

Investigation 8: *Extending our Knowledge*

Finally we have come to a point where we can look at hydrogen fuel cell technology and automobile development now and in the future. In this investigation you will look back at your questions from the beginning, your notes and investigation reports, and use your findings with Internet research. This will enable you to develop some understanding of what to expect as hydrogen fuel cell technology and practical applications come together and are made available for the general market. Imagine an unmanned plane that can fly for years or an isolated beacon that needs almost no maintenance.

In this investigation you will be acting as a research scientist and you will design a supplemental inquiry that could be ongoing. It may be possible to do your inquiry in the classroom with the knowledge and equipment you already have. Or you may find that your inquiry needs some specialized equipment that you, your fellow students and your teacher could try to obtain. Perhaps your inquiry will be into the unknown where very specialized equipment may be needed or developed. Your question may turn out to be one that researchers are presently wrestling with or may have to wrestle with in the future.

In short, you are invited to develop a question about hydrogen fuel cells that could be investigated scientifically. Science and technology often go hand in hand and are definitely influenced by human activity. If there is a perceived need for an unmanned airplane that can fly indefinitely and be directed from the surface of the earth then the need for that technology may drive scientists to find some answers. These answers might involve lightweight storage of hydrogen, very efficient electrolyzers, light electric motors or high efficiency lifting surfaces—perhaps even hydrogen filled!

You should begin by developing a question about fuel cells that can be scientifically investigated and then list several possibilities for inquiries that would help to answer your question or that may allow you to get closer to answering your question. From those possibilities you will need to decide which one has the highest interest level for you and your group. When that has been determined you are ready to develop a method of investigation and possibly obtain results. The statement of Louis Pasteur, a famous French research scientist, "Fortune favors the prepared mind" has been a touchstone for countless discoveries by alert observers.

The most important piece to develop is the question. Just as with computers, garbage-in yields garbage-out. If you ask 'nature' a good question you may get a good answer but if you ask a poor question

you will most likely not get a useful answer. Your teacher and the nature of your inquiry will decide the way you present your results. Good luck with your research!

Internet Research hints

If you do not search effectively Internet research often yields material that is not particularly valuable for your purpose. Using accurate search terms can narrow down the number of sources you find and emphasize useful sources. Some appropriate search terms may be:

"Fuel cell"	Hydrogen	"Electric motor"	Range
Power	Transmission	Storage	Safety
Technology	Speed	Acceleration	Weight
Power	Capacity	Emission	Waste
Pollution	Solar	Generation	Urban
Environment	Vehicle	Passenger	Repair
Disadvantages	Advantages	Expense	Efficiency
Co-generation	CHP	"Heat Recovery"	Renewable

You can combine these terms to get to the particular sources that may be helpful. If you were searching for typical speeds reached by vehicles powered by hydrogen technology you would use the most important words first, for example: Hydrogen Vehicles Speed in that order as your search words. Your search would yield a selection of websites that mentioned all of these words and after looking at five or six sites you would have an idea of the speeds current hydrogen powered vehicles could travel at. You would be surprised!

You may also find information that could help other research teams who are working on different questions. This information could be shared and add to the collective information base of your laboratory. Such teamwork is common in industry where everyone stands to benefit greatly if answers can be found quickly. Research should not be a competition but a team effort. We need to find solutions to many problems or we may find humanity in difficulties we cannot overcome.

Teaching supplement for Investigation 8: *Extending our Knowledge*

The major objective of this investigation is to allow students to review and summarize their learning about hydrogen fuel cells from these investigations and pose a question that they can investigate scientifically. The learning objectives for this investigation may be written:

- Students will develop a question that could be investigated scientifically.
- Students will refine their question and design an investigation that will allow them to get closer to the answer of their question.
- Students will present the results of their research to their classmates.

Teacher Notes

This investigation is designed to summarize and extend the learning from this unit in a manner that will realize the synergy between fixed laboratory investigations and freeform scientific thinking about what has been learned. The students will brainstorm, reflect, develop, research and refine their questions until they come up with one inquiry that they are most interested in. How this is brought about is your personal preference as the teacher. It could be another activity that has not been done in this unit, a research project that could be part of a science fair, or even something that the students recognize could not be completed within the scope of their experience and current skills. You will have to decide whether students will work in groups or allow individual projects. Flexibility in grouping is recommended and will maximize learning opportunities for all students.

The summation of this activity will be group presentations of the answers to the students' questions. These answers will provide a strong summation of the entire unit of hydrogen fuel cells as well as some departure points for further study and analysis as the students continue to follow the progress of hydrogen technology, as it unfolds in the next few years.

Other bonus presentations could be undertaken, in the form of a final report, a PowerPoint presentation, the beginning of a science fair board, a journal or newspaper article, a role play, phone call or television documentary or some other method that you would like them to undertake. The scientific piece of the presentation is paramount but the delivery method should allow variation to ensure exciting learning opportunities for all. As a comprehensive experience for this unit it could provide the beginnings of a lifelong interest in the hydrogen technology that is certain to affect us all in the coming years.