



## Guide for teachers – Secondary school

### Structure of scenarios

The didactical path consists of some lesson units, to span over subjects of energy-environment-hydrogen (EEH). The teacher, with the help of FCHgo university staff should implement three of the five proposed subjects. The choice depends on particular needs of students and the social background discussion on EEH. This “cultural contents” will be different for example in Germany where hydrogen technology is well understood and developed, and different in Poland where there is still no political convincement to stop burning coal.

The sequence of 3 chosen subjects is as follows: on the first lesson the FCHgo staff introduces the subject, starts the discussion with pupils, explains the experiments to be performed. On the second lesson, the teacher collects the material prepared by pupils for the discussion, leads the discussion, helps students to formulate final conclusions and helps to perform experiments related to the subject. The exact sharing of time depends on the teacher.

### Principal goals

Independently from the chosen path, all pupils should arrive to the same goal of understanding:

- 1) analysis of natural and technical phenomena in terms of energy carriers and energy couplers/exchangers;
- 2) recognize conserved and not conserved energy carriers;
- 3) recognize energy storage elements;
- 4) learn to create process diagrams for natural and technical processes;
- 5) learn to understand the simplicity of using fuels;
- 6) learn to understand why fuels should not be burned;
- 7) learn about possible applications of hydrogen fuel cells;
- 8) understand the principle of operation of fuel cells;
- 9) know about technical challenges of hydrogen cell technologies.

Collateral teaching on energy, its forms and transformations (lesson *Energy and its forms*) and on electro-chemistry (lesson *Volta Batteries* and *Electrolysis*) should help teacher to define these goals.

## Social competences

In each unit we propose some questions for the discussion. This is to teach students to participate in discussions that are based on scientific arguments rather than on political bias. Teachers, after all necessary introduction into different aspects should allow pupils to express their opinions, and formulate written conclusions.

Particularly welcome would be activities based on the division of roles, individual presentations, narrative paths and the use of free imagination.

## Contents:

- *Introduction to FCH technology: How, What for, and Why?*
- *Perpetuum Mobile* video
- Five short Power Point presentations – introductions into subjects:
  - 1) *Climate changes;*
  - 2) *Alternative energies;*
  - 3) *Volta Pile and Electrochemistry;*
  - 4) *Hydrogen fuel cells;*
  - 5) *Energy.*
- The description of two experiments (*Volta's Batteries and Electrolysis*).
- A Power Point tool on *FCH Model Car and Energy Carriers*.
- *Thesaurus* of c.a. 30 simple experiments on the energy, electricity, electrochemistry, hydrogen (pdf file with photos and references).
- The *Project Evaluation Form*, to be filled in by the teachers at the end of the educational path.
- Support information on hydrogen technologies can also be found at the following website:  
<https://www.hydrogeneurope.eu/technologies>

## Experimental equipment

We tried to base experiments on materials that teachers and pupils can acquire without costs: eurocent coins, nails, aluminum strips, pieces of polymer foils, home chemicals, cheap voltmeters etc.

The FCHGo partners can help in providing an elementary kit to measure characteristics of fuel cells (Horizon Fuel Cell Car)

The FCHGo partners can help in providing also simple materials: Al/ Cu pieces, nafion foil, Cu/Fe joints for “human battery experiment”, wire for “two-loop” electrical engine and Pohl's experiment (no neodymium magnets, as they may be not accepted for air parcels).

## EXAMPLES OF POSSIBLE SEQUENCE of UNITS

### EXAMPLE 1

#### Unit 1

- Viewing the *Perpetuum mobile* video;
- Discussion of the video in terms of energy carriers and energy couplers/exchangers;
- Development of the process diagram for the *Perpetuum mobile*.

#### In between Units 1 and 2

- Construction of the Hydrogen Model Car and observation of its functioning;
- Experimenting with *Electrolysis* and *Volta's batteries*;

#### Unit 2

- First analysis of the Hydrogen Model Car with energy carriers and couplers/exchangers, using *FCH Model Car and Carriers*;
- Discussion of conserved and non-conserved energy carriers;
- Discussion of energy storage elements;
- Development of the process diagram for the Hydrogen Model Car.

#### In between Units 2 and 3

- Exploration of technical and natural processes and systems, and development of process diagrams for these systems (suggested by students or teachers);
- Viewing of ppt presentation(s) (see Contents above).

#### Unit 3

- Viewing of ppt presentation(s) (see Contents above).

### EXAMPLE 2

#### Unit 1 (expert): Climate and environment

- Presentation of the Project and aims
- Power Point presentation on climate and environment
- Introduction into experiment (solar constant)

#### In-between unit 1 and 2

- Students study the arguments of Climate changes (from newspapers, internet, opinions in the family) and prepare the discussion
- Students can also individually (and it is highly indicated) perform measurements of the solar constant at home, in different weather conditions: they compare results in the class and explain the differences.
- Teacher collects any possible "toys" using photovoltaic or wind energy sources.

#### Unit 2 (teacher): Climate and alternative sources of energy

Role playing. The teacher divides the class into three groups: 2/5 (*pro*), 2/5 (*contro*) and 1/5 (judicators) and allows 20 minutes for the discussion, with equal time to *pro* and *contro*. In 5 minutes the judicators should resume the discussion.

If possible, some experiments with alternative source of energy should be done. "Toys" can be shown. Schools equipped with sensor systems can use them.

### Unit 3 (expert): Electrochemistry and fuel cells

- The expert, with simple experiments (like the "human battery chain" or "IQ meter", see Thesaurus) introduces the principles of voltaic electricity sources.
- The expert shows the electrolysis of water (transparent glass, two stick batteries – 1.2 V and 1.5 eV, half spoon of salt): the threshold of the electrolysis depends on the voltage, the intensity on the ionic conductivity.
- In experiment with the strong basis (granulates for cleaning waste tubes) and aluminum strips he shows the chemical formation of hydrogen.
- The expert, with help of Power Point file (No. 4) explains the main features of fuel cells as compared to voltaic sources. The second part of the presentation no. 4 the expert leaves for the teacher for the next lesson.

### In-between unit 3 and 4

- Student search for, possibly local, applications of fuel cells, presence of charging stations for electrical cars, the public transportation not using petrol etc.
- For the next unit students should bring some pieces of polymer foils.

### Unit 4 (teacher): Fuel cells – technology and applications

- The teacher deepens the subject of technical applications and scientific aspects, using PowerPoint lesson no. 4, and two texts ("Physics in School" and "Introduction into fuel cells" – in the Doodle depository).
- Students discuss different aspects of fuel cells and make a *list* of questions to the expert.

### In-between unit 4 and 5

- Students re-read lessons 1-4 and prepare possible questions to the expert.
- The teacher contacts via e-mail the expert, asking to prepare additional experiments/ explanations etc.

### Unit 5 (expert)

- Depending on the request of students/ teachers and on the type of the secondary school (technical/ lyceum) the expert presents the lesson(s) *Alternative Energies*, and/or *Volta's batteries* and/or *Energy and its forms*.
- Expert brings some more complex experiments, if available by the partner (e.g. a double fuel cell)
- Expert answers questions of the teacher and students.

### Unit 6 (teacher)

- The teacher makes the evaluation of the Project: a short (10 min) test on the construction and applications of fuel cells.

In separate tests, students should answer the *quality* questions:

- Were these lessons useful for the knowledge of physics, technology and chemistry? (0-5)
- Did these lessons open students to interlinked subjects of energy – environment – hydrogen?

### ALTERNATIVE SEQUENCE

Teachers may choose also a sequence of the five subjects, like in Power Point presentations, limiting the discussion and performing experiment *ex catedra* instead of experiments in groups of pupils.

The last unit should be obligatory dedicated to the evaluation, according to the principal competences goals listed at the beginning of this document. This evaluation consists in a short test for students and the personal evaluation of the utility of FCHgo subjects in development of scientific and social competences by students.