

Should Zero Emission Cars Be Made Compulsory – Is It Feasible?

Created by: Ingo Eiks and Jack Holbrook, edited by Jack Holbrook

Institute: ICASE
Country: Germany



Teaching Guide

This module is intended to

- (a) raise the problem of the internal combustion engine
- (b) introduce the production of hydrogen
- (c) introduce and realize the potential of using fuel cells.

Lesson Learning Outcomes

Lesson 1

At the end of this lesson, students are expected to be able to:

- Create, within small groups, suitable questions for further investigation
- Present questions formulated to other groups
- Discussion on ecological friendly cars and the fuel that would be appropriate for them to use. Recognise this is hydrogen.
- Appreciate that hydrogen is obtained by breaking down hydrogen compounds such as acids, water and hydrocarbons.
- Recognise that the problem with current fuels is C, CO and CO₂ emissions. This is also true for cars running on electricity. Also solar cells are fine, but they cannot function without strong sunlight, are not very efficient and also need storage mechanisms which add much weight.

Lesson 2

At the end of this lesson, students are expected to be able to:

- Plan an investigation to produce hydrogen and give explanations for its formation based on metal-acid reactions, electrolysis and industrial preparative methods.
- Collaborate as a group in seeking suitable information.
- Plan making hydrogen by first determining potential sources and then suggest the process for getting the hydrogen.

Lesson 3

At the end of this lesson, students are expected to be able to:

- Undertake activities related to one or more of the following:
- Group A explores the making hydrogen by reduction of acids using different metals.
- Group B explores the making hydrogen by reduction of substances using electrolysis
- Group C explores the making of hydrogen by breaking down of water and the cracking of hydrocarbons.
- Each group recognizes the product by testing for relative density and solubility in water.

Lesson 4

At the end of this lesson, students are expected to be able to :

- Present outcomes for the production of hydrogen by the various approaches and giving explanations for the processes related to the reactivity series, half cells and the two stage breakdown of water using natural gas (methane).

Lesson 5

At the end of this lesson, students are expected to be able to:

- Recognise different ways of storing hydrogen and to ascertain issues/problems in using hydrogen as a fuel, each of which adds to the coast of hydrogen production.
- Suggest the most appropriate storage method for cars with reasons.
- Illustrate using models the making of ammonia from hydrogen, the flammability of hydrogen and the use of hydrogen in a fuel cell to produce electricity.

Lesson 6

At the end of this lesson, students are expected to be able to:

- Create a report of all activities.
- Make presentation to the class on the usefulness of hydrogen.

Lesson 7

At the end of this lesson, students are expected to be able to:

- Participate in a discussion on whether zero emission cars should be made compulsory.
- Make a justified, socio-scientific decision regarding zero emission cars.



Suggested Teaching Strategy based on the Jigsaw

Lesson 1

1. The teaching of the unit starts with a consideration of the issue related to the scenario.

2. In the students' material, no recipe tasks are stated leading them through the whole process. It is intended to let the students ask their own questions, starting from their pre-experiences and pre-knowledge.
3. The guidance of the teacher on different aspects here is dependent on the learning group. From the material, it is expected that the students are stating several questions which have the potential to set up a frame for all following activities. It is expected that there are questions on the function of the «Hydrogen-Car», the properties and gathering of hydrogen and on the question whether it is true that there are really 'good' alternative.
4. A possible activity in this part is brainstorming and working in small groups.

Lesson 2

5. After setting up the frame for how hydrogen can be produced, the students can be involved in planning ways of producing hydrogen. A suggested approach is the use of the jigsaw method. Here the students are planning and seeking knowledge in small groups of about 4 to 6. Then they undertake the experiments in lesson 3 before the groups break up and reform so as to be able to present all ideas in the new groups where in each group only one or two members are from the original groups.

Lesson 3

6. The groups carry out the experimental work or literature search and develop their presentations in the next lessons to the different groups. This should include
 - reflecting on degrees of reactivity of the various metals in an electrochemical cell.
 - investigations on the function of electrolysis and the idea of half cells.
 - investigations on industrial methods to produce hydrogen. This may start with letting the students find out possible sources. Water will be one possible resource.. At higher levels, new tendencies of making hydrogen from methanol right in the car by a catalytic reaction could be investigated in an experimental way.
 - finding out ways to produce hydrogen. This means looking for the sources or raw materials and evaluate which of them are needed, which processes are done and which kind of emissions or pollution may be caused by this step. Here e.g. a search on the internet or an evaluation of given information which may include data either in a table or graphical format are possible activities.

Lesson 4

7. The students form new groups and each student explains their work in the previous two lessons to the others.
8. The students make a record of their findings with explanations covering the work of all three previous groupings.

Lesson 5

7. This phase should be organized as group work. If it is intended that all students are working on all aspects, «working on stations» approach may be a suitable method. [Here the teacher organizes in advance different stations to work on. These are based on different materials and activities (e.g. experiments) and each of them is dealing with a different aspect of the topic].
8. Then students start working on one of the stations of their choice and change to another after finishing. The stations need to be organized so that time need for completion of the task do not differ too much from station to station and that the sequence of working does not affect the results or understanding. It is not necessary that all materials have to be available for all groups, they can be offered only once. This more open form of working may also promote the ability of the students to organize their learning and take responsibility for it. They have to decide in which sequence they undertake their work and, if they are trained in open forms of working, they may be also allowed to decide about the time to spend on each of the stations. But also working out the different aspects in groups seems to be possible where each group becomes an expert group on a different part of the topic.

Lesson 6

9. In the first part of the lessons, a general class discussion considers the most appropriate method of storage of hydrogen and the students justify their choice. There is no absolute answer to this section and the teacher may give examples of all methods being in use, but all have the disadvantage that they increase the cost of hydrogen production.
10. Groups communicate their results to the others by giving a presentation orally, or by means of a poster.

Lessons 7

11. Students discussing different aspects and perspectives becomes important. This should include statements or views from different interest, or pressure groups, e.g. the producers of the car, environment protection organizations, crude oil industry or the government. It is also important to become aware that there are many aspects involved in this decision which are from science as well as from other fields like economy. This may give an insight that answering the question whether a new technology is 'better' than an old one cannot be easily or objectively answered in most cases. The individual has to make up his own mind about it as a consumer or elector in a democratic society. In a representative group, the discussion about other alternatives may be included, meaning e.g. the production of conventional fuel from renewable sources or a car concept directly based on solar technology.
12. This part is carried out in a method dependent on the learning group. For younger students, it seems a good idea to do this as a role play with prepared role cards. Students follow the roles of different pressure groups, companies or organizations and stand for the respective interests in a

discussion round. For older students, a discussion with the whole group directly, starting with their own positions, seems to be more appropriate. Dependent on the abilities of the students this can be prepared by given materials, or an own search on viewpoints and arguments, maybe on the internet. In both cases, at the end, the students should state their own position and give reasons for it. If this done in written format, it can contribute to the formative assessment of the educational objective (see below).

13. Here it is important that the students become aware that the Hydrogen in the Hydrogen Car causes no emissions beside water. But the question whether the whole technology causes emissions has to be answered considering a broader view. It has to be mentioned that this kind of technology is only neutral to the environment, if the hydrogen itself is produced without emissions, e.g. by getting electricity from renewable energy sources like solar or wind energy use. Here it is possible to discuss that it is always a whole process that has to be characterized before valuing the economic and ecological background. Methods for products, or technologies like ecological balances, or life cycle analysis can be introduced and discussed with their chances and problems.



Achieving the Objectives

Objective	This is achieved by
Deciding, with justification, whether zero emission cars should be made compulsory.	participating in the whole class discussion and being able to justify the decision made
Investigating different aspects of hydrogen production and the function of the hydrogen-oxygen-cell, so that the students show that they are able to carry out and evaluate different experimental works on this topic.	undertaking the group work and recording the observations and the interpretations
Gathering and evaluating information on the exhaust of fuel engines and electricity production, so that the students become able to give an estimation which kind of engine leads to less or no emissions.	undertaking group work and recording information obtained
Promoting communication abilities by students playing an active role in carrying out group work, discussions, role plays and describing positions to be taken including the critical arguments	preparing to present information and findings to other students; participating in the group and whole class discussions
Cooperating as a member of a group by	playing a positive role in devising questions

participating in group work	and in carrying out the investigations
Explaining that hydrogen will react with oxygen in air or by electron transfer in a fuel cell to produce water. Offering explanations for all ways of hydrogen production (especially for metal/acid and the electrolysis of water).	preparing for the presentation of the group investigation results to the rest of the class
Explaining that all engines give emissions and that the hotter the temperature, the more that the production of oxides of nitrogen become a problem	preparing for the discussion on the issue