—SUMMARY FOR CONFERENCE PLENARY—

Is Hydrogen the Future of Nuclear Energy?

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INTRODUCTION

The traditionally held belief is that the future of nuclear energy is for electricity production. However, another possible future exists: nuclear energy used primarily for the production of hydrogen. The hydrogen, in turn, would be used to meet our demands for transport fuels, materials such as steel and cement, and backup electricity production. Such a future would follow from three factors: (1) the potential for low-cost electricity from technologies such as solar photovoltaic, (2) the fundamental differences between hydrogen and electricity, and (3) the centralized characteristics of nuclear energy.

SOLAR ELECTRICITY

Preferred technologies for electricity production change as new technologies are developed and are dependent upon societal requirements. The wild card in our energy futures is electricity production from solar cells. Solar cells today are too expensive for large-scale production of electricity; however, there is no intrinsic reason why they are expensive. The material quantities required per unit of power output are very small. The limitation is that the current technology results in high costs─a major technological challenge but not a fundamental barrier.

Consider what happens if solar cells become inexpensive. Daytime electricity would become inexpensive. Inexpensive solar cells would potentially make heating and cooling inexpensive because of the availability of low-cost, high-temperature methods to store heat if the heat can be inputted into the storage devices as high-temperature heat from electric resistance heaters. The limitation is that solar radiation varies daily, seasonally, and locally depending upon the weather.

CHARACTERISTICS OF HYDROGEN AND ELECTRICITY

Hydrogen is fundamentally different from electricity as an energy source. Electricity on a small or large scale can be transported efficiently at relatively low costs with transformers, power electronics, and transmission lines. The electrical distribution system is a two-way system in which electricity can move both directions through transformers. In contrast, hydrogen transport involves the moving of mass. The cost per unit of hydrogen and the efficiency of compressing hydrogen are strongly dependent on the scale of operations. Hydrogen leaks out of many systems, whereas it is easy to insulate electrical systems and easy to detect leaks (short circuits). Unlike electricity, hydrogen can be stored inexpensively for days, weeks, or months in large underground facilities─much as natural gas is stored in today. The required technology has massive economics of scale and is expensive on a small scale. Although it is expensive to move hydrogen from distributed production sources to centralized low-cost storage facilities to meet the requirements for variable demand, it is relatively easy to move hydrogen from centralized facilities to distributed users down the pressure gradient.

Hydrogen may become the foundation for our metallurgical industries, transportation, and backup electricity production. Today hydrogen is used on a limited scale to convert iron ore and other ores to metal. Hydrogen is used to make ammonia─our primary fertilizer and a potential fuel. Hydrogen can be added to any carbon source to produce liquid fuels and can also be directly used as a fuel. Carbon sources for liquid-fuel production include coal, shale oil, biomass, and the carbon dioxide from the air. The last two sources of carbon, if used for liquid fuel production with hydrogen, avoid greenhouse impacts by recycle of carbon dioxide from the atmosphere into liquid fuels, which are then burnt with the carbon dioxide released back to the atmosphere. Multiple low-cost methods are available to convert hydrogen to electricity to meet variable electrical demands, the type of situation that might occur in an electrical system dominated by solar electricity with the need for backup power when the sun does not shine.

NUCLEAR ENERGY

Nuclear energy is intrinsically a large-scale centralized source of energy that requires high levels of technological competence. Large economic incentives (security, training, maintenance, etc.) favor siting multiple reactors in large nuclear parks. Many of the institutional challenges would be reduced if nuclear energy could be confined to such nuclear parks.

CONCLUSIONS

Nuclear energy is not intrinsically coupled electricity. However, with our current technologies, nuclear energy is a highly economic method to produce electricity relative to its competitors. Still, a natural technological alliance does not exist. Technological changes, such as the development of low-cost photovoltaic cells, may alter the relative economics.

In contrast, for fundamental technological reasons, the characteristics of nuclear energy and hydrogen match. The economics of both systems strongly favor large-scale centralized facilities. Large-scale hydrogen production, storage, and use also require high levels of competence. Hydrogen and nuclear energy are natural complements, independent of whether the hydrogen is made by low-temperature electrolysis, high-temperature electrolysis, or thermochemical systems.

Hydrogen production may be the future of nuclear energy. In such a future, we may see that solar systems meet a large fraction of our electricity demand. Nuclear energy would be used primarily for hydrogen production which, in turn, is used to meet our demands for transport fuels, materials, and electricity production when the sun does not shine.