Energy Storage for Power Grids and Electric Transportation: A Technology Assessment

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Energy storage technology has great potential to improve electric power grids, to enable growth in renewable electricity generation, and to provide alternatives to oil-derived fuels in the nation’s transportation sector. In the electric power system, the promise of this technology lies in its potential to increase grid efficiency and reliability—optimizing power flows and supporting variable power supplies from wind and solar generation. In transportation, vehicles powered by batteries or other electric technologies have the potential to displace vehicles burning gasoline and diesel fuel, reducing associated emissions and demand for oil. Federal policy makers have become increasingly interested in promoting energy storage technology as a key enabler of broad electric power and transportation sector objectives. The Storage Technology for Renewable and Green Energy Act of 2011 (S. 1845), introduced on November 10, 2011, and the Federal Energy Regulatory Commission’s Order 755, Frequency Regulation Compensation in the Organized Wholesale Power Markets, are just two recent initiatives intended to promote energy storage deployment in the United States. Numerous private companies and national laboratories, many with federal support, are engaged in storage research and development efforts across a very wide range of technologies and applications. This report attempts to summarize the current state of knowledge regarding energy storage technologies for both electric power grid and electric vehicle applications. It is intended to serve as a reference for policymakers interested in understanding the range of technologies and applications associated with energy storage, comparing them, when possible, in a structured way to highlight key characteristics relevant to widespread use. While the emphasis is on technology (including key performance metrics such as cost and efficiency), this report also addresses the significant policy, market, and other non-technical factors that may impede storage adoption. It considers eight major categories of storage technology: pumped hydro, compressed air, batteries, capacitors, superconducting magnetic energy storage, flywheels, thermal storage, and hydrogen. Energy storage technologies for electric applications have achieved various levels of technical and economic maturity in the marketplace. For grid storage, challenges include roundtrip efficiencies that range from under 30% to over 90%. Efficiency losses represent a tradeoff between the increased cost of electricity cycled through storage, and the increased value of greater dispatchability and other services to the grid. The capital cost of many grid storage technologies is also very high relative to conventional alternatives, such as gas-fired power plants, which can be constructed quickly and are perceived as a low risk investment by both regulated utilities and independent power producers. The existing market structures in the electric sector also may undervalue the many services that electricity storage can provide. For transportation storage, the current primary challenges are the limited availability and high costs of both battery-electric and hydrogen-fueled vehicles. Additional challenges are new infrastructure requirements, particularly for hydrogen, which requires new distribution and fueling infrastructure, while battery electric vehicles are limited by range and charging times, especially when compared to conventional gasoline vehicles. Substantial research and development activities are underway in the United States and elsewhere to improve the economic and technical performance of electricity storage options. Changes to market structures and policies may also be critical components of achieving competitiveness for electricity storage devices. Removing non-technical barriers may be as important as technology improvements in increasing adoption of energy storage to improve grid and vehicle performance.

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