Environmental Science Institute
UNIVERSITY OF TEXAS AT AUSTIN

Efficiency in a Supergrid

Subject: Physics

Grade Level: 11th – 12th

Rational or Purpose: This lesson is designed to introduce the latest development of Supergrids to students. With oil price soaring and the rising risk of using up fossil fuel sooner than expected, a more efficient method to transmit electricity can greatly reduce wasted energy due to resistance.

Materials: Student worksheet

Lesson Duration: 40 minutes

TEKS Objectives:
112.47. Physics.
(c) (6) (D) (E) (F) (G)

Background Information:
Lighting a light bulb is only 1.6% efficient because much energy is lost at the power plant and the heat radiated from a light bulb. To solve the energy loss problem, we now have fluorescent light bulbs to increase efficiency. To enhance efficiency in the transmission process, scientists developed a Supergrid to solve the problem. Supergrids are composed of Supercables, which consist of superconductor and liquid hydrogen. Superconductors are materials that have no resistance against electric current and must work under very low temperatures (near absolute zero). The Supergrid system can provide a very efficient pathway for electricity transmission and, transport hydrogen for a future hydrogen economy. When such technology becomes more sophisticated, it could considerably reduce the country's dependence on huge imports of oil.

Activity

1. Introduce the activity by assessing student's knowledge about efficiency in general. In the case of a light bulb, there is a huge energy loss because electrical energy is lost as heat energy. In practice, there is hardly any 100% efficient transmission process because some energy is always lost to conducting material's resistance. Such resistance will convert electrical energy to heat energy.

2. Students will be asked for ideas to address the efficiency problem.

3. There are some terms that students should know before they learn about Supergrids. Direct Current: Invented by Thomas Edison; unidirection in electron flow; usually for short distance usage but more efficient in long distance with high voltage.

Alternating Current: Invented by George Westinghouse; transmitted in waveform; effective transmission ranges about hundreds of miles; only efficient in medium distance.
Resistance: a measure of resistance against electric current; different materials have different resistance on electric current.
Superconductor: a material that has no resistance to electric current; usually achieved in very low temperature (near absolute zero); first observed by Dutch physicist Heike Kamerlingh Onnes of Leiden University.

	Direct Current	**Alternating Current**
Inventor	Thomas Edison	George Westinghouse
Electron Flowing Direction	Unidirection	Waveform
Effective Transmission Distance	About a mile	Hundreds of Miles
Efficiency	Better in long distance (with high voltage)	Better in medium distance

4. Then students will take 3-5 minutes to look at the diagram of Supercables. They will study the structure of Supercable and see how liquid hydrogen is incorporated into the cable.

5. The teacher will lead the class a comparison of the tradition grid system and a Supergrid system by looking at the second diagram.

Sources:
"AC/DC: What's the difference." PBS Online.
http://www.pbs.org/wgbh/amex/edison/sfeature/acdc.html

Grant, Paul M. et al. "A Power Grid for the Hydrogen Economy" Scientific American Magazine. July 2006.

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Efficiency in a Supergrid

When we talk about efficiency in general, what do we actually mean?

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When we use a light bulb, is it possible to convert all electrical energy to light energy? Explain.

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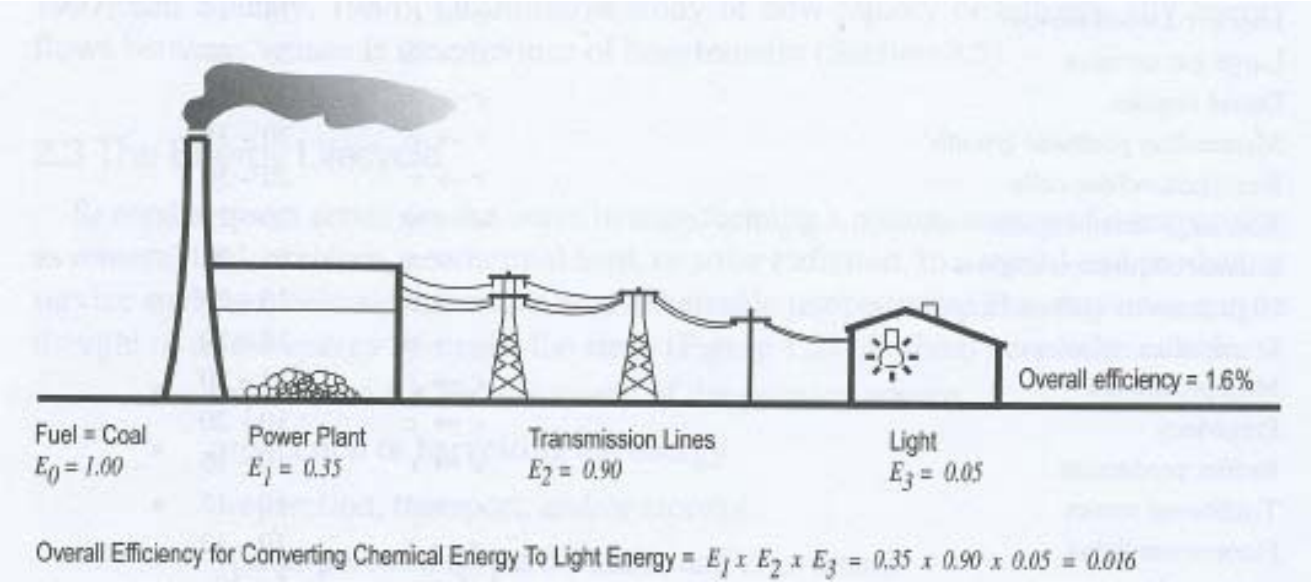
Let's look at the following diagram:



We see that a lot of energy is lost at the power plant and at the light bulb. Although transmission lines are quite efficient, there is still 10% lost in efficiency. If we want to challenge this efficiency problem, what are some possible solutions in your mind?

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Before we learn about what a Supergrid is, there are some terms we need to clarify:

DC (Direct Current)

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AC (Alternating Current)

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Resistance

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Superconductor

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	Direct Current	**Alternating Current**
Inventor		
Electron Flowing Direction		
Effective Transmission Distance		
Efficiency		

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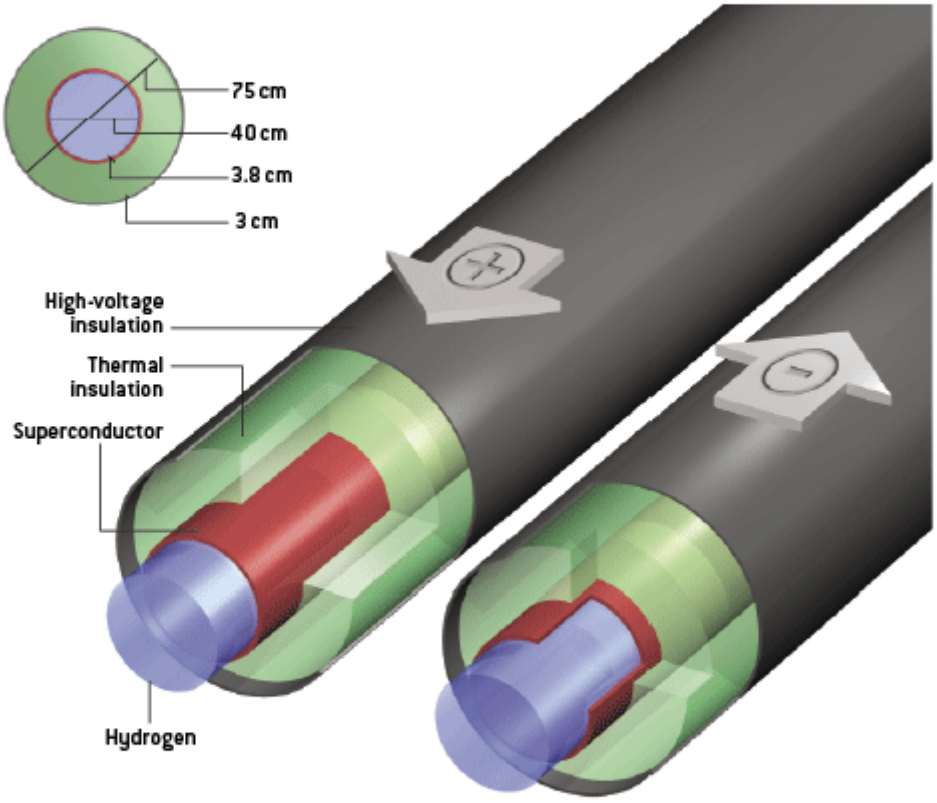
SUPERCABLES

SuperCables could transport energy in both electrical and chemical form. Electricity would travel nearly resistance-free through pipes (*red*) made of a superconducting material. Chilled hydrogen flowing as a liquid (*blue*) inside the conductors would keep their temperature near absolute zero. A SuperCable with two conduits, each about a meter in diameter, could simultaneously transmit five gigawatts of electricity and 10 gigawatts of thermal power (*table*).



	Voltage/Temperature	Flow rate	Power delivered
DC circuit	+50,000 volts and −50,000 volts	50,000 amperes	5,000 megawatts electric
Liquid hydrogen	20 kelvins	0.6 cubic meter/ second in each pipe	10,000 megawatts thermal

SLIM FILMS

(Picture from Scientific American Magazine)

Why do we need liquid hydrogen?

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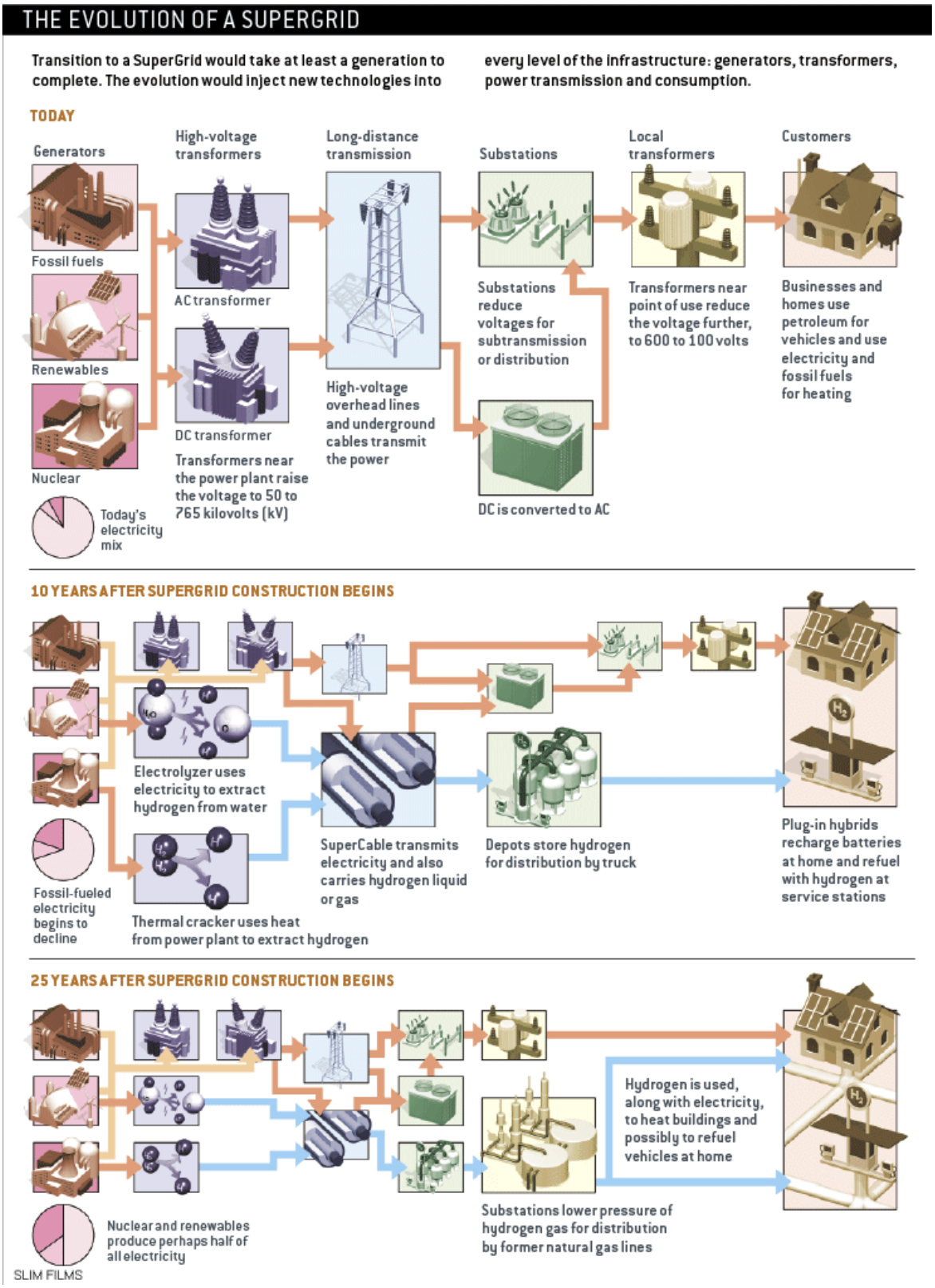

(Picture from Scientific American Magazine)

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In a paragraph, briefly explain the relationship between a Supergrid and a hydrogen based economy.

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