**1.Name of the solution**
Wind turbine model

**2.Category of solution** *e.g. energy source* | *scale* | *etc*
Educational - energy source for very small needs

**3.Short intro (***What it is/General idea of)*

Wind turbine model is a working device demonstrating the principles of wind turbine operation. It is a simple easy-to-build turbine with an optimally designed, efficient blade set that can light an LED bulb using a small house fan. It consists of several basic wind turbine components (foundation, tower, generator, nacelle, hub and blades) and is capable of generating a certain amount of energy. Wind turbine models rotate under the impact of an air stream coming from a fan and an integrated generator produces electricity.

Max generating voltage - 2,4 V, current - up to 20 mA, power capacity - up to 48 mW.

**4.Complexity of building, operating and cost of the solution***LowMediumHigh*

Models can be assembled from prefabricated parts in several minutes. Blades take more time to make, because they are hand made by the user from cardboard, balsa wood or plastic materials.

Cost of the materials for this model can reach up to 50 EUR.

**5.A representable good quality photo** (not technical but for a cover)

**6.Description of the solution**

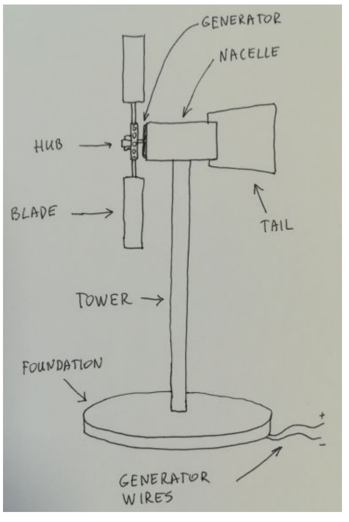
**6.1. More details of the solution and technical description**

Wind turbine model in its shape reminds real wind turbines, but it is not a desktop replica of a certain turbine. It serves as an educational device and provides possibilities for wind energy research activities at school or college level. Model allows students to explore basic wind energy production and blade design concepts such as pitch, area, mass, quantity, and material on a desk using a small house fan.

All parts are available to purchase as ready-to-use, but it is also possible to produce parts at home from materials available at technical stores.

Foundation can be made of a round timber or plywood plate (diameter 150 mm), you will need to drill a hole at the center of the tower. Tower is a small aluminium pipe. Nacelle given in the picture is prefabricated, but that fancy form can be replaced by a piece of plastic tube with diameter suitable to accommodate a small DC generator tightly. Wind turbine tail (small plastic plate) can be attached to the nacelle. Hub is the most difficult to fabricate, it should be purchased separately. The blades are made of 7 mm diameter wooden sticks and a rectangular piece of cardboard or thin plastic.

### 6.2. Technical drawings and drafts (can be handmade and simple)




### 6.3. Materials, skills and tools required

To make this wind turbine model at home one will need some simple materials and instruments (apart from the parts which need to be purchased):

- round wooden plate (10-20 mm thick, 150-200 mm diameter);
- aluminium pipe (length up to 350 mm, outer diameter 15-20 mm);
- plastic tube (length 50-70 mm, inner diameter 32 mm);
- plastic plate (30x80 mm, 2 mm thick);
- generator (voltage output: 0-10 V, current output: 0-0,3 A, diameter: 31,75 mm, shaft diameter: 2 mm);
- hub (available at https://www.vernier.com/product/kidwind-wind-turbine-hub-3-pack/);
- wooden sticks (diameter 7 mm, length 120 mm)
- cardboard or plastic plate (80x200 mm, up to 3 mm thick)

### 6.4. Other preconditions and/or requirements

### 6.5. Results, learnings and errors to avoid

Main part of the model is blades, they have a huge impact on how well the turbine works. Some experiments should be performed to see which blades work best. Some blade variables to test include: length, shape, number, materials, pitch, and weight. Here are some quick tips on improving blades:
• Shorten Blades. Although in real life turbines with longer blades have better energy yield, in this case long blades add more drag. Shortening them a few centimeters might have substantial influence on rotation speed.
• Change the pitch. Pitch dramatically affects power output. Often, students set the angle of their blades to around 45° the first time they use the turbine. Several experiments with different pitch angles will show the trend. If the blades are attached and they are not spinning, you should check the pitch.
• Use fewer blades. To reduce drag, you should try using fewer blades.
• Use lighter material. To reduce the weight of the blades, it is advantageous to use less material or lighter material.
• Use stiffer material. If the blades are bending in the wind or deflecting when the wind hits, you should find a stiffer material.
• Smooth surfaces. Smoother blade surfaces experience less drag. A blade with lots of tape and rough edges will have more drag.
• Get more wind. Wind turbine models are driven by an air flow created by a room fan. Make sure you are using a sufficiently powerful fan to rotate your model.
• Blades versus fans. Blades may not turn fast because they may be bigger than the fan. This could be a problem, as the tips of the blades are not catching any wind and are just adding drag.

• Blade shape. Blade tips travel much faster than the roots. This fact may help solving rotation problems as wide tips add drag.

**Activity ideas**

This model can be used to carry out fun experiments, explore various parameters and further improve its design. Parameters of generated electricity can be measured with a multimeter (in case of power – a couple of them) or any more sophisticated device. Power is calculated by multiplying voltage (measured in volts) and current (measured in amps).

By changing the number of blades, their pitch and shape one can determine which rotor design is most efficient as all these parameters influence the rotation speed and energy generation. Also energy output can be recorded under different air flows – various distances from the fan or different fans may be used for this test.

Last but not least – different generators can be tested on the same model. Make sure to use nacelle with the right diameter to fit the generator tightly.

**7.Step by step guidelines for building the solution** (add photos when needed)

**1. Prepare the foundation**

Find or cut a round wooden plate and drill a hole in the center. The diameter of the hole should match or be slightly wider than the outer diameter of the tower. It can be useful to attach a few small pieces of rubber or a few drops of hot glue at the bottom of the plate to prevent sliding on smooth surfaces.

**2. Insert the tower**

Tower should fit tightly into the hole otherwise the turbine may vibrate or bend during operation. In case the tower is too loose, add some plastic tape on the end. Tower should be hollow as generator wires will be put through it.

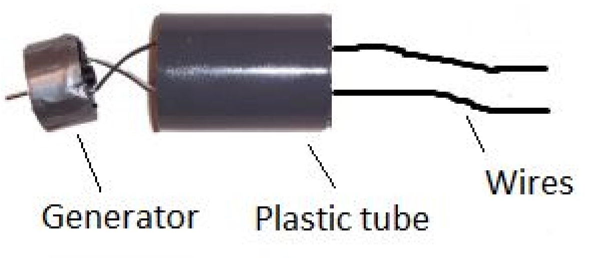
**3. Make the nacelle**

Construction of the nacelle requires some skills. First of all a generator (small DC motor) must be purchased, many of them are available at eBay or Amazon. Motors with lower rotational speed are recommended (e.g. https://www.amazon.com/Topoox-1730RPM-Electric-Turbine-Generator/dp/B07Q44YYKG/ref=sr_1_7?keywords=mini+dc+motor&qid=1579767658&sr=8-7).

Once you have a generator the next task is to find a plastic tube with the inner diameter matching the dimensions of the generator. If the tube is slightly wider, you may want to put some plastic tape around the generator. Hot glue may also work, just make sure that generator shaft position is horizontal.

Tail is optional: if the nacelle is attached firmly and cannot whirl, tail won't have influence on the yaw position. If the nacelle can easily turn horizontally then the tail may add stability to the rotation of the rotor and consequently energy generation.

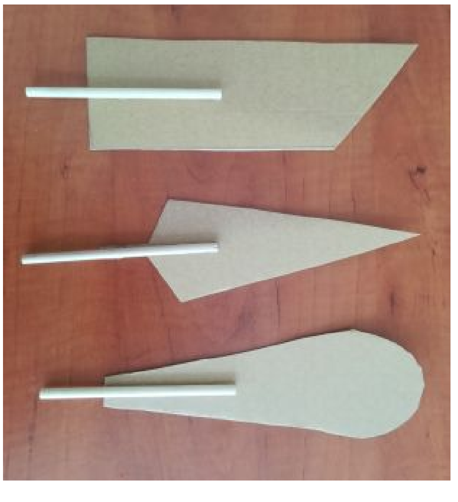
Finally, a hole should be made in the bottom of the nacelle to draw the generator wires down.




**4. Attach the nacelle to the tower**

If the nacelle is made of a straight tube, it can be attached to the tower with hot glue, right under the hole with generator wires. If a bended tube is used for the nacelle, then it can be just put tightly on the tower. Make sure the nacelle is not too loose, otherwise you may have an unstable turbine operation.

**5. Design the blades**



Blades typically consist of a wooden stick and a piece of cardboard. It would be best to glue the stick to the cardboard, but it can also be attached with an insulation tape. It's most important to attach it strongly so that the blade doesn't break apart when rotating at high speed.

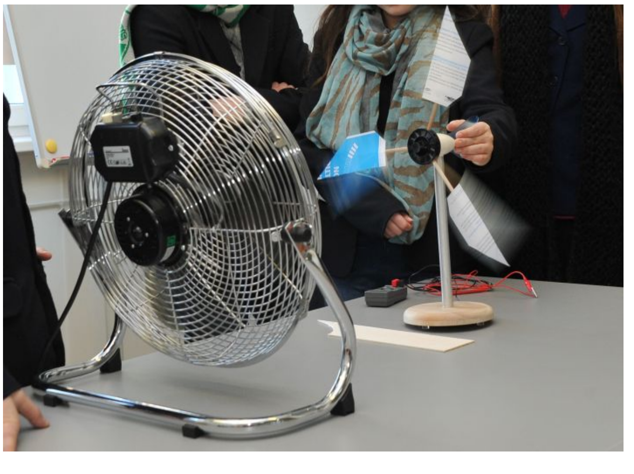
Next task is to shape the blade: you can use your imagination here, because you never know which design works best. There are some basic principles described in Chapter 6.5.

**6. Assemble the rotor**

Rotor is assembled by putting the blades in the right holes of a hub. Design of a rotor depends on a number of blades used. There are 12 holes in the hub, so you can use 2, 3, 4, 6 or 12 blades to construct a symmetric and balanced rotor. Make sure you use the right pitch angle.

The assembled rotor is simply put on the generator shaft.

**7. Prepare test equipment and have fun!**



Wind turbine model test equipment consists of a fan and a multimeter. Also you can use a portable anemometer to assess wind turbine output under different wind speeds.

If any kind of load is used (LED, buzzer, etc.), generated power can be estimated by using two multimeters: one connected in series, showing amperage, and the other connected to the load in parallel, showing voltage. Power is calculated by multiplying voltage and amperage.

**8.Video of the solution building workshop or process** (optional)

-Video from Kaišiadorys LAG workshop - https://www.youtube.com/watch?v=CtKmxtCMJgA

**9.Relevant links and articles**

Wind turbine model parts are available here:
https://www.vernier.com/product-category/?category=kidwind

At vernier.com and kidwind.com you can also find a large amount of educational information, advices, curriculums and ideas for both students and teachers.

**10.Cost Analysis and Life Cycle Analysis**

Not applicable.

**11.Local Prototype(s)**

**11.1. Geographical territory -** in schools of Kaišiadorys district

**11.2. Context of the prototype -** students retained prototypes after the workshop.

**11.3. Who are the people, communities, institutions and organisations operating the prototype?** Schools.

**11.4. Photos from the location**

11.5. **Videos**
https://youtu.be/Opp2zrI0wKc

**12.Who has collected the information** (who filled in this framework)

Dr. Mantas Marciukaitis, Head of the Laboratory for Renewable Energy and Energy Efficiency at Lithuanian Energy Institute (www.lei.lt)

**13.Experts involved** (in developing the prototype or built the same solution somewhere else**)**

Dr. Mantas Marciukaitis, Head of the Laboratory for Renewable Energy and Energy Efficiency at Lithuanian Energy Institute (www.lei.lt)

**14.Contact information for more information about the solution and its location if publicly accessible**

Kaišiadorys Local Action group, Lithuania (www.kaisiadorysvvg.lt)