 Aluminum case 1710 blue
- 2 x L2-01-120 Pot holder BioEnergy
- 1 x L2-02-017 Propeller
- 1,5 x L2-02-046 Silicone tube 4mm
- 1 x L2-02-083 Y-switch 4mm
- 2 x L2-04-194 Plant light
- 1 x L2-05-141 Hose clamp
- 1 x L2-06-012 Test lead black 25 cm
- 1 x L2-06-013 Test lead red 25 cm
- 2 x L2-06-033 Short-circuit plug
- 1 x L2-06-075 Erlenmeyer 1000 ml
- 2 x L2-06-185 Timer
- 1 x L2-06-186 Air pump
- 2 x L2-06-187 Aeration stone
- 50 x L2-06-188 Net cup planter
- 1 x L2-06-189 EC meter
- 1 x L2-06-190 Temperature logger
- 1 x L2-06-191 Weight
- 1 x L2-06-192 Tweezers
- 24 x L2-06-199 Stopper red
- 1 x L2-06-200 Nebulizer
- 2 x L3-01-012 Plastic box Gratnells 75 mm deep
- 1 x L3-01-210 Insert BioEnergy Rtg 1710
- 2 x L3-03-258 Info sheet initial startup
- 1 x L3-03-274 Layout diagram 1710 BioEnergy Ready-to-go







lexsolar-BioFuel deals with the different technologies of producing and using biomass fuel. Biofuels have two important advantages: they store renewable energies and they can easily replace fossil fuel in transportation.

## Topic BioFuel

### 1 leXsolar-Ethanol-Fuel cell Item No. 1700-01

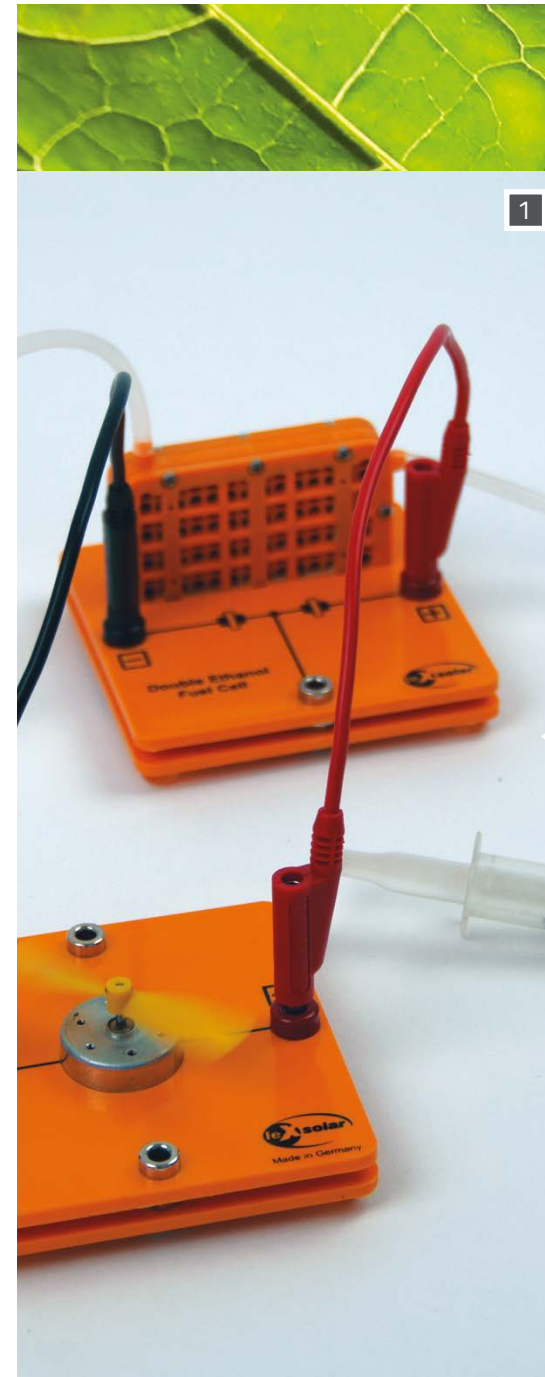
The direct conversion of ethanol into electric energy can be impressively demonstrated with the leXsolar-Ethanol-Fuel cell. The cell is robust, easy to use and the most powerful on the market especially designed for experimentation.

### 2 leXsolar-Condensor Item No. L2-06-071

leXsolar has developed an innovative cooling system that doesn't require a constant flow of cooling water. Instead, one filling is enough to distill up to 0.5 l of liquid. This makes it perfect for classrooms without the need of a direct access to water.

### 3 leXsolar-BioDiesel production set

We know small is beautiful. So again, we created a small and simple combination of necessary components to produce BioDiesel in a laboratory scale. The extraction of fats from edibles or oil crops and the transesterification of these fats into biodiesel (FAME) are only two possibilities to use our BioFuel system. Therefore it is perfect to prepare future engineers with the basics of process engineering and chemistry courses.







## leXsolar-BioFuel Ready-to-go

Item No. 1703

The entire process of producing biofuel is demonstrated with leXsolar-Biofuel Ready-to-go as a student experiment. The case contains all necessary components and can be used anywhere.

The first step is resource selection and fermentation. The resulting mash is then distilled with custom-built leXsolar-Condenser, and the ethanol obtained will be characterized.

Lastly, the bio fuel collected needs to be converted into usable energy – for example into electricity with the provided Ethanol-Fuel cell. leXsolar-BioFuel Ready-to-go does not only cover bio ethanol production but also the generation of biodiesel through transesterification of fats.



## Experiments

### Part 1: Biodiesel production

- Transesterification of fat into biodiesel (FAME)
- Measurement of fat parameters of biodiesel
- Extraction of fats from edibles or oil crops

### Part 2: Alcoholic fermentation

- Setting up a mash / fermentation
- Fermentation of different sugars (including catalytic decomposition of starch into monosaccharide)
- Detection of fermentation gases

### Part 3: Distillation and generation of bioethanol

- Distillation of a mash
- Characterization of the produced ethanol

### Part 4: Ethanol fuel cell

- Introduction ethanol fuel cell
- Characteristics of ethanol fuel cell
- Dependency of the ethanol fuel cell on concentration and temperature
- Energy balance of the entire process

Scan!

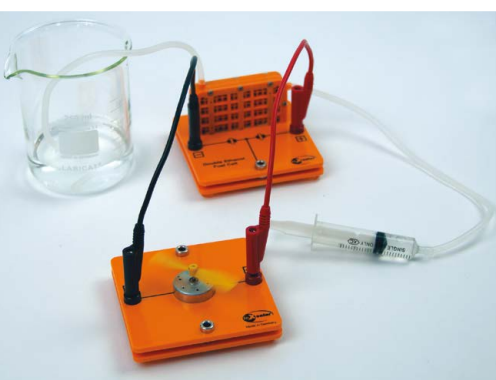


## Components

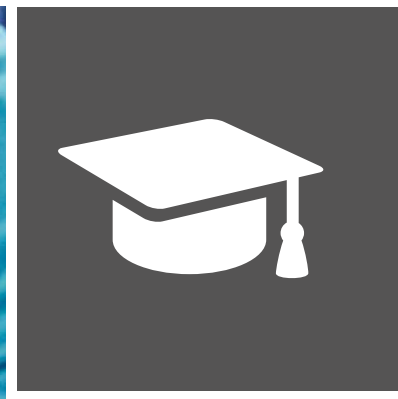
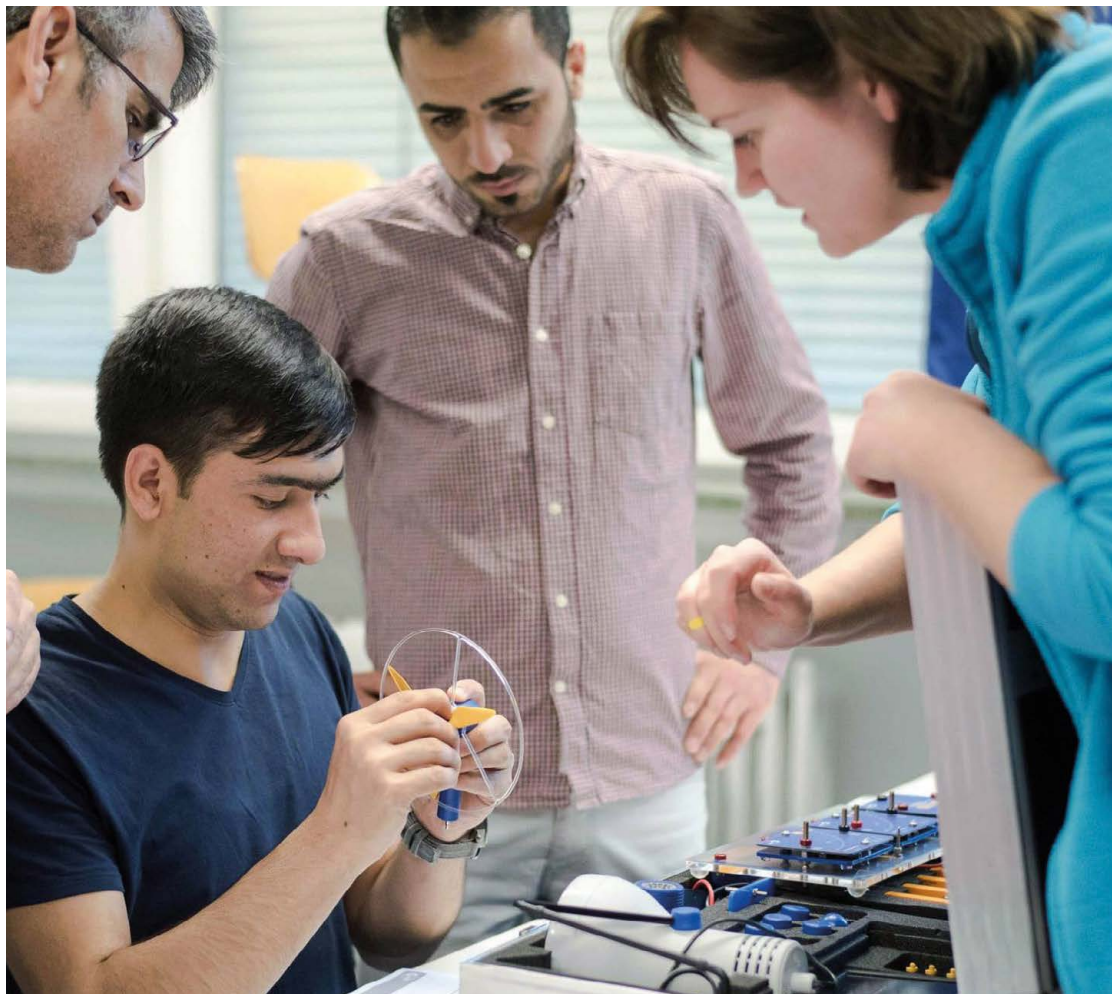
- 1x 1100-23 leXsolar-Potentiometer module
- 1x 1100-27 leXsolar-Motor module without gear
- 1x 1700-01 leXsolar-Ethanol-Fuel cell
- 1x 1702-01 Plug with hose
- 1x 1702-02 Yeast
- 1x 1700-02 Chain clamp
- 2x L2-06-011 Digital multimeter
- 2x L2-06-012 Testing lead, black, 25 cm
- 2x L2-06-013 Testing lead, red, 25 cm
- 4x L2-02-016 Bump on
- 1x L2-06-017 Propeller yellow
- 1x L2-06-016 Laboratory thermometer
- 1x L2-06-070 Distillation attachment
- 1x L2-06-071 Condenser
- 1x L2-06-072 Alcohol meter
- 1x L2-06-075 Erlenmeyer flask 1000 mL
- 1x L2-06-076 Fermentation lock
- 1x L2-06-077 Rubber plug
- 1x L2-06-079 Densitometer
- 1x L2-06-082 Beaker 250 mL
- 3x L2-06-083 Test tube
- 1x L2-06-084 Lamellar plug
- 3x L2-06-085 Pasteur pipette
- 1x L2-06-086 Measuring cylinder 100 mL
- 1x L2-06-087 Syringe
- 1x L2-06-110 Silicone ring
- 1x L3-03-016 leXsolar-CD
- 1x L3-01-099 Suitcase „BioFuel Ready-to-go“
- 1x L3-01-107 Inlay „BioFuel Ready-to-go“
- 1x L2-06-114 Bunsen burner
- 1x L2-06-116 Universal stand clamp
- 1x L2-06-119 Stand rod 60 cm, M10
- 1x L2-06-120 Double clamp
- 1x L2-06-118 Stand base plate

### extras available

- Manuals available to download
- L2-04-044 Electric grid adapter set
- 1100-63 DC converter 120V - 240V







## leXsolar-Academy

Apart from our convenient and practical experimenting kits, leXsolar offers to communicate theoretical knowledge within the framework of several different events.

### leXsolar-Teacher training courses

With our teacher training courses leXsolar offers a new service of connecting education- and cooperation partners. The aim of this event is to intensify the communication between partners and teachers and to realize new educational projects.

### leXsolar-Training exercises

On these topical training events participants can gain theoretical knowledge on the chosen topic, learn the handling of the experimenting kits or single modules and can practice experimenting. After such an event, everyone will be able to confidently pass on this knowledge.

### leXsolar-Events

Whether it is at private company functions, public street festivals or school events: With leXsolar you will have a partner, that can excellently and individually guide through your event and will flexibly and didactically communicate the topic of renewable energies in your name.

The leXsolar Academy provides you with the necessary knowledge to all renewable energy technologies and makes you a competent contact person on this topic for their students and colleagues.





# leXsolar- Teacher Training Courses

Prior to any educational project, two questions have to be answered: Which forms of renewable energies are teachers interested in and which form of support do they wish for?

In order to determine this, leXsolar organizes teacher training events, which bring together teachers with local cooperation partners.

To start with, leXsolar informs about different kinds of renewable energies and different forms of support by cooperation partners. These will in turn provide information on current projects in schools and educational institutions. In the practical part, teachers will be given an overview over different experimenting kits by our product developers and will be given the opportunity to freely experiment, ask questions and make suggestions.

These will later be evaluated and create the basis for a successful realization of educational projects.



Which **topics** are most relevant to you?



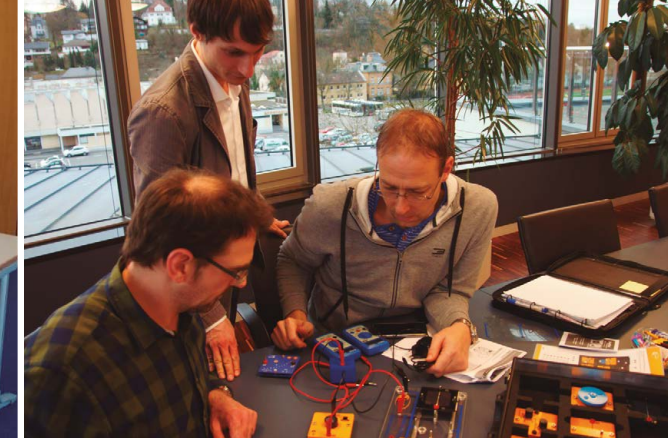
Which **type of students** are you interested in?



In which kind of **situations** would you be using the experimental setups?







# leXsolar-Training Exercises

In order to learn about the usage of the experimental setups and the facts and theory of different types of renewable energies, leXsolar-Academy offers different types of training courses.

## Photovoltaics



### Key data:

- Physical basics and aspects of photovoltaics
- A solar module design
- Current facts and data
- Practical experimenting

## Wind energy



### Key data:

- Wind formation
- Types of wind energy plants
- Physical aspects of wind power
- Current facts and data
- Practical experimenting

## Fuel cells



### Key data:

- Hydropower technologies and types of fuel cells
- Physical basics and aspects of fuel cells
- Current applications
- Outlook on fuel cell usage
- Practical experimenting

## Biofuel



### Key data:

- Comparison with non-biological production methods
- Consideration of industrial usage of biodiesel and bioethanol
- Bioethanol production via distillation
- Use of bioethanol in an ethanol fuel cell
- Esterification of oil into biodiesel (fatty acid methyl ester (FAME))

## Solar thermal installations



### Key data:

- Physical basics
- Industrial usage of solarthermics
- Current facts and data
- Practical experimenting

## Energy storage



### Key data:

- Types of energy storage
- Types of batteries and characteristic values
- Current state of electromobility and comparison with fuel and hydrogen engines
- Practical experimenting

## SmartGrid



### Key data:

- Physics of a solar cell
- Physics of wind power
- Physics of electrolysis and fuel cells
  - Types
  - Hydrogen production
  - Setup
  - Working principle of a PEM fuel cell
- Smart grid
  - Layout and working principle of a conventional power grid
  - Challenges and issues due to the implementation of renewable energies
  - Smart concepts to maintain security of supply
- Practical experimenting

## ESave



### Key data:

- Energy consumption
- Heating behavior
- Air quality
- Water consumption in schools and homes
- Lighting
- Practical experimenting



## Student's Manual ▶

Every leXsolar product includes a comprehensive and age-appropriate instructions manual with various experiments. The manuals can be printed out and used as a guideline to follow. The experiments are then performed step by step through experiment-description and a layout. Table and diagram templates are already included.



## Teacher's Manual ▶

In addition to the student's manual teachers have also their own manual with all the solutions and further background information for all experiments. In this way they can easily compare students results with answer provided in the manual and give them further explanations.



### Equipment needed

Task

Layout

**Experiment 7**  
**7.1 Funktionsweise von Shunt-Regler und Serienregler**

**Aufgabe**  
 Erläutern Sie die Funktionsweise eines Shunt-Reglers und eines Serienreglers. Erläutern Sie den Unterschied zwischen beiden Lastregler-Arten und ermitteln Sie deren Schaltverhalten.

**Aufbau**

**Benötigte Geräte**

- Grundeinheit
- 1 Diode
- 1 Lampe
- 1 Widerstand
- 1 Shunt-Regler
- 1 Serienregler
- 1 Strommessgerät
- 1 Spannungsmessgerät
- 1 LED-Modul
- Zusätzlich benötigt:  
1 Stoppscheibe

**Durchführung**

1. Bauen Sie den Versuch wie vorgegeben auf (verwenden Sie zuerst den Shunt-Regler) und beleuchten Sie das Solarmodul mit der Lampe! Hinweise zur Handhabung der Lampe finden Sie auf Seite 2.
2. Beobachten Sie die Leuchtwerte der Lampe des Reglers und messen Sie zu den vorgegebenen Zeiten die Spannung am Regler.
3. Beginnen Sie die Messung bei  $U_{\text{Solar}} = 4V$  und  $I_{\text{Solar}} = 10mA$ .
4. Messen Sie immer zum selben Zeitpunkt auch die Stromstärke.
5. Wiederholen Sie den Versuch mit dem Serienregler.

**Messwerte**

**Shunt-Regler**  
 (Achtung: ab 120s vergrößert sich in den Tabellen das Messintervall von 20s auf 40s)

t (s)	0	20	40	60	80	100	120	160
U (V)								
I (mA)								

**Serienregler**  
 (Achtung: ab 120s vergrößert sich in den Tabellen das Messintervall von 20s auf 40s)

t (s)	200	240	280	320	340	360	380	420
U (V)								
I (mA)								

**Diagramme**

Shunt-Regler

Serienregler

Diagrams

Execution

Measurements

Evaluation

Solutions

**Experiment 7**  
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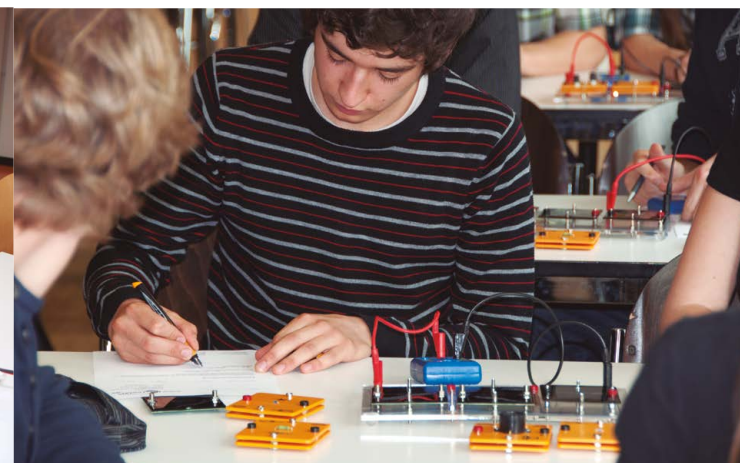
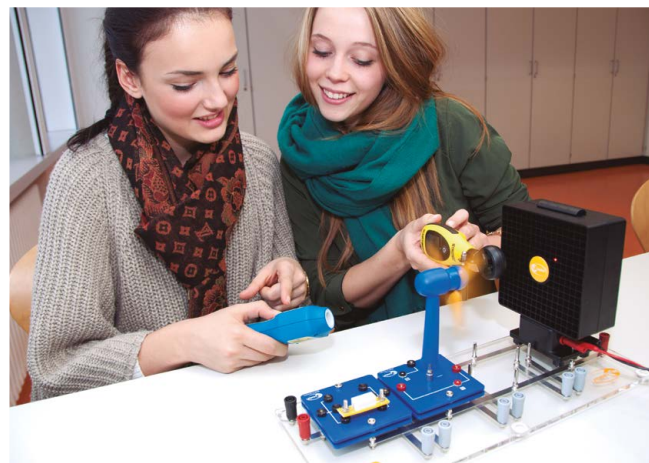
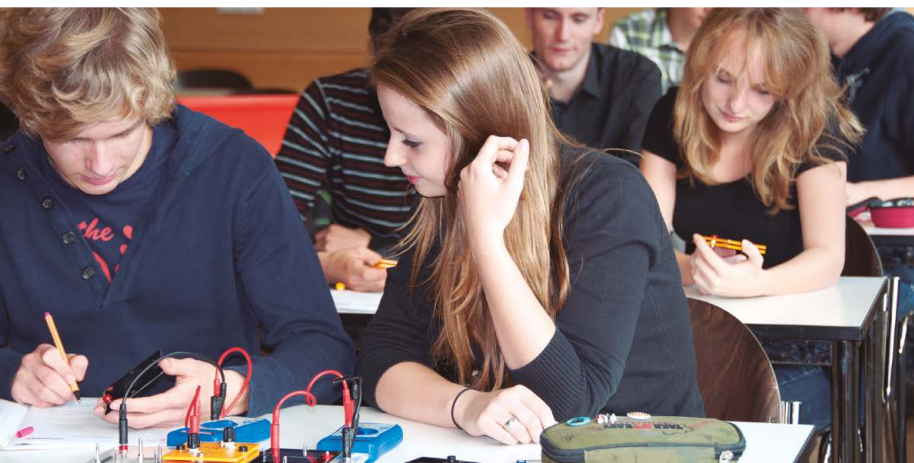
t (s)	200	240	280	320	340	360	380	420
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**Diagramme**

Shunt-Regler

Serienregler

The digital versions of both manuals include Word and PDF documents where detailed information about every product is provided. The manuals available to download.





# leXsolar innovation and quality made in Dresden

The source of innovation and quality ...

of the leXsolar products is located in the capital of Saxony and not without reason. In Dresden you can find both qualified scientific centers and an unique cultural scenery.

Ten universities and colleges, three Max Planck-, four Leibnitz- and eleven Fraunhofer-institutes are accompanied by numerous competence centers and facilities for the transfer of technologies.

On the other side, Semperoper, GrünesGewölbe, Sächsische Staatskapelle or the Frauenkirche offer an unique cultural richness.

Through this inspiring background, it is possible to develop further ideas that will help you and your students to understand new energies.

