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Economics of Meeting Peak Electrical Demand Using Nuclear Hydrogen and Oxygen

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INTRODUCTION

Electricity demand varies daily, weekly, and seasonally. Today fossil fuels are used to match electricity production with fluctuating electricity demand. However, traditional methods of using fossil fuels to meet fluctuating electrical demand may be limited because of concerns about climate change and rising fuel costs, particularly the cost of natural gas. Therefore, alternative methods to produce low-cost peak electricity are required.

HYDROGEN INTERMEDIATE AND PEAK ELECRICAL SYSTEM (HIPES)

HIPES is a new technology to match electricity production to the variable electricity demand. Hydrogen and oxygen are produced from water using off-peak electricity (electrolysis) or nuclear hydrogen systems (thermochemical cycles). The two gases are stored in underground facilities (using the same technology used for the seasonal storage of natural gas). Underground gas storage is 1-to-2 orders of magnitude less expensive than other gas storage systems and allows weekly and seasonal H_2 and O_2 storage to match peak electricity production with consumption. Central storage of H_2 favors central production of H_2 and O_2 to avoid the costs and risks of transporting these gases from distributed generation systems to central storage systems.

HIPES uses the stored H_2 and O_2 to produce electricity to match production with consumption using technologies with the electricity production requirements of (1) low capital costs per kilowatt (electric) and (2) efficient conversion of H_2 and O_2 to electricity. A leading option is an advanced steam turbine with a burner that combines H_2, O_2, and water to produce 1500ºC steam that serves as feed to a special high-temperature steam turbine with actively cooled blades. No expensive boiler is required. Efficiencies approach 70%.

CONCLUSIONS

Historically, nuclear energy has only been competitive for base-load electricity demands. The successful deployment of HIPES would enable nuclear systems to supply a significant faction of the peak electricity demand. A preliminary economic assessment is being conducted based on experience with related technologies: underground storage of natural gas, natural-gas-fired combined-cycle plants, steam turbines, and related technologies. Hydrogen production costs dominate system costs. Hydrogen and oxygen storage are not significant cost drivers. There are strong incentives to develop low-cost pressurized electrolyzers to enable the use of nighttime electricity production for hydrogen production and to level the daily demand for electricity. The results and sensitivities are described.