Title: Chemistry Connections on the Grid: “The Generation Gap”

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Introduction: Concerns over increasing atmospheric carbon dioxide (CO₂) levels and dwindling fossil fuel supplies have led to increased research on ways to improve the efficiency and reliability of renewable energy sources being incorporated in the electrical power grid. Central to the renewable energy transition is finding the means to harness significant amounts of renewable energy for storage on the grid or for production of CO₂-neutral fuels, such as hydrogen and syngas.

A unit investigating chemical concepts at work in the electrical power grid was developed to provide advanced chemistry students an opportunity to problem solve, model and evaluate grid components and issues. A focus on energy storage from renewable resources is emphasized through activities and experiments using photovoltaic cells, an experimental Edison cell, and power grid simulations. An Inquiry approach enables students to be exposed to engineering-type practices and connect with the structure and function of the electric power grid.

OPENING ACTIVITY – Energy Transformations & the Power Grid

Using small scale experiments from the American Chemical Society’s “Energy Foundation for High School Chemistry” (2013) and the applet for interactive simulations of electrical power grid concepts, students review thermodynamic/thermochemical principles and implications to the power grid to familiarize them with the structure and function of the grid.

An Experimental Edison Cell – Addressing Energy Storage on the Grid

A simple Nickel-Iron voltaic cell is made with a Mason jar, 20% KOH (potassium hydroxide) and two electrodes. Students investigate factors affecting variations in voltage with changes in cell composition and environmental factors. Initial voltage measured 1.08 V (prior to being charged).

Renewable Energy and Alternate Fuels

In addition to developing ways to store renewable energy sources, excess energy could be harnessed to produce alternate fuels such as hydrogen and carbon-neutral synthetic gas (syngas). Using a simple water decomposition process, students can analyze the thermodynamics of producing hydrogen gas from H₂O and subsequent combustion of H₂ and heat of reaction. Extensions of this activity incorporate recent developments in applying these concepts to large scale power grid production, such as the solar reactor.


A subsequent experiment provides an opportunity to test physical conditions and variables effecting the voltage produced from a photovoltaic cell to simulate variations that occur with the use of solar energy. By relating the voltage data produced by the Edison cell activity to that of the photovoltaic voltage, students design a system that could theoretically recharge the Edison Cell using the voltage produced by photovoltaic cells.

Other Promising Energy Storage & Increased Efficiency

A grid-scale development in renewable energy storage is the liquid-metal battery. Cells operate at elevated temperatures which allow the cathode-anode components to remain separated due to density differences, separated by a salt layer. The simple design uses low cost materials and avoids the problems associated with wear of solid components. Stanford scientists have increased the performance of the Edison battery using nanotechnology.

Conclusion

The structure and function of the electric power grid provides a useful and practical base from which chemistry students can make connections with concepts and experimental skills obtained from an introductory chemistry course or advanced course to real-life applications. Hands-on inquiry activities encourage creativity and enthusiasm which help inspire students to seek ways to use their own abilities and gifts to help meet the increasing demand for energy.

Works Cited

- Power Grid Simulations. http://tcip.mste.illinois.edu