Introduction

LEGO® Education is pleased to bring you the curriculum pack for the Renewable Energy Add-on Set.

Who is it for?

The material is designed for introducing and teaching the topic of renewable energy to middle and high school students. Working in teams, students can build, investigate and learn from the models and activities.

Please refer to the Next Generation Science Standards (NGSS) and the Common Core State Standards grids in the 'Curriculum' section of this curriculum pack to see which activities match your current teaching program.

What is it for?

The 'Renewable Energy' curriculum pack and Add-on Set enables students to work as young scientists, engaging them in science, engineering, technology, design and mathematics. The 'Renewable Energy' curriculum pack and Add-on Set promotes a challenging classroom environment and actively engages students in scientific inquiries, reasoning and critical thinking. They are challenged to make assumptions and predictions, bringing together their many experiences and knowledge from different subjects. They utilize their skills, creativity and intuition to actively create new understanding.

Using our curriculum pack students are encouraged to involve themselves in real world investigations and problem-solving. They make assumptions and predictions. They design and make models and then observe the behavior of these models; they reflect and re-design, and then record and present their findings.

The 'Renewable Energy' curriculum pack enables teachers to partially cover the following Crosscutting Concepts and overall Science and Engineering Practices, which have been set forth in the NGSS:

Science and Engineering Practices:
- Asking questions (for science) and defining problems (for engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

Crosscutting Concepts:
- Patterns
- Cause and Effect (Mechanism and explanation)
- Scale, Proportion, and Quantity
- Systems and System Models
- Energy and Matter (Flows, cycles, and conservation)
- Structure and Function
- Stability and Change

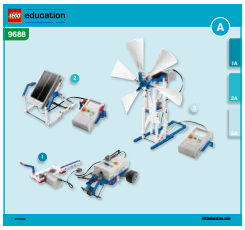
What is in it?

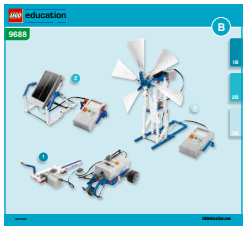
The 9688 Elements

The set consists of five full-color building instructions booklets for the six main model activities, and the following elements: LEGO® Energy Meter (consisting of two separate elements: Energy Display and Energy Storage), LEGO Solar Panel, E-Motor, Blades, LED Lights and a 50 cm (= 19 in.) Extension Wire. This set is an add-on set to be built with the 9686 set. All of the 9688 elements fit into the bottom section of the 9686 storage box.

Building Instructions Booklets

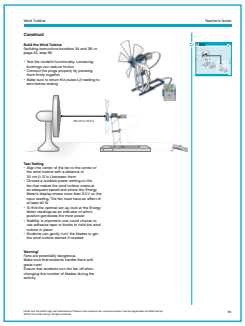
For each of the activity models there are two building instructions, a booklet A and B. The building instructions are designed for two separate building processes, each building only half a model. By combining the two sub-assemblies, students work together to create a single, sophisticated and powerful model.

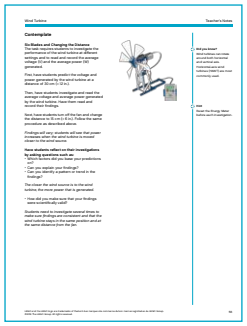




Teacher's Notes

In the Teacher's Notes you will find all the information, tips and clues you need to set up a lesson. Each model the students build has specific key learning focus areas, vocabulary, questions, and answers, and further ideas for investigations.

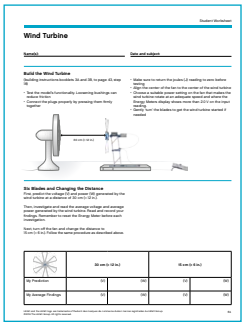


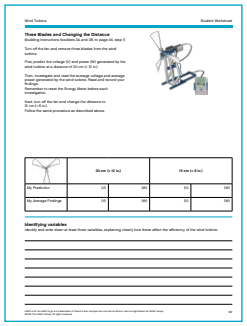


Student Worksheets

Each worksheet guides students to predict, try out, measure and record data, change the models to compare and contrast findings, and draw conclusions.

Students should be encouraged to investigate their predictions at least three times to be confident that their results are reliable. When their main findings are recorded, they discuss their results, reflect on them and adapt ideas. Finally, students are challenged to identify variables and explain clearly how these affected the model's efficiency.





Assessments

Three different assessment materials are provided for all six of the activities and the four problem-solving activities. These materials define clear learning goals before the students start each activity and motivate the students to challenge themselves throughout the learning process. You can also use these materials to assess your students' development in different learning areas.

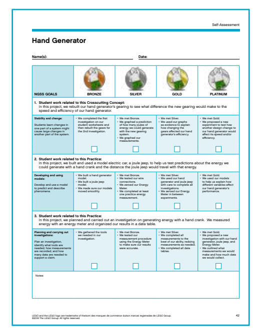
Student Worksheets

The student worksheets should be used to record each student's work throughout each activity. These worksheets are an easy-to-use tool that will give you a clear picture of each student's level and achievement during each activity. They can also comprise a valuable part of the students' log books.

Rubrics

- **Activity Assessment**

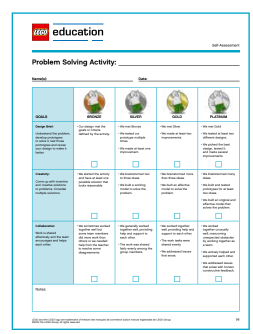
This rubric page can help students to evaluate their activity work according to learning goals based on two science-related NGSS Practices and one theme from the NGSS Crosscutting Concepts.


Hand Generator

- **Problem-Solving Assessment**

This rubric can help students to evaluate their problem-solving work according to the engineering-related learning goals from the NGSS and learning objectives that are prominent in both the Common Core State Standards and 21st century skill set, specifically:

- How well did their design meet the requirements of the design brief?
- How creative was their solution?
- How well did their team work together?


Problem Solving Activity:

Each rubric includes four levels: Bronze, Silver, Gold, and Platinum. The intention of the rubrics is to help students reflect on what they have done well in relation to the learning goals and what they might have done better. Students can write comments or questions in the 'Notes' section of each rubric.

Students should mark the rubric. If you prefer to emphasize formative assessment, ask the students to set their learning goals before they start each activity and to record the dates that correspond to their completion of each level.

You can also use the rubrics as a tool for your own evaluation of your students' work by marking a grade in the appropriate column and writing optional comments in the 'Notes' section.

- **Observation Checklist**

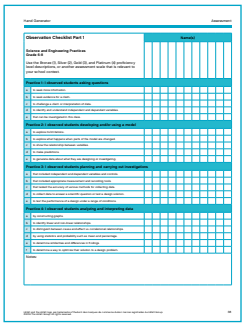
You can use the observation checklist if a more science and engineering practices assessment approach is required in Problem-Solving Activities. Grades can be recorded on the Observation Checklist provided in the Teacher's Notes. Use it to assess individual students, a pair of students or several students.

If a more science and engineering practices based approach to assessment is required in the problem-solving activities, you can use the Observation Checklist provided in the Teacher's Notes to assess students individually, in pairs, or in groups.

You can either use the Bronze (1), Silver (2), Gold (3), and Platinum (4) proficiency level descriptions, or use other assessment criteria that are relevant to your school context.

Where can I find the assessment materials?

You can find the assessment materials in the Teacher's Notes for each of the activities and problem-solving activities.



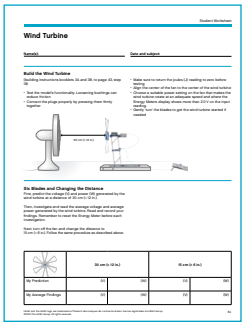
Two Levels of Progression

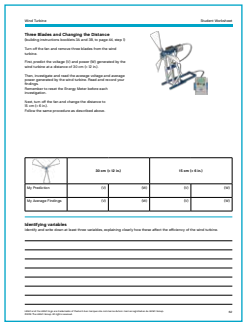
The 'Renewable Energy' curriculum pack consists of six activities and four problem-solving activities that deal with potential and kinetic energy.

Activities

The six activities allow students to apply and develop their knowledge of science and engineering design. These activities create a positive learning environment and offer a complete scientific learning process in which students are able to make predictions, build models, run tests, record data, make comparisons, and improve their models in order to create a better solution.

These six activities connect with the concepts introduced by the principle models and help students to prepare for the increasingly difficult challenges they will meet in the problem-solving activities.





Problem-Solving Activities

The four problem-solving activities all feature real-life problems that can be solved in several ways. Students will be able to test and integrate more than just one principle at a time.

The problem descriptions and the closely-defined design briefs are provided in the student worksheet. Descriptions of learning focus areas, materials needed, extra challenges and how to progress can be found in the Teacher's Notes.

The Teacher's Notes for each challenge provides tips on what and how to measure while at the same time carrying out fair testing of the solutions.

As a support we have included suggested solutions to the problems posed. Use these as 'tips and tricks', or print them and hang them as posters as inspiration for the students. The suggested problem-solving model solutions are only meant as guiding principles for any workable solution the students will come up with themselves.

Teacher's Resources

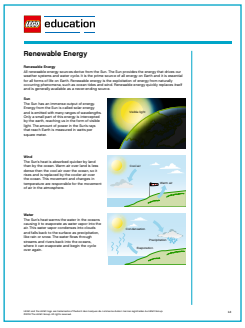
Teacher's Resources contain a short introduction to the topic of renewable energy and a section regarding potential and kinetic energy, an element guide and a glossary with definitions of essential terms.

This area contains the following three sections:
- Renewable Energy
- Potential and Kinetic Energy
- Element Guide

Each section includes materials that can be used to present the topic of renewable energy to both students and teachers.

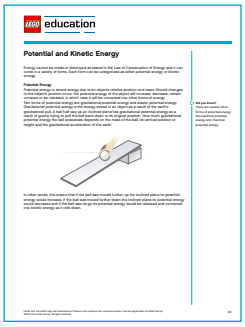
Renewable Energy

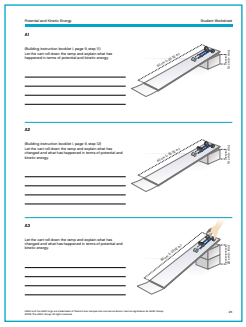
This section describes how the sun, as our primary energy source, drives our weather systems and our water cycle. The topic can be presented in class with the help of the illustrations provided. Following the illustrations is an introduction to some of the technologies behind capturing and exploiting renewable energy sources. This section also provides a potential consolidation and clarification of the concept of renewable energy, including a section on class discussion.



Potential and Kinetic Energy

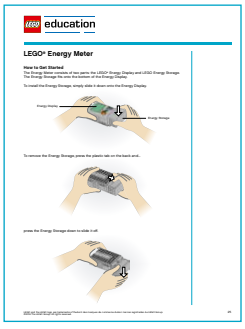
This section describes how potential and kinetic energy can be introduced to students through hands-on and engaging investigations. Students are challenged to first study the definition and explanations of potential and kinetic energy. While progressing sequentially through the activities using the student worksheets and building instructions booklets, students will be challenged further to apply their knowledge while investigating and recording their findings. In the Teacher's Notes, you will find suggested answers to the questions posed in the student worksheets.

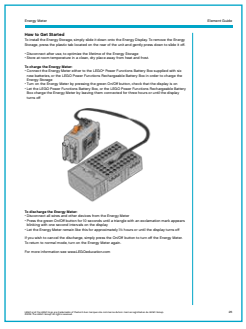




Element Guide

This section describes how to get started with the Renewable Energy Add-on Set (9688). The elements, their features, functionality, technical specifications and their operating instructions are described. Before introducing the main activities, we recommend that you demonstrate the energy meter to your students.





Classroom Management Tips

For Your First LEGO® Education Activity, and Beyond

1. Before Class
- Open one of the LEGO® brick sets and sort the bricks according to the sorting suggestion on the back of the top card.
- Label the boxes so that you can recognize which box belongs to which student(s).
- Download the curriculum pack from the URL that is printed on the lid of each set.
- Try to complete the activity using the student worksheets.

2. During Class
- Let the students sort their LEGO brick sets at the beginning of the first lesson.
- Have the students use the lid of their set as a working tray.
- Use a jar to collect stray pieces.
- Make adjustments in order to challenge the students who are ready to improve and develop new skills.
- Allow time for students to use the self-assessment rubric when they are done with the activity.

3. After Class
- Plan to stop the lesson with enough time to allow the students to tidy up.
- If you did not finish the activity, store the LEGO sets and the models so that they are ready for the next lesson.
- Evaluate the lesson.
- Book a LEGO Education training session if you need further inspiration.

How do I handle the building instructions booklets?
For easy classroom management we suggest storing the building instructions booklets in separate plastic folders in binders so that they are at hand and ready to use at the beginning of each lesson.

You can also ask your students to download the building instructions booklets from the URL that is printed on the lid of each set, and save them to their devices.

How much time is needed?
Two class periods are ideal to be able to explore, build and investigate in depth most of the extension ideas built into the activities. For the students to make any creative variations of their own, extra time might be needed with the Hydro Turbine and Wind Turbine activities. However, the remaining activity models can be built, investigated and explored, and the parts put away again within a class period if the students are already experienced LEGO builders.

Students can tackle the problem-solving activities in a sequence of two class periods. However, it is worth organizing this time as two or more back-to-back class periods so that they can immerse themselves in the problem as would a real engineer or designer.

What's needed in my classroom?
Tables may be pushed aside to let models roll across a smooth floor. Ideally, a computer or computers should be available for students to explore the Jack and Jill animated activity briefings.

Students need to be able to construct in pairs facing each other or side-by-side. From teachers and classrooms we have learned that cafeteria-type trays are ideal to build on, and to stop elements rolling onto the floor. It is also an advantage to have a cupboard or shelves to store the sets lying flat with any unfinished models on top of them.

LEGO® Education 4C Approach

The lessons follow LEGO® Education's 4C approach; Connect, Construct, Contemplate, and Continue. This enables you to progress naturally through the activities.

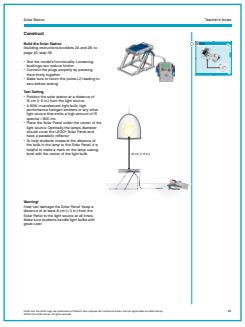
Connect

Connect a new learning experience to those you already have and you add to your knowledge. An initial learning experience is a seed stimulating the growth of new knowledge. Real-life photographs with a short text are provided to help students identify and connect to the chosen activity and the main model.

We suggest using the text and photograph as a starting point for a class discussion or draw on your own experiences to provide an engaging introduction to the activity. Please also consider involving current events related to the topic, both near and far, to set the scene for the students.

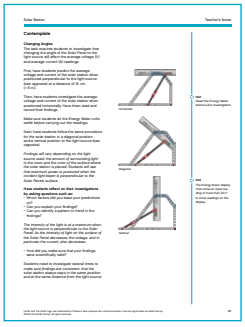
Construct

The construction of models engages both hands and minds. Using the building instructions, students build models embodying the concepts related to the key learning areas. Tips are provided for testing and ensuring each model functions as intended.



Contemplate

Contemplation provides the opportunity to deepen the understanding of previous knowledge and new experiences. The scientific nature of the activities encourages the students to discuss and reflect on their investigations and adapt ideas to the task at hand. This phase provides the opportunity for you to begin evaluating the learning outcome and progress of individual students.



Continue

Continued learning is always more enjoyable and creative when it is adequately challenging. Maintaining a challenge and the pleasure of accomplishment naturally inspires the continuation of more advanced work. Extension ideas are therefore provided to encourage the students to change or add features to their models and to investigate further – always with the key learning area in mind. This phase allows the students to operate at different speeds and levels conducive to their individual capabilities. Activities challenge the students to creatively apply their knowledge and reflect on model design and the effect of changing certain variables.