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Explore energy production with the escape game 'Village of the Future'

Description of the riddles

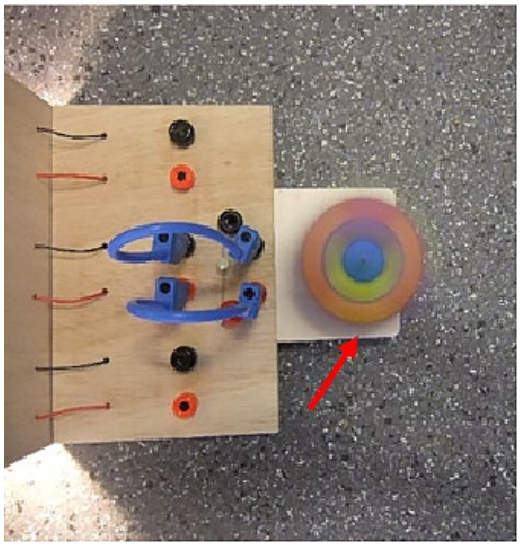
Riddle 1: Switching solar cells

Materials

- Module with solar cells, the LED, and motor
- 4 cables,
- LED spotlight
- Information on the solar module

Notes on creating the solar module unit:

The three solar cells are mounted next to each other on a module, and two sockets for plugging in electronic cables are attached to each. In addition, a small direct-current motor (rated at approx. 0.2 A) and a white LED are attached to the module. These are also electrically connected with sockets for plugging in cables. Attach the note (see copy template) to the module and the coloured disk (also in the copy template) to the top of the motor shaft.



Images courtesy of the author

Task

From the poster, the students get the following hint:

"If a solar thermal system consisting of different modules is to be installed, these modules should not simply be combined in any kind of way with each other. The type of interconnection and the key data of the solar cells have a major impact on the voltage and current."

In addition, the students will also find instructions for measuring current and voltage on poster 1, along with the following hint on the solar module: if used and switched correctly, the LED can light up and the motor can be made to run. Distance from the LED spotlight (sun): 10 cm.

The students have to deduce from these instructions that they have to switch on the motor and the LED using the solar cells on the solar module.

LED task

Required voltage: ~2.5 V

A solar cell supplies a maximum voltage of 0.5 V. To achieve a voltage of 2.5 V, the two existing solar cells and the solar module (3 solar cells, 1.5 V) must be connected in series.

Important! The experimental unit must be held in front of the spotlight, so that all cells are illuminated. The experimental unit can also be held very close to the lamp for a short time.

Outcome

The LED lights up with a white colour.

Motor task

The highest possible current is required.

The current generated is much more dependent on the lighting than the voltage generated. This means that sufficient illumination of the solar cells used must be ensured when carrying out the experiment. To achieve a high current, the solar cells must be connected in parallel and sufficiently illuminated. The large solar cell delivers the highest amperage.

If the experimental unit is held very close to the spotlight, the motor will run. The colour fields of the square on the disc merge to form coloured circles (additive colour mixing).

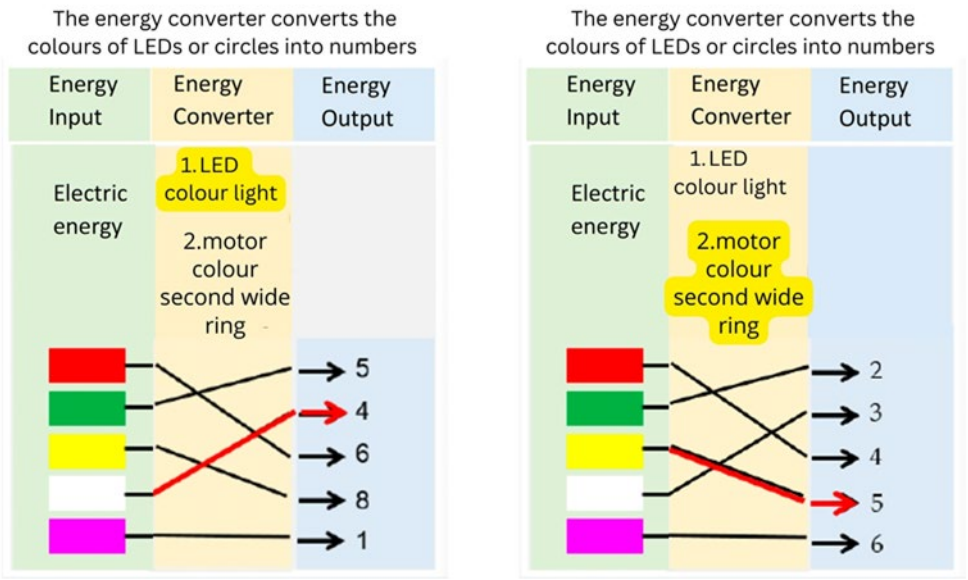
Outcome

The motor turns and the second wide ring is yellow in colour.

Riddle 2: Energy converter

Materials

- Energy converter graphics with notes (poster)
- Cards on forms of energy (copy template)



Images courtesy of the author

Task

Find the forms of energy that are converted into each other:

1. The LED converts electrical energy into radiant energy.
2. The electrical energy input side is already given, so the card with radiant energy has to be laid on the output side.
3. The LED shines white. If you follow the lines starting from the white square on the input side (electrical energy), you reach the number four on the output side (radiant energy).
4. The motor converts electrical energy into kinetic energy.
5. The middle circle shows the colour yellow. If you follow the lines starting from the yellow square on the input side (electrical energy), you reach the number five on the output side (kinetic energy)

Outcome

First number: four (colour of LED: white)

Second number: five (coloured ring on motor: yellow)

Riddle 3: Characteristic curve of the solar cell

Materials

- Module with solar cells (see riddle 1)
- LED spotlight
- Multimeter
- 4 cables
- Note solar module: important parameters (on the first poster)
- 3 diagrams without the characteristic curve (on the first poster)
- Overhead transparency with the characteristic curve (copy template)

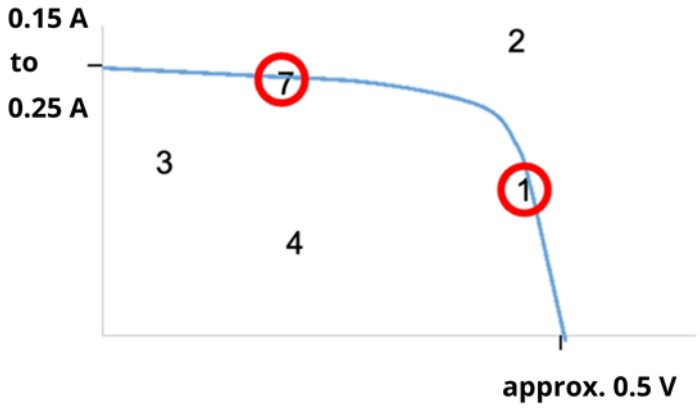


Image courtesy of the author

Task

1. On the poster, the students get the following hint:

   "If you are looking for a suitable electronic component, it is always helpful to take a look at the data sheet and the characteristic curve. The open-circuit voltage and the short-circuit current are important characteristics. Which diagram matches one of the three solar cells? And where did the characteristic curve go?"

   Therefore, the students have to measure a solar cell and find out which of the characteristic curves drawn is the correct one.

2. Afterwards, the students must determine the open-circuit voltage and the short-circuit current of the two solar cells and the module:
   - solar cell, small: U = ~ 0.5 V; I = ~ 0.03 A
   - solar cell, large: U = ~ 0.5 V; I = ~ 0.2 A
   - solar module: U = ~ 1.5 V; I = ~ 0.03 A
3. Then, the students have to use the measured values to choose the right diagram on poster 1 and insert the overhead transparency with the characteristic curve to get the numbers for the QR code.

Notes

- The results for the current depend heavily on the lighting. This means you have to choose the diagram that fits best.
- The diagram with I = 0.03 A, U = 1 V is disqualified because no cell or module has 1 V.
- The diagram with I = 0.5 A, U = 1.5 V is disqualified because the module (which has the requested 1.5 V) has only 0.03 A.
- The diagram with I = 0.2 A, U = 0.5 V fits best, and the characteristic curve connects to two numbers.

Outcome

Third number: seven

Fourth number: one

Riddle 4: Picture puzzle

Materials

- Picture puzzles (on poster 1)

Image courtesy of the author

Task

The students have to solve the picture puzzles by changing the names of the things shown as pictures according to the instructions given.

- word 1: RED + FIST + CANOE = RESISTANCE
- word 2: TAXI + DRUM = MAXIMUM
- word 3: SHOWER = POWER
- word 4: WINE = POINT
- word 5: FIRE = FIVE
- word 6: OX = OHM

Outcome

As a result, the students receive the clue “resistance maximum power point: 5 ohm”, which they need to solve riddle 5.

Riddle 5: Maximum power point

Materials

- Module with solar cells (see riddle 1)
- LED spot
- Multimeter
- Cables
- Resistance board with resistors of 2.2 kΩ, 1 kΩ 100 Ω, 50 Ω, 5 Ω, 1.6 Ω
- Note on the poster:
    - MPP – maximum power point
    - To reach the MPP, a resistor needs to be fitted
- Solution to riddle 4 (picture puzzle):
    - resistor maximum power point: 5 Ω
- Note above the picture puzzle: "For the solar cell matching the characteristic curve, the following applies"

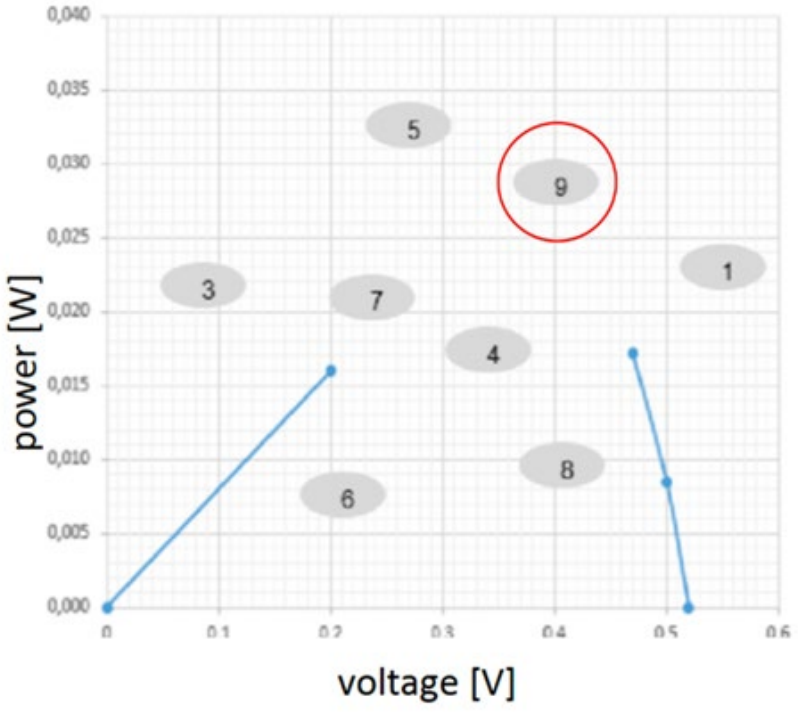


Image courtesy of the author

Task

On the poster, the students get the following hint:

"It is always important to ensure that an energy source and a 'consumer' are coordinated with each other, because the maximum possible power should be provided. This is the case at the **m**aximum **p**ower **p**oint."

1. To solve this puzzle, the students need the solution to the picture puzzle (riddle 4). They have found out that they need a 5 Ω resistor.
2. Therefore, the students have to find the 5 Ω resistor on the board by using the multimeter.
3. Connect the large solar cell (see riddle 3) with the resistor, and measure the voltage and the current at the resistor. Use the values to calculate the MPP. (Distance between the spotlight and the solar cell: 5–8 cm.)
4. Approximate values at 5 Ω:
    - voltage: ~ 0.4 V
    - current: ~ 0.07 A
    - power: ~ 0.028 W
5. The students then find the point on the curve and obtain the solution number from it.

Outcomes

Fifth number: nine

Riddle 6: QR code

Materials

- Sheets with a QR code to complete (digital or analogue)
- Permanent marker (Edding) if you use the analogue one
- Digital devices to read QR codes
- Outcome of riddles 2, 4, 5, 7, and 9

Image courtesy of the author

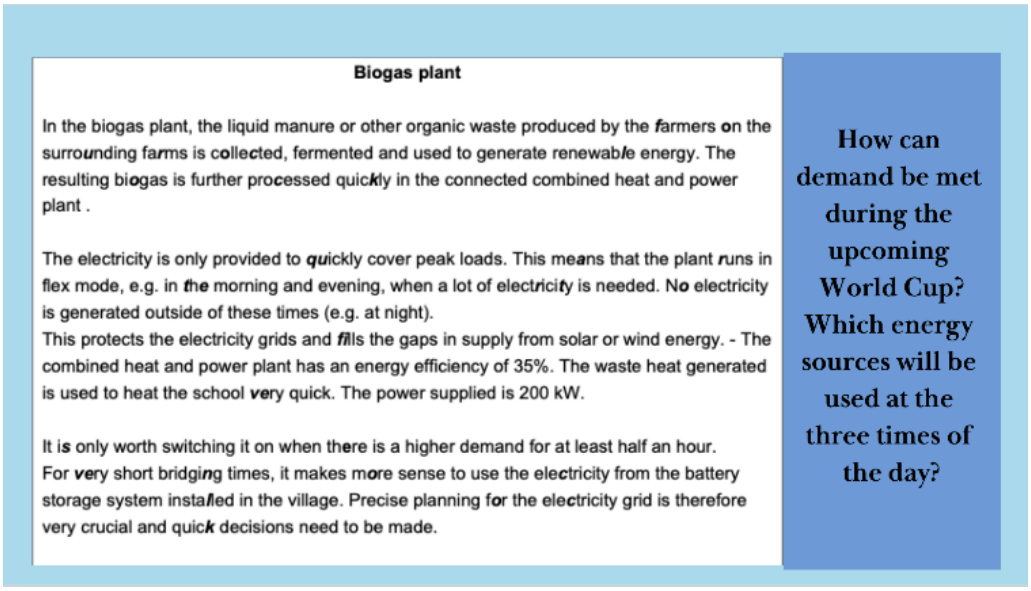
Task

1. In this part, the students have to colour in the fields of the QR code with the numbers two, four, five, seven, and nine.
2. Then they scan the QR code with the digital device.
3. Access to the webpage: https://forscherino.my.canva.site/village-of-the-future.

Riddle 7: Biogas plant

Materials

- Biogas plant text on the webpage containing italic letters



Biogas plant

In the biogas plant, the liquid manure or other organic waste produced by the *f*armers *o*n the surro*u*nding fa*r*ms is co*l*le*c*ted, fermented and used to generate renewab*l*e energy. The resulting bi*o*gas is further pro*c*essed quic*k*ly in the connected combined heat and power plant .

The electricity is only provided to *qu*ickly cover peak loads. This mea*n*s that the plant *r*uns in flex mode, e.g. in *t*he morning and evening, when a lot of electric*i*t*y* is needed. N*o* electricity is generated outside of these times (e.g. at night).
This protects the electricity grids and *fi*lls the gaps in supply from solar or wind energy. - The combined heat and power plant has an energy efficiency of 35%. The waste heat generated is used to heat the school *ve*ry quick. The power supplied is 200 kW.

It i*s* only worth switching it on when th*e*re is a higher demand for at least half an hour.
For *v*ery short bridgi*n*g times, it makes m*o*re sense to use the ele*c*tricity from the battery storage system insta*l*led in the village. Precise planning f*o*r the ele*c*tricity grid is therefore very crucial and quic*k* decisions need to be made.

How can demand be met during the upcoming World Cup? Which energy sources will be used at the three times of the day?

Image courtesy of the author

Task

The students have to read the text about the biogas plant. Then they have to connect the italicised letters to form words. A time is hidden in each section.

Outcome

Results: four o'clock, quarter to five, seven o'clock

Riddle 8: Power demand

Materials

- Power demand reference day diagram (on the webpage)
- Expected load chart (on poster 2)
- Cards for power: 2 x 60 kW, 1 x 80 kW, 2 x 180 kW, 1 x 300 kW (in the envelope, see copy template)

Task

Time of day	Game status	Power demand	kW
3:00 (pm)	Before the game	Less than usual: In preparation of the game, other activities like doing the laundry, washing dishes, hoover the flat, starting the dish washer, ... come to an end.	
4:00 (pm)	First half	The demand reduces even more. Most activities have ceased - only more TVs than usual are running.	
4:45 (pm)	Half time	The demand rises almost instantaneously. Lights i.e. in the bathrooms are turned on, fridges are opened, and meals are prepared.	
5:00 (pm)	Second half	The demand reduces significantly, because other activities have ceased.	
6:05 (pm)	End of extra time	There is a strong rise in the demand and from 6.15 on it is higher than usual. This is because in many households' meals are cooked simultaneously and other activities are resumed.	
7:00 (pm)	After the game	The demand is expected to peak, because all postponed activities are resumed at the same time.	

The students have to read the description in the "Power demand" column of the chart and the diagram for the reference day. They must then use the information to decide which energy card to assign to the individual lines. Each energy card is assigned to a row and none are left over.

Outcome

3.00 pm: 80 kW

4.00 pm: 60 kW

4.45 pm: 180 kW

5.00 pm: 60 kW

6.05 pm: 180 kW

7.00 pm: 300 kW

Riddle 9: Wind turbine performance curve

Materials

- Wind turbine performance curve (on poster 2)
- Weather forecast (on the webpage)
- Red-coloured overhead transparency (in the envelope)
- Encrypted hint to use the overhead transparency (on poster 2)
- Times of day: 4:00 pm, 4:45 pm, 7:00 pm (see riddle 7)

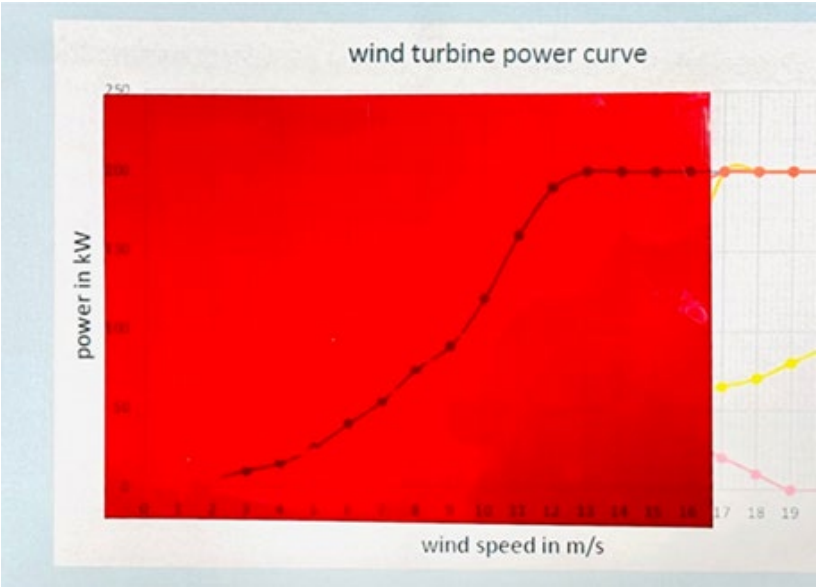


Image courtesy of the author

Task

1. The students have to come up with the solution based on the clue next to the diagram upon which they place the red-coloured overhead transparency. Only the necessary performance curve is then visible and all others become invisible.
2. Then they have to read the weather forecast carefully to find out the wind forecast at the given times (4:00 pm, 4:45 pm, 7:00 pm) and use the chart to extract the yields of the turbine at these times.

Outcome

4:00 pm: wind speed is 39.6 km/h (11 m/s) → output of the turbine: 160 kW

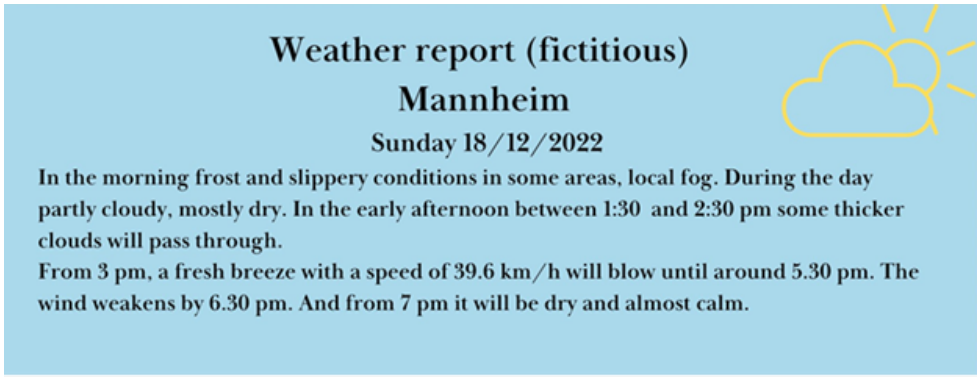
4:45 pm: wind speed is 39.6 km/h (11 m/s) → output of the turbine: 160 kW

7:00 pm: there is no wind -> output of the turbine: 0 kW

Riddle 10: PV unit

Materials

- Expected yield of the PV unit chart, which contains a gap (on poster 2)
- Overhead transparency with the missing part of the curve (in the envelope)
- Weather forecast



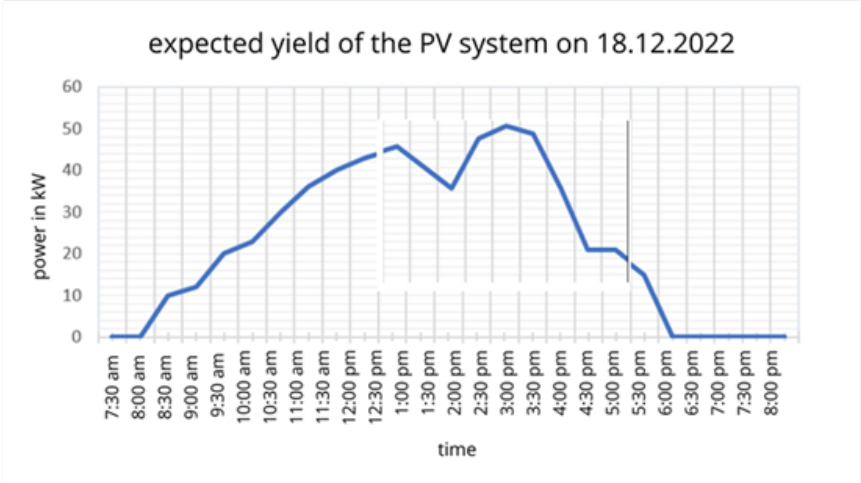


Image courtesy of the author

Task

Place the overhead transparency on the chart. Pay attention to the direction (see forecast).

Extract the expected yields of the PV unit at 4:00 pm, 4:45 pm, and 7:00 pm.

Outcome

- 4:00 pm: expected yield of the PV unit → 35 kW
- 4:45 pm: expected yield of the PV unit → 20 kW
- 7:00 pm: expected yield of the PV unit → 0 kW

Riddle 11: Control power plant

Materials

- Digital device to open the link "Control power plant – village of the future"
- Solutions to the previous riddles
- Yields of the PV unit and performance of the wind turbine at 4:00 pm, 4:45 pm, 7:00 pm
- Information about energy storage in combination with a hint that the power demand has to be covered exactly at all times (on the webpage)
- The amount of energy needed at 4:00 pm, 4:45 pm, and 7:00 pm
- Power output of the biogas plant (200 kW) and the hint that the use of the plant is only efficient if the demand lasts for at least half an hour (biogas plant information and webpage)

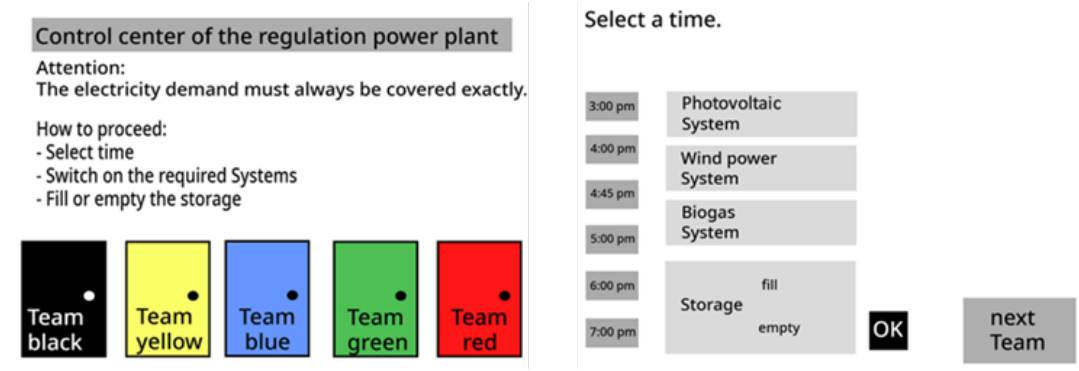


Image courtesy of the author

Task

- To solve this riddle, the students have to combine all the results of puzzle part 2. Therefore, they have to deliver the right amount of energy at the given times, and consider if it makes sense to use the biogas plant and if the energy storage is filled or empty.
- In the Scratch program, the students first click on the colour of the lock they need to open. If the selection is made incorrectly at the respective time, an error appears. If the selection is correct, "Very good. Select the next time." appears.
- If the students have entered the correct solutions for the three times, a picture appears, behind which a binary code is hidden. In the picture shown for the yellow lock, for example, the codes are

  4:00 pm: 1001

  4:45 pm: 0110

  7:00 pm: 0101

- This binary code is then converted into a decimal number, so that the combination lock can be opened with this code. In the example of the yellow lock, the number would be 965.

Outcome

- Code black lock: 975
- Code yellow lock: 965
- Code blue lock: 863
- Code red lock: 973
- Code green lock: 865